DEVELOPING TECHNOLOGICAL AND PEDAGOGICAL AFFORDANCES TO SUPPORT COLLABORATIVE INQUIRY SCIENCE PROCESSES

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ABSTRACT

One key feature of scientific community is collaborative shared enquiry and problem solving mediated by electronic networks. We report on the development and evaluation of an ICT tool to support learning how to learn together (L2L2) in Science Education as part of an EC funded project called 'Metafora' (FP7-ICT-2009.4.2/257872). Through literature review we isolated some key features of L2L2 and inquiry science processes. We turned these into icons within an ICT environment to support planning and reflection of inquiries stimulated by real-world challenges. In this paper we report the design-based research study carried out in secondary schools in Spain in order to gain understanding about the Metafora's technological and pedagogical affordances to support students' awareness of the key aspects of learning together and the key scientific inquiry processes. Our findings suggest that the ICT environment may help rise students' awareness of key collaborative scientific processes. These findings may contribute to the development of tools to support more web-mediated collaborative learning.

KEYWORDS

Learning to learning together (L2L2), Computer Supported Collaborative Learning (CSCL), Knowledge-age skills, Technology Enhanced Learning (TEL), Secondary Education, Inquiry-based science learning (IBSE).

1. INTRODUCTION

Collaboration is a central tenet of knowledge era. In 2.0 societies, citizens are massively engaged in social networking activities to exchange information, collaborate in virtual games and create multimedia artifacts. In the economic world, collaborative technologies are mediating knowledge creation processes and project management. There can be no doubt that the society requires people to possess the adequate skills to participate actively and constructively in collaborative and creative practices (Minocha & Thomas, 2007).

Although, young people could gain from various kinds of informal computer supported collaborative experience, there are no specific web-based tools designed to support them to learn how to learn together in subject-specific domains. Furthermore, the current education systems do little to equip children and young people with the complex competence of problem solving and learning together with others online.

The Metafora project[1] funded by the EC Framework 7 ICT program aims to design a pedagogy using web-based tools to support learning to learn together in the context of Maths and Science for schools. A key technical and pedagogic innovation of the project will be to support learning to learn within a community. To gain deep knowledge of any specific domain learners need to integrate learning experiences with shared reflection through dialogue in a way that builds conceptual understanding cumulatively.

[1] 'Metafora', Learning to learn together: A visual language for social orchestration of educational activities. FP7-ICT-2009.4.2 Technology Enhanced Learning contract no. 257872

2. THE WEB-BASED LEANING ENVIRONMENT: METAFORA

Metafora aims to provide a holistic environment in which students will collaboratively plan and organize their work, as well as collaborate in solving science challenges and problems over a relatively long time period.

A web-based Metafora learning environment is being developed that includes 4 main tools: a) the challenge; b) the planning and reflection tool; c) the argumentation tool and d) the microworlds. Next we describe each of these tools integrated in the Metafora platform:

2.1 The Challange

Challenge-based learning methodology was pioneered by education staff at Apple Inc. and aims to engage learners in meaningful learning context; authentic connection with multiple disciplines, multiple points and multiple possible solutions and focus on the development of 21st century skills (Johnson & Adams, 2011).

Metafora project incorporates challenge-based learning objectives and at the beginning of a typical Metafora-based activity, a group of students is formed and receives a relatively complex assignment –the challenge. The challenge is built in way that will require the students to plan how they are going to approach the solution in order to reach it on time. After planning, the group begins with an iterative process entailing enactment – discussion - revision of the plan, until the peers obtain a solution for the challenge.

2.2 The Planning and Reflection Tool

The planning and reflection implements an understanding of the key features of learning together in a visual language intended to facilitate greater awareness of the process of learning together.

