Doing cross-border science experiments: using ICT for co-planning, documentation and evaluation as a method for increased motivation to participate in, and learn about, science experiments.

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Two ninth grade classes – one Swedish and one Danish worked together doing practical science laboratory tasks. Their assignment was to seek out and choose an chemical experiment to perform, then plan for, and execute the experiment while making a videotape of the experiment to upload onto their mutual blog, and finally, to give feedback on the videos. Analysis of the students’ activities and the material they produced indicated that they attained the goals in relation to planning and documenting the practical laboratory tasks. Their level of enthusiasm was deemed to be high, and they were apparently motivated by working with students from another school in another country. However, a deeper analysis of the experimental content showed that the specifically scientific learning was rather superficial, and would have benefitted from greater teacher guidance during the assignment.

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**Introduction**

In recent years, interest in science has been shown to be low among teenagers in Sweden, as well as in most parts of the world (Osborne et al 2003, Sjöberg 2010, DeWitt et al 2011, Jidesjö et al 2009). Studies suggest that many students perceive science as boring (Spall et al 2004), and lacking in relevance and challenges (Osborn & Collins 2001). A common issue in science education in school has been associated with students’ difficulties in relating the subject-specific lessons they receive in school to everyday situations (Löfgren & Helldén 2009, Berg 2007) spending a good deal of their time on non-critical practical work and little time on discussion and reflection (Newton et al 1999, Kind et al 2011).

Numerous suggestions have been presented on how to come to terms with the challenges, including proposals for the use of teaching methods other than traditional ones (Millar 2006, Luehman & Borasi 2011). Laboratory activities are frequently used as a tool for learning in the science classroom, based on the main argument that understanding science and the scientific approach, is facilitated by executing practical laboratory tasks. A well-known fact, however, is that the students not always learn what the teacher intended them to learn during the practical laboratory work, but often mainly interact with the laboratory material without reflecting much over the scientific content in the experiment (Hofstein & Lunetta 2003, Wickman 2002, Hamza & Wickman 2012).

Newton et al (1999) strongly argues for increased opportunities for social construction of scientific knowledge through discussions and activities where students themselves take responsibility for their own learning. Also Millar (2006) stress the importance of discussions about science-related issues in the classroom to increase scientific literacy. Osborne et al (2003) suggest that increased motivation and involvement in science learning can be achieved through allowing student greater personal autonomy, and stress the importance of possibilities to do practical work and to engage in discussions about science as tools for making school science teaching more interesting for students.

Recent studies focus on how the use of information and communication technologies (ICTs) provide new opportunities for education (Karlsson 2012), encouraging students to take more responsibility for the learning process, and hopefully increasing their interest in science. For instance, blogs on teaching, which provide an opportunity for students to engage in learning science in a way that makes them both producers and consumers of knowledge, are one example of new approaches to science education in schools (Luehman & Borasi 2011).

In addition to the call for increased science literacy, there is also greater awareness of the need for general development of digital competence among students as well as teachers. In Sweden, for example, digital competence has been acknowledged as one of the major competence areas for schools to develop for all students alongside with reading, writing, mathematics and democratic competence (Skolverket, 2011), and digital competence is also one of the eight key competences the European Union call attention to in the The European Qualifications Framework (EQF) for education and training (EU 2006).

Digital technology has the potential to reduce the physical bounds of a learning situation in science education, and has the potential to facilitate the individual’s participation in extended networks and interactive learning experiences online (Kroksmark 2009). Still, potential is not the same as implementation, and local variations regarding curricula and teaching practices will also influence what is possible to do. There is a need for empirical investigations in order to detect in what way potential might be transformed into actual learning and what obstacles might hinder defined goal achievement and enhanced motivation in science education in school for increased science literacy.

**Aim**

The aim of the study was to investigate and analyze how a designed learning situation involving autonomously chosen science laboratory work and cross-border collaboration and communication could be executed, and hopefully enhance motivation for science learning and understanding among the students.
Project description and aim of the GNU cross-border collaboration project

The study presented in this paper focused on science, and was conducted within the framework of a larger EU-funded project related to cross border collaboration for educational purposes supported by information and communication technologies between Danish, Norwegian and Swedish schools. **Nordic curricula share similarities in some subject areas such as Nordic languages (Swedish, Norwegian and Danish), math, history and science,** for example, **thus creating structural possibilities for cross border collaboration without major adjustment to each other’s everyday practice regarding content in the real learning situation in class** (Pareto et al 2013, Spante et al 2013, Johansson-Svensson et al 2013). This way forward towards cross-border collaboration in educational practice has been seen as one of the major shifts that will permeate educational institutions in the near future (Lee 2012).

