The Metafora Tool: Supporting Learning to Learn Together

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Abstract: Collaboration in complex learning scenarios does not succeed automatically without structuring the learning process. The Metafora project (http://www.metfora-project.org) is designing a pedagogy and a platform of web-based software to support learning to learn together (L2L2) in the context of math and science. The platform serves both as a toolbox of various learning tools and as a communication architecture to support cross-tool interoperability. The central tool in the Metafora system is a web-based application offering a visual language for planning, enacting and reflecting on learning activities. In the demonstration we will present our pedagogical approach for supporting L2L2 activities and the platform developed on the basis of this understanding. In particular we will demonstrate how the platform can be integrated in successive activities.

Learning to Learn Together and the Metafora tool

Most knowledge creation is conducted by teams and not by individuals. In addition, learning mediated by the Internet is often focused on learning together with others. It is therefore important that we teach and support the complex competence of learning to learn together (L2L2). While there has been some research on learning how to learn (L2L, e.g., Claxton, 2004; Fredriksson & Hoskins, 2007; Higgins et al., 2006), there has been little research on L2L2. Learning how to learn together implies that all the group members are able to coordinate, regulate and plan the learning task by balancing issues of individual ability, motivation and expectations through constant dialogue. The process of L2L2 can be described and studied by analyzing the groups' collaborative learning activities and behaviors as a set of sub-skills: distributed leadership, mutual engagement for fulfilling collaborative tasks, a dialogue where students can discuss their ideas and create new ones, and peer group assessment, where members give and accept feedback from each other, routinely reflecting on their work.

The Metafora project (http://www.metfora-project.org), funded by the EC, is designing a pedagogy and a platform of web-based software to support L2L2 in the context of math and science. A key technical and pedagogical innovation of the project is to support L2L2 within a group of learners. We present our platform (see Fig. 1), which serves both as a toolbox of various learning tools and as communication architecture to support cross-tool interoperability. The toolbox facet of the system provides a graphical container framework in which the diverse learning tools can be launched and used. Basic functionalities that is globally available are user management (login/logout and group membership for both local groups of students sitting at one computer as well as remote, collaborative groups), a chat system to discuss and organize work between group members, and a help request function that is present across the entire platform. Below we describe in some more detail certain components and features of the Metafora system.

The planning/reflection tool

The planning/reflection tool offers a visual language that enables students to create and map representations of their work for planning, enacting and reflecting on Metafora learning activities (see Fig. 1). The main feature of this tool is the use of cards and connectors to present a plan for future work or to create a diagram of work completed for reflection. The cards contain visual symbols and titles, as well as space to insert free text (see Fig. 1) The symbols and the titles represent different stages and processes related to inquiry learning (e.g., experimentation, building models, making hypotheses), attitudes taken towards the group work (e.g., being critical, being open) and cards that allow access to different resources within the Metafora tool box (e.g.

LASAD, microworlds, etc). The connectors represent relational heuristics ("is next", "needed for" and "related to") to explicate how the various cards are related in the given plan.

Although it is built as a stand-alone web application, it is most effective as an embedded tool within the Metafora platform, acting as an entry gate and pivot to the other tools. Students can create and modify plans for facing various challenges in math or science. The students can also invoke other tools, including microworlds and discussion tools, and utilize them through specialized resource cards that are part of the visual language. With the planning tool, students describe how they will tackle their current challenge using the visual language as a guide and then move together through the various planned stages, enacting activities and noting when activities are started and completed. Thus, the plan is also a visual representation of the groups' achievements and current status.

Microworlds integrated in the Metafora system

Metafora provides five microworlds that are fully integrated in the Metafora platform. These microworlds serve as an arena for inquiry and constructionist work. (1) eXpresser: a microworld designed to support students in generalizing rules based on the structure of figural patterns of square tiles. In eXpresser, students construct animated models comprising patterns of repeated building blocks of tiles. (2) The "3d Math" Authoring Tool: a 3d programmable environment inside which users may graphically represent and manipulate 3d objects that they either find ready-made in an embedded library or construct themselves when using Logo procedures and commands. (3) The "Physt 3d" Authoring Tool: a 3d programmable environment that allows teachers (i.e. "the Pedagogical Designers") to create 3d game-like microworlds (e.g. the 3D Juggler microworld), for simulating phenomena defined by Newtonian Laws. (4) Sus-City: a game template for non-technical users (teachers and students) to construct and play their own "Sustainable City" games. The game design is based upon two types of user intervention: a) adding content on the template, i.e., the city terrain, city sites and site properties and b) defining the initial set of values for the player and the threshold values which indicate violation of the system and end of the game. (5) PiKi: a microworld that addresses kinematics through a serious game with a pirate-based theme. Other microworlds like Geogebra can be integrated with the Metafora system in a less integrated way, but still allow productive collaborative inquiry based activities.