The visual language was designed after a detailed research carried out during the first year of the Metafora project. The consortium used literature review and design-based research in order to refine and develop a stable visual language for implementation in the Metafora planning and reflection tool (Wegerif et al. 2012). The visual language included in the planning and reflection tool has 6 types of components:

- Main activity stages implemented as icons in blue boxes: Explore, Reach agreement, Define questions, Build model, Find hypothesis, Test model, Refine model, Draw conclusions, Prepare presentation, Reflect on process, Blank (for students to define if required)
- Activity processes that occur within each activity stage implemented as icons in green circles that attach to the boxes: Build, Experiment, Hypothesize, Make notes, Propose an alternative, Report, Reach agreement, Anticipate, Brainstorm, Evaluate, Gather information, Present, Reflect, Discuss, Simulate, Analyze, Allocate roles, Blank (for students to define if required)
- Attitudes implemented as icons in different colored hats: Open, Positive, Critical, Creative, Ethical, Rational, Intuitive, Blank (for students to define if required)
- Roles, implemented as icons in grey circles: Manager, Evaluator, Note taker, Blank (for students to define if required)
- Resources, implemented as an icon that represent the specific available resource: LASAD and the Microworlds.
- Connectors, implemented as black, blue and red arrows indicating any relationship, causal relationship and temporal relationship.

In figure 1 we present the visual appearance of the Metafora platform and the planning and reflection tool.

2.3 The Argumentation Tool – LASAD

An online dialogue support system using a dynamic concept mapping tool called LASAD was integrated in Metafora platform. LASAD is web-based argumentation tool that enables groups of learners to discuss their work in a structured way (Loll, Pinkwart, Scheuer, & McLaren, 2009; Scheuer, McLaren, Loll, & Pinkwart, 2009). LASAD is a collaborative, shared workspace containing a graphical argumentation environment and a chat tool. Students can use this space to share ideas and organize their thoughts in order to solve the challenge.

2.4 Microworlds

Various microworlds (Kynigos, 2007) which support constructionist learning in mathematical, scientific and socio-environmental domains are also integrated in Metafora platform. Students, in order to solve specific math and science challenges might use one of these microworlds.

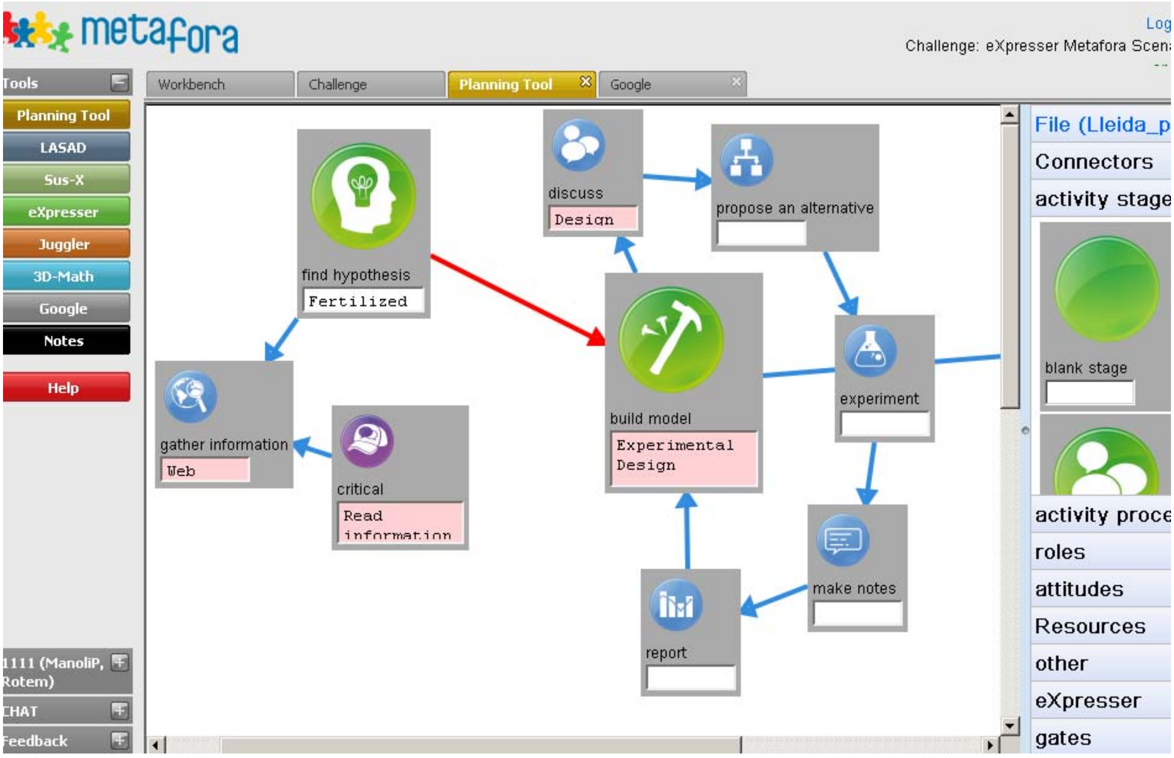

Figure 1. Screenshot of Metafora Platform

The research study we present in this paper focuses on the implementation and evaluation of the planning and reflection tool using a visual language representing the key components and features required for L2L2 and for shared scientific enquiry

