Design and Technologies for Supporting Collaborative Learning with Multiple Representations

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Abstract: The MUPEMURE in-practice showcase focuses on how learning with multiple external representations (MERs) can be promoted by technology and computer-mediated collaboration. The aim is to provide teachers (from schools and universities) and educational practitioners with guidelines for how to support learners in constructing, sharing and collaboratively reviewing MERs with the purpose of promoting learning in Science and Mathematics. One focus in this CSCL in-practice-showcase is to present, interact with and discuss the three MUPEMURE approaches–*productive failure*, *scripting* and *group awareness*–to facilitate learning with MERs in CSCL environments.

CSCL Aspects in Practice Project and Partners Involved

In CSCL environments dedicated to science and mathematics learning, students are provided with a large array of representational opportunities that can be used in constructing, manipulating and sharing multiple external representations (MERs) of knowledge. The potential benefits of giving students the opportunity to generate and interact with MERs have long been recognized in research on MERs (e.g. Ainsworth, 2006) and in computer-supported collaborative learning (CSCL; e.g. Suthers & Hundhausen, 2003). Generating and making sense of MERs are complex tasks, however. In many cases students have to cope with difficulties related to the translation between representations, and to the use of these representations to build their own internal models. Therefore, learners typically benefit from some degree of guidance to translate between MERs. Modern technologies have opened new possibilities for supporting learning with MERs, for example, by enabling learners to interact with MERs in a dynamic fashion and by providing automatic system feedback on learners' actions. Moreover, recent web 2.0 developments, such as social networking sites, blogs, and Wikis, can be built upon to realize scenarios of collaborative learning with MERs.

Building on research on MERs and CSCL, we, the MUPEMURE (MUltiple Perspectives on MUltiple Representations; see http://sites.google.com/site/mupemure/) Theme Team, focus on how learning with MERs can be promoted by technology and collaboration, in short, by CSCL. We aim to provide educational practitioners with guidelines for how to support learners in constructing, sharing, and collaboratively reviewing MERs with the purpose of promoting learning in science and mathematics concepts. Specifically, the MUPEMURE focus is to develop and investigate technology-enhanced instructional approaches – in particular, productive failure, scripting, and group awareness approaches – to facilitate learning with MERs in CSCL environments.

Partners Involved

MUPEMURE (MUltiple Perspectives on MUltiple REpresentations) is one of the few Theme Teams of young academics funded by the EU Network of Excellence STELLAR. The MUPEMURE Theme Team members are:

Dr. Daniel Bodemer, University of Tübingen, Germany,
Prof. Manu Kapur, National Institute of Education Singapore,
Prof. Gaëlle Molinari, Distance Learning University Switzerland,
Prof. Dr. Nikol Rummel, Ruhr-University Bochum, Germany,
Prof. Dr. Armin Weinberger, Saarland University, Germany.

The Theme Team is experienced in rendering MERs and CSCL research for educational practitioners and has conducted a 1st MUPEMURE workshop at the 2nd STELLARnet Alpine Rendez-Vous (La Clusaz, France, March 27th – 31st). Among the active participants of this previous workshop, who will be invited to join the proposed in-practice-showcase are Prof. Dr. Shaaron Ainsworth, University of Nottingham, England; Prof. Dr. Mireille Bétrancourt, University of Geneva, Switzerland; Prof. Dr. Gerhard Fischer, University of

Colorado, USA; Dr. Hannie Gijlers, University of Twente, The Netherlands; Prof. Dr. Sten Ludvigsen, Intermedia, Norway; and Prof. Dr. Sascha Schanze, Leibniz University Hannover, Germany.

Theme of the Session and Expected Outcomes

Theme of the Session

The session will focus on discussing and developing CSCL instructional approaches for facilitating students in working with multiple external representations (MERs) in different school and university learning environments. More specifically, three approaches to learning with MERs developed in the MUPEMURE project – namely, *productive failure*, *scripting* and *group awareness* approaches – will be presented to educational practitioners with the purpose of trying out and discussing how such approaches can be improved and integrated into teachers' classroom practices. In the present section, a quick overview of current educational and research issues in learning with MERs is provided, followed by a brief discussion of CSCL approaches to learning with MERs. Then, the three MUPEMURE approaches are described.

Students are increasingly confronted with MERs online that involve and combine texts, pictures, graphs, videos, etc. Additionally, more and more educational practitioners are challenging students to not only receive, but also create, link, and share MERs of knowledge with multimedia through text, picture, or video blogs and Wikis, by collecting photos and videos online (e.g., in sites such as Flickr and YouTube), or by contributing to discussion boards and social networking sites (e.g., in sites such as Facebook or MySpace). Hence, in CSCL, learners are supposed to become producers and reviewers of MERs. Especially in science and mathematics education, the rapid and continuous emergence of new information technologies provides students with a much greater array of representational opportunities (e.g., dynamic and interactive visualizations, microworlds, simulations, modeling, etc.) that can be used in constructing, manipulating and sharing representations to others. The challenge for teachers and other educational practitioners is therefore to leverage these multiple representational affordances to designing effective learning experiences for students.