The GNU project started in 2011 and will continue to 2014. The aim of the project is to develop innovative cross-border teaching models by the means of user-driven, practice-based co-design processes between practitioners and researchers. Aiming for sustainability in novel teaching models (Wang & Hannafin 2005), the combination of design-based research (Kali 2008) and action research, as a methodology for stimulation and support of innovation in learning and teaching models, has been shown to be advantageous (Majgaard et. al. 2011).

**Method**

In order to be able to present the range of activities and a deep understanding of factors that advance or hinder learning about the planning, implementation and documentation of school science laboratory work, several complementary methods were used. Classroom observation was combined with focus group interviews with students. Student presentations and discussions on online systems such as Google Docs were followed and also commented upon since the research strategy was driven by co-design with the participation of teachers, students and researchers. Online presentation and communication were analyzed in relation to the Swedish Science curriculum for grade 7-9 which states that one of the learning goals in Chemistry for grade 7-9 is to display the ability to plan, execute and document simple laboratory tasks (Skolverket 2011). In addition, students’ videos of the experiments they performed and uploaded to the shared blog were analyzed in relation to laboratory skills showed in the practical work with the experiments, technical skills in making the film and communicating the results online, and in relation to the science understanding and learning demonstrated when discussing the experiments. The rationale for this multi-method approach was linked to the aim of the study, i.e. to investigate and analyze how a designed learning situation based on cross-border collaboration and communication regarding a science experiment could be implemented, and hopefully enhance motivation and interest in involvement in science experiment planning.

**Science project set-up**

Two science teachers from Sweden and Denmark participating in the GNU-project discussed and planned the set-up of a joint science project in collaboration with researchers from University College Sjælland (UCSJ) in Denmark and University West in Sweden. It was decided that the students in one Swedish and one Danish grade nine (14-15 years old) class should participate in autonomous cross-border activities focusing on the chemical and physical properties of water.

The classes in Sweden and Denmark were divided into seven cross-border groups with 3-4 students from each country. Each group was assigned a field of their own to investigate. The seven fields were (1) saltwater, (2) acid water, (3) osmosis, (4) the sea, (5) water in human beings, (6) chemical properties of water and (7) the water cycle. The students were challenged to search online for simple, interesting science experiments illustrating the properties of water in different ways. Through discussions with their counterparts in Denmark via Skype, the students agreed upon a common experiment that would be conducted in both the Swedish and the Danish group in each field, and then discussed and evaluated. This study focus on the Swedish students’ planning, execution and interpretations of the experiments they had chosen in collaboration with their Danish counterparts.
The Swedish students planned and described the experiment setup in shared documents online. All participants in the group, their teacher and the researchers, had access to the shared documents. This made it possible for the students to get feedback on their experimental setup and performance.

When the students together in the group had chosen an experiment illustrating some properties of water in their assigned field, they implemented the experiment and filmed the result. The films were published in the class’s blog, and the results were discussed with the Danish students in the group via Skype, an online voice based real time communication tool.

**Results and analysis**

All the Swedish students showed great autonomy in working with their assigned field of water topic and almost all the seven groups managed to find suitable experiments without help.

The results of the seven groups’ videos from the experiment and their communication concerning results and conclusions in the shared documents are summarized in Table 1.

**Table 1. Summary of the Swedish groups results**

<table>
<thead>
<tr>
<th>Field of study</th>
<th>Group 1 Saltwater</th>
<th>Group 2 Acid water</th>
<th>Group 3 Osmosis</th>
<th>Group 4 The sea</th>
<th>Group 5 Water in human beings</th>
<th>Group 6 Properties of water</th>
<th>Group 7 The water cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chosen experiment</td>
<td>Melting of ice with/without salt</td>
<td>Investigation of acidity in different soil samples</td>
<td>Osmosis through film from egg</td>
<td>Stratification of warm and cold water</td>
<td>Drinking water standing upside-down</td>
<td>Experiment with surface tension</td>
<td>Boiling saltwater and condensing the water vapor</td>
</tr>
<tr>
<td>Working autonomously with experiments and films</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Scientific learning</td>
<td>Written review of the experiment Conclusion incorrect</td>
<td>Written review of the experiment Discussion sources of error Show partial understanding of the concept of “osmosis”</td>
<td>Written review of the experiment Show partial understanding of the concept of “stratification”</td>
<td>Written review of the experiment Show partial understanding of the role of water as transporting medium in the body</td>
<td>Poor review of the experiment</td>
<td>Written review of the experiment No new understanding (very basic knowledge)</td>
<td></td>
</tr>
</tbody>
</table>