3. OBJECTIVES AND RESEARCH QUESTIONS

In our research study we had two main objectives:

1. To understand and specify the Metafora's potential affordances to promote the learning and reflection about scientific enquire processes.
2. To study how Metafora's potential affordances may support students' development of L2L2 skills.

This study was conducted as design-based research (Wang & Hannafin, 2005) in which our research questions were:

RQ1: How does the visual language help students to solve the challenge using key scientific processes?
RQ2: How does the visual language stimulate discussion and reflection about scientific processes?
RQ3: Does the visual language help students to develop collaborative learning processes?

4. METHOD

4.1 Participants

Eleven secondary students of year 11 participated in our study. The students were the entire class of a Science subject. Students do not work in groups regularly and they were used to embed technology to support learning. Students work in 3 groups to solve a challenge-based science project. Students work on the challenge during 9 class sessions.

The Science teacher responsible of this class participated in the design-based research study as a co-researcher.

4.2 Procedure

Teacher began introducing the challenge and the visual language to the students. She used the interactive blackboard.

The challenge was:

The water and environmental European committee has fixed in its normative 2000/60/CE that all European rivers have to be in good ecological conditions in 2015.

A study of this European committee realized in 2008 found that Segre River (Lleida, Spain) was in good ecological condition only in 75% of its course. The most polluted section of the river is when the river crossed the town of Lleida.

What scientific and rigorous proposals could you think about to influence on the society on solving the rivers' problem. Your ideas and actions might be at different levels: authorities, media, society and peers-secondary schools.

Students were provided with some net resources about main causes that pollute more the river. These resources were selected by the Science teacher. However, students could check the open net.

Afterwards, students planned and solved the challenge using the Metafora planning and reflection tool. The pedagogy used during these sessions was:

- Students worked in small groups during all sessions.
- Work-in progress presentations and group debate sessions were carried out. During three times along the workshop, every group presented their working progress. In this presentation, students were asked to present the work done so far but also the group thinking process: reflect and present their discussions, problems, how they overcame them, use of visual language, collaboration…
- Final group work presentation and whole class discussion. Every group presented the whole work and the group proposal to influence on the society on solving the rivers' problem.

4.3 Data Collection

- We collected all students' group work realized on the computer and students' group discussion during small group work were video-audio-recording using video recorder programme –CAMSTUDIO.
- Video recording sessions of work-in progress presentation and final presentation.
- Video recording of students' dialogue while working together. For the purposes of this paper, we have transcribed and analyzed the dialogue of one group.

5. FINDINGS

5.1 How does the Visual Language Help Students to Solve the Challenge Using Key Scientific Processes?

To answer this research question we analyzed the small group work in the planning tool and their work-in progress presentations to the whole group class -in which students present what they did, for which purposes, how they were thinking in order to better solve the challenge. All the groups organized their challenge resolution process around the “activity stage” icons which represented a scientific objective to solve the challenge.

Analyzing the planning and the icons used by the three groups, we observed students took in consideration the next five scientific enquiry stages:

- Define the problem
- Hypothesis
- Methodology – Experimental design
- Analysis of results – discussion
- Conclusions and proposals to solve the challenge

These findings show that Metafora planning and reflection tool supported students’ creation of an enquire process because students establish the main scientific enquire stages highlighted in the literature (e.g. Hakkarien, 2010; Shimoda, White & Frederiksen, 2002).

Besides, students used the “activity processes” to unpack the processes and actions of the scientific activity stages. The use of the “activity processes” helped students to better define and fulfill the scientific objectives of each activity stages.

