ROGER SÄLJÖ

# REPRESENTATIONAL TOOLS AND THE TRANSFORMATION OF LEARNING

*Keynote Address*

ABSTRACT

Human learning, following Vygotsky, Dewey and others, is the appropriation and mastery of knowledge and skills that have accumulated in society. This ability to accumulate experiences over generations, and to communicate them in time and space, are two of the features that are so distinctive for the human species. A corollary of such a perspective on learning, and one that contrasts with most theoretical traditions, is that learning, and cognition in general, are historical phenomena subject to change in nature as the fabric of social practices changes, and as the mechanisms for storing and communicating information are transformed. Dewey recognised this sociohistorical contingency of cognition when pointing out that we have to rid ourselves "of the notion that "thinking" is a single, unalterable faculty" (1909/1997, p. 38). Already a hundred years ago, he argued in his vivid metaphorical language that "thinking is specific" and "not like a sausage machine which reduces all materials indifferently to one marketable commodity." (p. 39).

One of the most significant mechanisms through which learning is transformed is technology. Artefacts represent one of the forms of externalisation (Donald, 1991) that we make use of. Over the past three thousand years, a range of artefacts has been produced that have modified how people learn in various situated practices. Some of these technologies have had a very general impact (and here the artefacts and practices relating to literacy and uses of text are the most dramatic), while others have been more local, affecting the way in which a particular practice is organised (for instance, the invention of the chart and the compass for navigation at sea).

In the case of learning, and especially in relation to institutionalised forms of learning, representational tools that have to do with storing and representing information are particularly significant. During the past hundred years, a number of technical inventions in this field (the motion picture, the radio, the television, the VCR, computers and digital technology and several others) have been introduced, and they have changed our daily practices in many spheres of life quite dramatically. As Cuban (1986) points out, many of these have also been hailed as the start of a revolution where education will be transformed and learning vastly improved. The arguments have also had a rather similar flavour to them: books and lectures are boring; motion pictures, television programmes and computers are fun, and they will



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take most of the hardships out of learning. However, the experiences of introducing technologies into institutionalised forms of learning have never lived up to the initial expectations. The new media have found a place within institutional practices, but their impact has been considerably less than argued by the enthusiasts.

However, the significance of new technologies does not lie in their enhancing learning in a linear sense. Learning does not become better or more efficient. Rather, the important point about new technologies is that they, if they are powerful enough, transform basic features of how people communicate knowledge and skills in society and how information is organised. In this sense, new media may imply that learning will become different. This pattern of transformation of learning through new technologies has happened on several occasions in history, and one might argue that digital technology is another case in point.

## BIOGRAPHY

Roger Säljö is a Professor in educational psychology at Göteborgs University. His research interests include learning and communication within a sociocultural perspective. Säljö has an impressive list of publications on learning and development from sociocultural and cultural psychology perspectives. He is also scientific leader for the Swedish Knowledge Foundation's research programme Learning and IT (LearnIT).

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MASANORI SUGIMOTO

# HOW SENSING AND MOBILE TECHNOLOGIES CAN ENHANCE COLLABORATIVE LEARNING IN CLASSROOMS AND MUSEUMS?

*Keynote Address*


## ABSTRACT

We have so far developed several systems for supporting collaborative learning that are used and evaluated in classrooms and science museums. The underlying philosophy of these systems is that CSCL systems should raise the levels of learners' motivation and participation in a learning situation. We believe that enhancing interactions among learners in a physical world is an effective way for supporting their learning. Recent development of sensing and mobile technologies allows us to devise new computational systems for enhancing such interactions. In this talk, we discuss about design and development issues of the CSCL systems in our projects.


## BIOGRAPHY

Masanori Sugimoto is Associate Professor in the Department of Frontier Informatics, Graduate School of Frontier Sciences, University of Tokyo, Tokyo, Japan. He received B.Eng., M.Eng., and Dr.Eng. degrees from University of Tokyo, Japan, in 1990, 1992, and 1995, respectively. His research interests include human-computer interaction, computer supported collaborative work/learning, artificial intelligence, information visualization, database systems, and information retrieval. In recent years his research group has been developing several systems for supporting collaborative learning in face-to-face and networked environments using sensing and augmented reality technologies. The purpose of these systems is to raise learners' motivation and enhance their participation in a learning situation. The systems have been evaluated in elementary schools and museums.