Analysis of the material shows that the students achieved the goal of the project with respect to planning, implementing and documenting a science experiment on the theme of water and publishing it on a shared blog. In relation to communication and digital competence skills (Skolverket 2011), they surely did the best they could to reach out to their partners in Denmark. The exchange between the classes was characterized by positive willingness to communicate as students made an effort to make themselves understood using a range of strategies to facilitate communication. They actively used strategies such as speaking slowly and clearly in order to be able to understand each other’s different, yet related, languages, sometimes combining speech with text using the chat. They also actively used digital tools to translate written text to their mother tongue. During the
video sessions they used body language, sign language and sometimes, they turned to English as a final strategy if body language was not adequate to support oral and textual communication.

The cross-border design of the learning situation, with regard to the achievement of the goals of planning, implementing and documenting an experiment, as well as training students’ digital competence and communication skills, proved to be a good method to trigger motivation, enthusiasm and interaction among students. However, looking more closely at the subject-specific learning contained in the laboratory assignments, we observed that the subject-specific learning often was insufficient. The students planned the laboratory tasks well, and managed to fulfill the practical laboratory work successfully, but in the discussion of the experiments in the shared documents it was obvious that misapprehensions of important scientific concepts were common, and that the scientific content of the experiments was difficult for the students to interpret.

For instance showed the group investigating differences in melting-time between ice with and without added sodium chloride (Group 1) great difficulties in understanding the significance of the temperature data collected. They tried to accelerate the melting of the two pieces of ice using a Bunsen burner, and finally concluded that ice with salt added melts faster (melting-time 29 min 37 sec) than ice without salt (melting-time 30 min 06 sec), based on a “difference” in melting time of 29 seconds. It is obvious that the students neither understood the misleading effect on the results by using a Bunsen burner on the ice, nor had the ability to correctly interpret the collected temperature data.

Another example of poor understanding of the actual scientific content was present in the findings of the group investigating the phenomenon of osmosis (Group 3). They managed to successfully demonstrate osmosis over a semipermeable membrane taken from an egg, using colored plain water in a test-tube on one side of the membrane, and saltwater in a test-tube on the other side. In their conclusions, however, they discussed the phenomenon in terms of salt moving from one side of the membrane to the other, thus showing that they had not understood the phenomenon of osmosis which imply that it is the water molecules that are moving across the membrane and not the sodium and chloride ions.

**Discussion**

One can view practical laboratory tasks in science classes as part of a longer term strategy for using practical scientific work as a way to learn how to learn, since the laboratory procedure is important in itself and give the students opportunity to develop many different skills while working in the science laboratory context.

In this study of scientific practical work it was obvious that the mere preforming of science experiments did not imply science learning and understanding. On one hand, the students were successful in a range of goal achievements. On the other hand there expressed a range of scientific misinterpretations. Thus, co-existence of both success and failures were clearly present in this particular learning experience where the misinterpretation from the students were ignored by the teacher in favor of encouraging the other goal achievements. It is still unclear what type of impact such a learning experience has for scientific understanding. How does the lack of discussion and reflection effect the science learning outcome? Several studies stress the importance of opportunities for students to engage in discussions and reflections about scientific issues (i.e. Millar 2006, Newton et al 1999), and lack of reflection and argumentation has been shown to be problematic in science practical work (Kind et al 2011). Nevertheless, in this particular learning experience, the level of engagement in the process of student driven search for and execution of science experiments were interpreted as very high, which indicate growing interest and motivation in learning science among the students, and may serve as an opening for increased scientific literacy.

We note that the teacher has an important role also in situations when students are working autonomously planning and evaluating their own science laboratory tasks. The students really need their teachers not only to provide opportunities to be autonomous and involved, but also to guide them in their autonomous scientific work, and give support in the interpretation of data. The students also need their teachers’ help to trigger a
discussion about the bigger picture in which the science experiment could be placed, something that previously has been proven to be a problematic area in science education (Löfgren & Helldén 2009, Berg 2007). In spite of the observation that cross-border collaboration and autonomy in the work process enhanced motivation, there is still a need to improve the science literacy. The role of the teacher is important (Hattie 2012) and in the next phases of the GNU project we need to more actively work with follow-up activities to really make the best of the increased motivation the cross-border collaboration brought to the students in their science classes.
List of references