Benefits of multiple representations for learning have long been observed in practice and confirmed in research. In many cases, however, students do not take advantage of MERs since they fail to translate between different representations (Ainsworth, 2006). Moreover, even though teachers explicitly design their lessons with MERs, there is often a gap between their pedagogical goals and the students' interpretations of what is expected of them when working with MERs. As Amit and Fried (2005) pointed out, students "fail to grasp the idea of multiple representations and why they are important". It is important to note that the efficacy of multiple representations does not lie in the multiple representations per se, and thus the issue for educational practitioners and instructional designers is not only how to choose the relevant forms of representation or how to design learning environments with MERs. More importantly, the instructional challenge is how to help students develop an understanding of how to work with MERs, that is, how to interpret them, translate between them, and transform them into internal representations. In such a context, researchers and practitioners need to work in a complementary way to develop appropriate methodologies and tools that assist students in developing specific competencies associated with the use of MERs, that is, multiple/multimodal representational competencies (see diSessa, 2004; Yore & Hand, 2010).

Over the last three decades, research on MERs and in particular multimedia learning research (e.g., Mayer, 2005), has largely remained focused on their role in individual learning. Moreover, the focus of research was mainly on the effects of multimedia presentation of information (presented representations), and more specifically on how verbal and pictorial information should be arranged so as to decrease (extraneous) cognitive load and therefore facilitate learning (e.g., Sweller & Chandler, 1994). Based on multimedia learning research, a series of principles were developed from which design guidelines for effective multimedia learning environments have been derived (see e.g., Mayer's cognitive theory of multimedia learning, 2005). New directions in multimedia learning are currently emerging (see e.g., the DeFT – Design, Function, Tasks – framework proposed by Ainsworth, 2006) that are based on the idea that learners do not only need to take an active part in their learning process, but that they also need to be supported through appropriate scaffolding during their interactions with MERs. For example, there are recent studies that focus on learner-generated representations (and their relations with presented representations) (Kapur & Lee, 2010) or on the role of feedback during interactions with MERs (Rau, Aleven, & Rummel, 2009).

Some CSCL studies also focus on how collaborative learners generate, share and navigate MERs. Research on CSCL with MERs is close to those new research trends in multimedia learning. In such CSCL studies (e.g., Fischer & Mandl, 2005; Suthers & Hundhausen, 2003), learners can be asked to collaborate with one another by externalizing, sharing and working with external representations (of a particular topic) that can be presented or generated by themselves (they can be also individually or collaboratively built). Moreover, a representational tool can be used either as a medium of discussion or as a way of representing discussion between students on the learning topic (e.g., Lund, Molinari, Séjourné, & Baker, 2007). All these studies show a strong influence of external representations on the way students communicate with each other and construct shared knowledge. They also pointed out that the way representational tools are used as well as the pedagogical context in which they are placed should necessarily be chosen as a function of specific learning goals. Further work is still however needed to better understand how to facilitate learning with multiple external representations in CSCL scenarios, and also to address the potential roles of teachers in such scenarios.

The MUPEMURE project attempts to address these issues. In particular, one MUPEMURE focus is to develop and investigate technology-enhanced instructional approaches that may facilitate students to actively generate, modify, manipulate and share multiple representations in CSCL environments. We advance three contrasting designs for facilitating students. In the first design, called *productive failure*, we have students collaboratively generate representations and solution strategies to novel, complex problems without any facilitation initially, an effort that invariably leads to failure. However, this seeming failure can be productive when the support or facilitation is provided after students have worked on the task on their own. Therefore, this design delays the instructional or collaborative facilitation until after students have generated their own representations. In contrast, the second design, called *scripting*, focuses on the use of instructional guidance for collaborative groups from the beginning. The scripting approach builds on the idea that depending on learners' prior (procedural) knowledge or internal script, learners can greatly benefit from some initial guidance through an external script, that is, a socio-cognitive structure, which specifies sequences, and distributes roles and activities among learners (Kollar, Fischer & Hesse, 2006). The scripting approach orchestrates learners' activities and guides them to engage in specific sequences of roles and activities. Scripts typically include role rotation to foster equal opportunities for engaging in the relevant learning activities and help learners to consider multiple perspectives. Moreover, scripts can guide learners through different learning arrangements orchestrating individual, collaborative, and classroom learning arrangements. Script examples are the jigsaw classroom, in which learners attain expertise in specific sub-domains in expert groups and share their different expertise in their basic groups, or peer-critique-scripts that can guide learners to identify and discuss multiple perspectives on a subject. Scripts have been found an effective instructional approach, both in face-to-face collaborative learning and in CSCL for inducing specific interaction patterns and facilitating individual knowledge acquisition as well as knowledge convergence. In the third design, called *group awareness*, learners are made aware of group states and processes to foster self-regulation in groups. The awareness approach builds on technology-supported analysis of learners' knowledge or behavior, and on the idea of feeding that information back to a group of learners. Knowledge awareness approaches intend to support learners in accessing and using this information in a way that fosters meaningful learning and communication processes. For example, learners' perspectives on a subject can be gathered, transformed, and visualized in order to implicitly guide processes of social interaction that lead to an integrated view of the subject (e.g., Bodemer, 2011). These instructional approaches can be used in different learning settings such as school and university scenarios.