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M. VAN AMELSVOORT & J. ANDRIESSEN

# COMPARING GRAPHICAL AND TEXTUAL PREPARATION TOOLS FOR COLLABORATIVE ARGUMENTATION-BASED LEARNING

**Abstract.** In our research, part of a European project named SCALE[1], we study the effects of graphical and textual preparation tools on the quality of interaction in computer-supported collaborative argumentation-based learning. Students in upper secondary education had to discuss a topic in pairs, and write a collaborative argumentative text in an electronic environment. This was preceded by an individual phase in which students read information, and represented their individual opinion on the topic either in a text or in a diagram. These individual products were available for inspection during the collaborative phase. We study the way students broaden and deepen the space of debate on this topic.

## 1. INTRODUCTION

Recently, research focus on collaborative learning has shifted from the effects of collaborative learning to the interaction processes during collaborative learning (Dillenbourg et al., 1996). A crucial process in interaction processes is argumentation (Andriessen & Veerman, 2000). Reasoning about points of view, and supporting arguments may lead to acceptance or rejection of information. Moreover, to be able to express 'good' argumentation, you need to engage in activities that enhance learning, such as looking at information from different sides, and looking for causes and relations to defend certain points of view.

The pedagogical objective of the SCALE project is to create situations for collaborative argumentation-based learning (CABLE) by secondary school students using computer tools. We like students not to acquire factual information, but to co-construct the type of knowledge necessary in a certain space of debate. We want students to collaboratively acquire, refine, and restructure knowledge of a debatable topic (SCALE team, 2002). Students who have constructed this type of knowledge have a *broader* (in terms of different epistemological and societal points of view, with associated arguments) *and deeper* (in terms of related concepts and modes of reasoning) *understanding of the space of debate*.

Our main interest is in the way CABLE can be supported by representational tools. When communicating in a CSCL environment, it is difficult to express the feelings and emotions one would normally express non-verbally, or to point to objects in the environment to refer to something. Some of these problems of CSCL may be remedied by the use of diagrams. It is easy to refer to diagrams, which makes it easier to express one's thoughts (Lohner & Van Joolingen, 2001), and makes them easier to remember (Ainsworth, Bibby & Wood, 1999). Diagrams also make the differences between students' opinions easily visible to them (Baker, in



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press). However, while a diagram can give a visual overview, textual representation concentrates more on details (Larkin and Simon, 1987), and a linear line of thought.

In this paper, we investigate the effects of different forms of preparation tools (i.e., text, diagram, and diagram automatically made from text) on the quality of students' exploration of the space of debate. Our research questions are:

1. To what extent do students collaboratively explore the space of debate in depth and breadth?
2. How are preparation tools used in this exploration of the space of debate?

In comparing the three forms of individual preparation linked to use during subsequent discussion, we hypothesized that students who construct a diagram before discussion will express a broader set of arguments during debate, and will be able to more easily see the 'gaps' in their space of debate, whereas students writing a text individually before discussion will express arguments to a deeper extent in the debate. We predict the best qualitative discussion with 'automated' diagrams, in which students benefit from both text and diagram.

## 2. METHOD

### *2.1. Participants and Instruments*

Students from five classes in three upper secondary schools in the Netherlands participated (N=142). They were 16 to 17 years old. The experiments were conducted during regular hours in classes of Dutch language, General Sciences, or Biology. The tool we used is TC3, developed at the Department of Educational Sciences in Utrecht to support collaborative argumentative writing in pairs (Jaspers, Erkens & Kanselaar, 2001). Pairs of students, each at their own computer, can communicate by chat, write a collaborative text, construct a diagram, and read information on the task and topic of discussion. In the diagram students can construct an argumentative representation of the topic. There are two kinds of boxes and two kinds of arrows. One box is for representing opinions, the other for representing arguments to support or rebut the opinion. The arrows are green and red, respectively for indicating a positive relation ('in favour') and a negative relation ('against') between boxes.

### *2.3. Procedure*

The task in the SCALE experiment was divided into three phases:

1. Individual debate preparation: Individuals read information on Genetically Modified Organisms (GMOs), and put their opinion, with arguments and counterarguments, *either* in a *text* or a *diagram.*
2. Debate and collaborative writing: Students in pairs discuss the topic of GMOs and *collaboratively write an argumentative text* reflecting their joint opinion. Information is not available anymore, but the individually made *texts, diagrams*, or *a diagram made of a text* of both students are.

3. Individual debate consolidation: students go back to their individual text or diagram and can adjust this product to what they think and know about the topic after debate.

Students were randomly assigned to one of three conditions: one group had to write an individual argumentative text during debate preparation that was available to them during the discussion phase. The second group had to construct a diagram individually during debate preparation, also available during the discussion phase. In a third condition, students wrote a text that was converted into a diagram by the researchers for the collaborative phase.

## 3. ANALYSES

The program TC3 logs all actions of the two students. Since our focus is on the interaction processes between students in their discussion and collaborative writing, we analyse the logfiles, and not the collaborative text as a finished product.