Discussion tools and referable objects

Metafora provides discussion tools to allow general communication and collaboration, but also aims specifically to support the L2L2 process by allowing discussion and argumentation spaces to integrate artifacts created in other tools. Two discussion tools serve different purposes. First, the chat tool offers a quick and ever-present space for students to gain each other's attention and share informal thoughts in situ. Second, LASAD (Loll et al., 2012) offers a structured approach to discussion through argumentation graphs (see Fig. 2), which have been shown to improve discussion and argumentation skills (Scheuer et al., 2010). Both the chat functionality and the LASAD system are customized to display and offer links to *referable objects* that reside within other tools. These referable objects are artifacts shared from other tools that can be viewed (text or thumbnail images) as components of the discussion, but can also be accessed in the context of the original tool through return links (see an example in Fig. 2). This need emerged from early experimentation with the system and was supported by previous related research (e.g. Stahl, 2006).

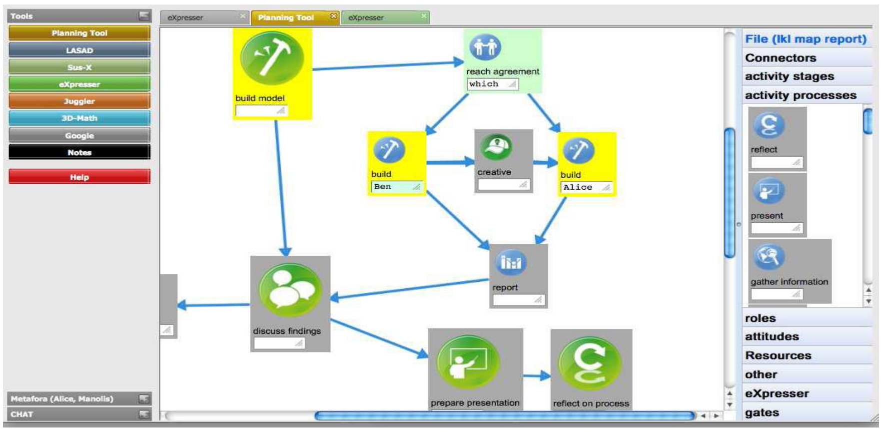

Figure 1. Screenshot of the Metafora platform with several learning tools opened (see tabs on the upper border). The planning tool is shown in the center (started activities are marked in yellow, finished activities in green; the arrows are connectors symbolizing the relations between the visual cards).

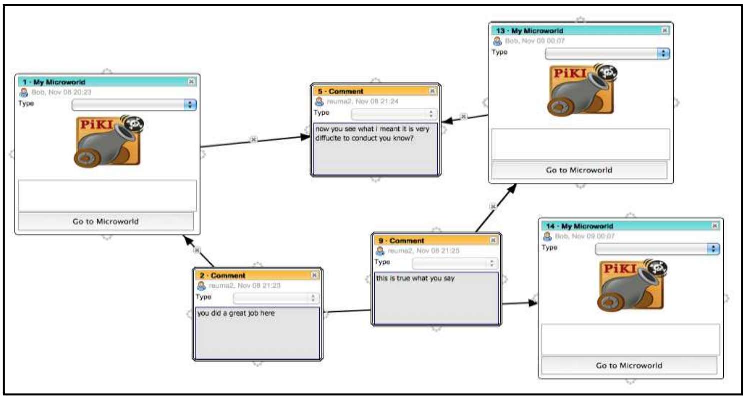

Figure 2. A discussion map in LASAD with embedded referable objects from a microworld (PiKi)

By using referable objects, students can include planning cards and/or microworld objects in their discussion without the need of anaphoric or deictic language. These direct references allow continuous dialog that is explicitly linked with and contextualized by the students' work in other tools. In this way, referable objects allow students to more easily and naturally engage in L2L2 activities such as offering help to one another, and reflecting on ideas and hypotheses in an ongoing process of negotiation of new meaning for created artifacts.