Expected Outcomes

The focus of this CSCL in-practice-showcase is to present, interact with and discuss the three MUPEMURE approaches—*productive failure*, *scripting*, and *group awareness*—for supporting collaborative groups in CSCL environments to generate, share, review, and translate between MERs. Teachers (from school and also university), practitioners as well as researchers from different countries interested in such issues will be invited to interact with and contribute to the development of the toolbox of instructional CSCL approaches developed by the MUPEMURE theme team. Contacts with participants of the showcase will be maintained and a larger practice-oriented dissemination will be made through the MUPEMURE interactive website (https://sites.google.com/site/mupemure/). Moreover, a longer-term expected outcome would be to get funding for developing a sustainable practitioner-researcher network in which both practitioners and researchers could contribute equally to a growing toolbox for computer-supported learning with MERs.

Session Activities

The table 1 provided below shows the sequence of activities during the 90-minute session. This session will be directed towards local as well as online users who will be able to interact by an e-voting system and to anonymously post questions and comments at any time. The online participants will also be provided with live video streams.

After a brief introduction of the MUPEMURE theme team and its main research focus, the first part of the session will be dedicated to the presentation and discussion of practice examples that illustrate the MUPEMURE work across different learning settings (school and university learning scenarios).

> *Case 1* will describe the productive failure design using a hands-on activity wherein participants will be asked to estimate how small groups of students may respond to a complex problem that targets concepts they have not learnt yet. After participants have estimated (which should take about 3 minutes), actual student-generated representations will be shared. The contrast between participants'

estimation and student-generated representations will be used to anchor the discussion about how teachers can build upon and facilitate subsequent learning for their students. In doing so, the notion of and implications for what, how, and when to support collaborative groups will be derived.

Case 2 will build upon the first case demonstrating how the instructional paradigm used there can be translated into a computer-supported setting using tabletop computers. The learning setting of both case 1 and case 2 are directed towards high school students.

Case 3 will focus on supporting joint creation and discussion of MERs by scripting and awareness features. Here, elementary school students have been guided to first make a drawing of a science topic on a tablet, second, to compare drawings and ask critical questions to their peers, and third, compose a joint drawing. We will discuss aspects of ownership and criticism among peers as well as scripting and awareness features of intelligent drawing software.

Case 4 will demonstrate how awareness about other students' conceptual and representational knowledge can be supported in a way that fosters meaningful collaborative learning processes. Taking the example of university students discussing statistics concepts on the basis of verbal, algebraic, and pictorial learning material, technologies and design features of group awareness tools will be discussed that can implicitly guide learning interactions.

The second part of the session will involve the audience and the MUPEMURE theme team in an interactive discussion on how the MUPEMURE toolbox can be improved and integrated into classroom learning scenarios. Jointly, we will strive to derive guidelines for computer-supported collaborative learning with MERs. Afterwards, participants will be enabled to continue such a discussion in our website (https://sites.google.com/site/mupemure/) so as contribute, e.g., to a growing toolbox of approaches to facilitate CSCL with MERs online.

Table 1: The MUPEMURE-in-practice session.

Session Part	Focus	Person(s) involved
1	- Presentation of the MUPEMURE theme team - Brief description of the MUPEMURE issues	Gaëlle Molinari, Daniel Bodemer, Manu Kapur, Nikol Rummel, Armin Weinberger
2	*Case 1*. A productive failure design for collaborative problem-solving with MERs	Manu Kapur
3	*Case 2*. How can children use tabletops for their drawings?	Nikol Rummel
4	*Case 3*. How can scripts and awareness tools orchestrate individual and collaborative drawing of elementary students for learning sciences?	Armin Weinberger
5	*Case 4*. How can group awareness tools facilitate collaborative learning with MERs in university contexts?	Daniel Bodemer
6	- Discussion with the audience on the MUPEMURE toolbox: How can it be used by teachers and integrated into classroom practices? How can it be developed further? - Conclusions: Audience's participation in the MUPEMURE website and also in a larger practitioner-researcher network on CSCL with MERs	Gaëlle Molinari, Daniel Bodemer, Manu Kapur, Nikol Rummel, Armin Weinberger + audience

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