To order our data and get a general overview, we first analysed the interaction processes with the Rainbow framework[2]. The framework comprises seven principal analytical categories, each represented by a colour of the rainbow: off-task, social relation, interaction management, task management, opinions, arguments, and explore and deepen arguments.

The final three categories constitute the basis for further analyses on the variable 'depth and breadth of the space of debate', used to determine to what extent students explore the space of debate in breadth and depth. To determine breadth of discussion and writing, we performed a content analysis. We distinguished five main topics and fourteen subtopics of the GMOs issue. The depth of the dyad's work is determined by coding all content-related utterances. A coding of 1 is used for stating an argument, 2 for explanations or examples, 4 for supports or rebuttals, and 8 for stating an explicit relation between arguments (Table 1). The individual products are also scored on depth and breadth. Further analysis will be aimed at the *inter*activity in exploring the space of debate, to find out whether students really collaborate in this exploration of the space of debate (see column 'Who' in Table 1).

*Table 1. Example of part of protocol scoring on space of debate*

| Nr | Content of Argument (with topics—breadth) | Who | From where | What happens | Depth |
|---|---|---|---|---|---|
| 1 | Health-nutrients; I am pro, because it is good for the 3rd world, they can use extra vitamins | 1 | Own diagram | Argument and explanation | 1+2 |
| 2 | Affluence-division; no, 3rd world cannot afford Genetical Modification, it is only meant for the rich West, and then nobody will buy products from the 3rd world anymore. | 0 | New | Rebuttal, explicit relation and explanation | 4+8 +2 |
| 3 | Affluence-division; but the rich countries will help the poor countries with money and funding. | 1 | New | Rebuttal and explanation | 4+2 |
| 4 | Af-division; that happens already (funding), but with Genetical Modification nobody will buy things from the 3rd world and they will become even more poor. | 0 | New | Rebuttal and further explanation of argument #2. | 4+2 |
| Tot | | | | | 29 |

J. VAN DRIE, C. VAN BOXTEL, G. ERKENS & G. KANSELAAR

# SUPPORTING HISTORICAL REASONING IN CSCL

**Abstract.** In this paper we focus on how features of a CSCL environment can elicit and support domain-specific reasoning and more specifically historical reasoning. The CSCL environment we use, enables students to collaborate on a historical inquiry task and in writing an argumentative text. In order to support historical reasoning we compared two representational tools: a graphical representation (argumentative diagram) and a linear representation (argument list). As it is assumed that an argumentative diagram can support both cognitive and interaction processes, we expected that using this tool would result in more qualitative historical reasoning, in the chat as well as in the text. However, the results of this study did not show a significant difference in the amount and type of historical reasoning between the two conditions. A possible explanation can be found in the way the students make use of the tool while executing the task.

## 1. INTRODUCTION

A computer-supported collaborative learning environment is a learning environment in which a large amount of information can be easily accessed, and in which knowledge can be shared and co-constructed through computer mediated communication and joint construction of products. It is believed that these characteristics make CSCL an environment with much potential to provoke and support the construction of knowledge (Lethinen, Hakkarainen, Lipponen, Rahikainen & Muukonen, 2001). However, using a CSCL-environment is no guarantee of productive student interaction or positive effects on learning. Research on collaborative learning has shown that meaningful learning is related to the quality of the interaction processes (Van der Linden, Erkens, Schmidt & Renshaw, 2000). The design of the task and the tools that are available can be considered important factors that affect the quality of the student interaction (Van Boxtel, 2000; O'Donnell, 1999). Our main interest in this research project is how features of task and tools in a CSCL environment can elicit and support interaction processes that contribute to the learning of history.

Studying interaction processes from different (theoretical) perspectives may give more insight in the complex relation between collaborative learning tasks, interaction processes and learning outcomes (Van Boxtel, 2002). In line with Van Boxtel's suggestion we study peer interaction from three perspectives: a domain-specific perspective, an elaboration perspective and a co-construction perspective. First, from the domain specific perspective the main focus is on the content of the student interaction. The domain of history is central in this research project and we are specifically interested in the improvement of historical reasoning within an inquiry task. Historical reasoning implies that students situate historical phenomena in time, that they describe and explain historical phenomena, distinguish processes