Analysis and visualization

Each software tool stands as an independent learning tool and can offer its own automated analysis of student work through individual analysis components. Analysis ranges from low-level activity indicators (such as indicating the creation or modification of artifacts) to high-level analyses (such as identification of whether a student is struggling). The intelligent components of the tools that create these various analyses report them to a centralized analysis communication channel for the entire Metafora platform. A cross-tool analysis agent then monitors this channel and offers higher-level analyses of student work. Defining and creating these high-level analyses is an ongoing effort based on prototypes and Wizard-of-Oz experimentation. The theory behind this work and first implementation steps is described in more detail in (Dragon et al., 2011). This analysis information is used to offer both direct feedback to students (through a notification system) and useful summary information to both students and teachers (through visualization tools that filter and aggregate information). The specifics of the information that should be displayed, to whom and when, are currently under investigation.

L2L2 in Metafora and its significance for CSCL research and practice

The Metafora system is conceptualized and implemented as a full-fledged web-based application, with the platform and diverse learning tools running in a web browser. Thus, it is easily accessible and built to integrate third-party web tools to support complex L2L2 scenarios. Our current primary set of learning tools described in the earlier section is specifically designed with the L2L2 principles in mind and with a high degree of semantic interoperability, i.e., seamless transition between the different tools via referable objects and the potential for cross-tool analyses. The growing maturity of the system has already been demonstrated with extensive experimentation of the pedagogical scenarios in classrooms (see, e.g, Metafora public deliverable[1]). This practical application and the empowerment of teachers will continue. In the future, the system will also be used as a research platform for a variety of complex learning scenarios. The ongoing data analysis of experimental data will provide insights into the nature of L2L2 and how the analytic system of Metafora can be enhanced to support students. The automated analysis of Metafora extends the automated work of collaborative learning scenarios that has been developed in earlier work (see, e.g., the work on ARGUNAUT (McLaren, Scheuer, & Mikšátko, 2010) and that of Rosé and colleagues (Rosé et al, 2008)). Metafora pushes the envelope on prior automated analyses by providing analyses across a variety of learning tools (Dragon et al., in press).

We argue that Metafora's unique contribution to the CSCL agenda is its ability to afford and explicitly represent the group work as a collaborative artifact (in the planning/reflection tool) and as such expose it as a subject of group discussion. Planning and reflecting activities make students focus on the meta-level task of understanding how their group succeeds or struggles in planning and enacting their work. The planning tool - used as a gate to all the tools integrated in the Metafora toolbox - plays a crucial role in this process and as such is the most significant tool developed in the project. This tool allows students to elevate their thoughts and discussion beyond the content of their task, and motivates reflection on how they work together and how, as a group, they can succeed in their learning objectives. We recognize this higher-level student effort as Learning To Learn Together (L2L2), a collaborative learning process involving several key competencies that can be practiced and recognized within the Metafora platform. Defined earlier in this document, the L2L2 learning performances can be characterized by a set of learning behaviors such as willingness to share, give feedback and reflect, distribute tasks and roles. To this end, the Metafora system allows a smooth interplay between dual interaction spaces (e.g. Mühlpfordt & Stahl, 2007) of the microworlds, the planning/reflection tool and the LASAD discussion tool. Referable objects allow students to make cross-tool reference to objects, and shared resources represented as artifacts allow students to seamlessly move between planning, enacting, and reflecting. These dual interaction spaces serve as an appropriate arena for students' sharing artifacts and ideas along their collaborative work and as such support their L2L2 behavior.

Preliminary insights from our studies (reported in project deliverables[1]) show that the students tend to use the planning tool for reflecting upon their work and concretizing their next steps accordingly. Discourse analysis of the groups' oral discussions (while working with the planning tool) reveal a clear picture of collaborative meaning-making processes over the scientific concepts symbolized in the cards. Moreover, discussions around elements of the visual language and their possible meaning in the context of the groups' work supported processes of L2L2 such as role and task re-allocation, mutual engagement and reflection.

Structure of the demonstration

The demonstration will be divided into three parts. In the first part (15 minutes) we will present the pedagogical concepts behind our work and introduce our pedagogical approach to L2L2. Next we will devote 10 minutes to introduce the Metafora tool. In the third part (30 minutes) we will invite the participants to work in groups and solve a challenge in science (a problem related to kinematics) with the use of the planning tool and a microworld in Metafora. Participants will be asked to work collaboratively on their plan and devise a solution with the use of the microworld. In the final part of the demonstration (15 minutes) we will conduct a reflective discussion on the affordances of the Metafora tool and its aim to support L2L2.

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[1] Metafora public deliverable D3.1 - The scenarios, the microworlds and a descr. of the research design (2012) . Via http://www.metafora-project.org/index.php?option=com_content&view=article &id=33&Itemid=50