Furthermore, the analyses of the data showed that “activity processes” icons were mainly used for the next three purposes: a) as an aid to start thinking in possible actions: brain storming; b) to reflect about what they did and consequently plan the next step to solve the challenge and c) to organize and structure their actions. Next we present three excerpts of the dialogue students showed in their discussions about what to do and how the visual language mediate in their scientific discussions in order to solve the challenge.

Next we will present an example of the use of the “activity processes” visual icons as an aid to start thinking in possible actions: brain storming.

We all agree we have to start defining the problem. But.. what next? Let’s see what actions we can do [[student drags some process icons to the screen and all the members started a discussion about what processes should follow]]

An example of the use of the “activity processes” visual icons as an aid to reflect about what they did and plan next step is presented bellow:

Ok, let’s see, previous knowledge, and then we observed the data, explored the cartography link and the water agency link, and then we researched for new information.
…But we don’t have enough I think now we have to obtain new data about the river: look at this map [[open a link from the web resources]] it’s clickable! It shows the quantity of water of the river at different points. How much water does it have in the different stages of the river? and in Lleida? Look We can compare them.

An example of the use of the “activity processes” visual icons as an aid to organize and structure their actions is presented next:

Ada: I would put all of this in one block: reflect and analyze. All the information we have in here …
Thus, all this information [[pointing at text written in one of the boxes]] is the information we got reading on the web.
Alan: Yes
Ada: I will put the icons reflect and analyse, because we have already analysed it, haven’t we?
Alan: wait, wait, say it again and I will put the icons
Ada:I try to say what we are doing now?
Alan: Yes, and I agree [[she looks for an icon and drug to the computer screen]]
Ada: Brain storming [[this is the icon that Aln druged]] no, no, this later. We have done the analyses…

Observation of the planning process combined with feedback from students’ in-progress presentations suggests that “activity stages” and “activity processes” visual icons promoted students to consider aspects of the scientific research process that they would not thought otherwise. Therefore, the visual language included in the planning tool enrich students’ scientific enquire processes.

5.2 How does the Visual Language Stimulate Discussion and Reflection about Scientific Processes?

We transcript and analyzed the dialogue of students of one group of students and in one class session. First, we track in the transcription for words related with the visual language. During this session students intensively used the words of the visual language in their discussion. In this line, students used 30 times words related with the "activity stages" but they only put one icon of this category in their planning map. Students used in their discussion words such as: conceptualize the challenge, methodology, predict the results, hypothesis, and steps to follow.

Regarding to the visual language referred to "activity processes", students also included intensively during their group discussion words related to processes as: analyze, observe, brainstorm, explore, search for new information, discuss.

From our point of view, this finding is very important because it might confirm that the visual language had a positive impact on students' dialogue and on the way students organize their science thinking.

In future research studies, we are intended to use of "text analyses software" as "Wordsmith tools" to better analyse the use and the impact of visual language on the learning of scientific enquiry processes.

Additionally, a deeper analysis of students' dialogue showed the presence of students' reflection about the most appropriate scientific processes to carry out in order to solve the science challenge. In this dialogue it can be seen how Metafora visual language promoted and mediated the reflection about scientific process to solve the task.

Ada: let's see. Then, when we do that then?
Alan: so, in theory we are still here. We have not done anything, right? ((laughs))
Ada: yeh ... but from this, we should do an experimental design shouldn't we? Or something.
Alan: if
Ada: This is experimental design, right? [[Looking for experimental design icon]]
Alan: wait, wait, and wait. First is the hypothesis
Ada: We put and if we do better steps to follow first, and observe second
Anna: if ... and reflect as well. Now we are reflecting, aren't we?
Aln, if also
Ada: thinking...
Alan: here and to reflect put an arrow. So, after everything we've done we look in the mirror. Can I do it? ... [[Ask for the photocopies of the icons]]
[[Ada recorded in the Freestyler put icons on the last day]]

5.3 Does the Visual Language Help Students To Develop Group Learning Processes?

In collaborative learning situations, the process of shared meaning making is seen as just as important as the actual outcome of the activity. In this respect, Mercer and Littleton (2007:25) argue that collaboration involves "a co-ordinated joint commitment to a shared goal, reciprocity, mutuality and the continual (re)negotiation of meaning."