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of change and continuity, consider the trustworthiness and value of sources and support their viewpoint or opinions with arguments. Reasoning within the domain of history also involves the use of historical concepts. From the elaboration perspective, the importance of elaboration in peer interaction is emphasized. The idea of elaboration is based on the constructivist idea that knowledge is not transmitted or passively received, but actively constructed (Brown, Collins & Duguid, 1989). Processes, such as asking and answering questions, reasoning and argumentation to resolve controversy, elicit elaborate interaction and contribute to the learning process. A third way to study the relationship between student interaction and meaningful learning is to put in focus the co-construction of knowledge. In recent years, especially from a socio-cultural perspective on learning, the joint and situated construction of meanings through communication and the role of mediational tools have been emphasized. When students work on a common task, mutual understanding must be created and sustained continuously (Roschelle, 1992). Knowledge can be co-constructed through the integration of ideas or through productive argument, questioning and exploration. Furthermore, student interactions can differ from each other in the amount of co-construction. Interaction in which one of the students is dominating, or that shows unproductive dispute or the accumulation of ideas without critical challenges is not believed to be valuable for learning (Mercer, 1995). We consider interaction episodes that contain all three above-mentioned aspects important for learning history. We will refer to this by the term '*co-elaborated historical reasoning*'. Thus, by co-elaborated historical reasoning we mean elaborate historical reasoning episodes in which both students equally contribute to the elaboration.

The results of a first study we conducted on historical reasoning in a CSCL environment showed that although the students did reason about history, this reasoning was often of poor quality (Van Drie, Van Boxtel & Van der Linden, accepted). The chat protocols did not show much co-elaborated historical reasoning. The students only briefly discussed their point of view on the historical issue at hand, and which arguments they would use to support their viewpoint. Discussion about counter arguments rarely occurred. The texts produced showed the same pattern. Based on these results we tried to support the quality of historical reasoning in the text and eliciting co-elaborated historical reasoning in the chat discussions. We decided to use a representational tool, an argumentative diagram, to support the process of argumentation within historical reasoning. In an argumentative diagram students can represent different arguments pro and contra and relate these to each other by using arrows. Graphical representations such as an argumentative diagram can be meaningful because of their communicative and cognitive function (Suthers & Hundhausen, 2001; Erkens, Kanselaar, Jaspers & Schijf, 2001). From a communicative function perspective, it contributes to a shared understanding and a joint problem space between co-learners, and enables them to focus on salient knowledge (Suthers & Hundhausen 2001; Veerman & Treasure-Jones, 1999; Crook, 1998). From a cognitive function perspective, a graphical representation can be meaningful for two reasons. First, it focuses attention to central problems, relations and structures in the task, helping to distinguish central, main or core issues from more peripheral ones (Suthers & Hundhausen, 2001). Second, it stimulates the process of elaboration, for it can refine and structure the content of students' knowledge and makes participants aware of gaps in their knowledge, for instance about what specific relations are present or about the balance between arguments against and in favour of a position (Suthers & Hundhausen, 2002). Based on these considerations we believe that an argumentative diagram can also be a useful tool for supporting argumentation within historical reasoning.

In the study presented here, we compared the use of a graphical representation (argumentative diagram) with a non-graphical representation (argument list). A diagram differs from an argument list in the way the arguments are represented. In a diagram the arguments are represented in a graphical way, which enables students to link different arguments with one another. A diagram gives a more overall view and structures the argumentation. An argument list, on the other hand, represents the arguments in a more linear way and gives less structure to the argumentation. By comparing these two types of representation, we try to get more insight in how the use of these representational tools influence the amount and quality of historical reasoning in the chat and text. We expect that the use of the argumentative diagram, compared to the argument list, will elicit more interaction on the arguments and on the relations between the arguments, and therefore will show more co-elaborated historical reasoning. We expect that the amount of arguments pro and contra is more balanced in the diagram, for the diagram makes the amount of arguments pro and contra more directly visible, whereas in the argument list one has to run through all the arguments on the list and count them. Concerning the learning outcomes, we expect the students in the diagram condition to produce texts of higher quality and have higher scores on the (individual) post test.

## 2. METHOD

### *2.1. Design*

The main question of this study is in which way the use of a argumentative diagram in a CSCL environment, compared to an argument list, influences the amount and type of historical reasoning in the chat discussions, and how it affects the quality of the texts produced and the individual learning outcomes. Subjects of the study were 60 students from three history classes in pre-university education (aged 16-17). Sixteen student pairs participated in the experimental condition and used the argumentative diagram; fourteen pairs used the argument list. The students were randomly assigned in pairs and to one of the conditions.

The students worked in a computer-supported learning environment called Virtual Collaborative Research Institute (see http://edugate.fss.uu.nl/vcri). VCRI is a groupware program that enables students to work collaboratively on an inquiry task and text writing. Each student works at one computer, physically separated from the partner. Communication takes place by means of chat. Figure 1 shows the main screen of VCRI in the diagram condition. Information about the task and relevant historical sources can be found in the database menu. The upper left window contains a chat facility and the chat history. The text (lower left) is a shared text