A key concept, related to this idea is the concept of 'intersubjectivity', which signifies the process of developing communality in joint activity. Linell (1998:225) argues that, for collaborative projects to be successful and truly collaborative, all parties must be 'mutually other-oriented'. Additionaly, in the context of Computer-Supported Collaborative Learning, Wegerif (2007:181) claimed that it is necessary to develop, through social interaction, a "dialogic space", which he sees as the social realm of the activity within which people can think and act collectively, thus opening up a space between people in which creative thought and reflection can occur.

In this section we wondered if the Metafora planning and reflection tool stimulated and mediated the development of key collaborative processes.

The analyses of the session we transcript showed students shared meaning making, took reciprocal perspective, students were mutually other-orientated and students created a dialogic space in which they thought and acted collectively. Next we present an excerpt in which collaborative learning processes are explicit.

The context of the next extract is: students are discussing the different concentration of nitrites and phosphates in the water in different points of the river. They are analyzing different graphics from a web resource.

Ada: that's strange…However, I still do not understand why during the watering season there is less [referring nitrites]. Maybe because they are more dissolved. I do not know.

Anna: I suppose, because of those about the fields, and how many times you can water the fields, right?

Ada: yes

Anna: You have to water the fields every 15 days, ok? When you do not have to water is because the humid is high.

Ada: then, during the watering season, there is less water because the plants absorb it?

Anna: yes. Because the land absorb it. They have that...

Ada: Likewise. So the land, during the watering season absorbs water and in the water is where are the phosphates and nitrites, so is logical that there are less… and just when there is no watering ... land does not absorb the water and then the water would pass without any difficulty and go to the river again.

Alan: good explanation, different to my one… but yes, what you have said is also possible.

Anna: I know this because my uncle has a field, and I know that he waters every 15 days, and for 4 to 5 hours, they put water in the field till the whole field is watered

Alan: yeh… it can be, can be

Ada: yeh, then we can base on this.

Aln: Ok

Ada: with what you are saying DNLA. It is true.

Alan: so if there is no watering, they are not fixed in the land [referring to fertilize] and they go to the river.

Ada: yes

In this extract students are making explicit their own ideas and arguments and provide reasons, justifications, warrants and evidences to support one's opinions. Ada started the dialogue explicitly expressing a doubt. Anna tried to explain the issue, giving arguments and reasons. Students showed an explicit effort to try to construct common knowledge which would enable them to make a conclusion. In doing so, students re-elaborate their own and other's ideas and reasons.

Students, in this extract, made the effort to provide different kind of arguments, for example, Alan gave evidence that came from his own experience (his uncle). Besides, students made the effort to agree in the conclusion.

6. CONCLUSIONS

This paper discusses the affordances of a new learning environment, supported by new technology that is currently under development -Metafora. Learning how to learn together (L2L2) in science is a key complex skill or competence for knowledge age work. The Metafora project aims at developing a better understanding of this complex skill through specifying key features of learning together science processes that students need to be aware of and able to work with, and by embodying these features in a visual language which forms the main component of a planning and reflection tool.

We have reported a design-based research study in which the main objectives were to understand and specify the Metafora's potential affordances in promoting the learning and reflection about scientific enquire processes and in supporting students' development of L2L2 skills.

Findings suggest that the visual language we have developed can help raise students' awareness of key collaborative scientific enquiry processes. The Metafora visual language helped students to unpack and reflect about the scientific processes to solve a complex science challenge. Additionally, the Metafora visual language promoted students' awareness about aspects and components of their collaborative learning processes in science.

The development of this visual language and its initial successful trials has potential pedagogy significance in Science Education. In our study, the tool has shown itself to be of value to science teachers who need to teach not only the content of science but also the process of scientific enquiry. Students of our study reported that Metafora helped them to reflect about the nature of scientific methodology and about scientific inquiry processes followed by the group. The Metafora planning tool allows the representation of a shared inquiry process. This representation helped students to better understand the scientific methodology and how to apply it in a specific context.

However, further research is needed to investigate the impact of using this tool on the ability of students to learn together with others in new situations. This web-based support for groups learning to learn together has to prove its significance in more disciplinary fields, across educational contexts and with larger studies. Further research is already planned to explore the potential of the Metafora planning and reflection tool to support distributed individuals learning together via the web.

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