Collaborative Work and ICT Tools Enabling Science Teaching and Learning in a Cross-Border Context

Maria Svedäng, University West, Sweden
Maria Spante, University West, Sweden

The Third European Conference on Technology in the Classroom 2015
Official Conference Proceedings

Abstract
The collaboration and cross-border communication of 14–16-year-old students from Sweden and Denmark working with various science assignments using ICT was followed in an action-influenced project. The students collaborated in a complex learning context, including searching for information, planning, executing, and reporting experiments, posing questions, collecting facts, and communicating, using the Internet, shared documents and presentations, Blog, Skype, and Adobe Connect. The asynchronous ICT communication tools used in the project enabled the teachers to include information and instructions for the students in the documents as well as following the students work online. The synchronous communication tools were important for the students to get to know each other and make friends. Most of the student groups were successful in using the ICTs provided, in executing the experiments, communicating, and sharing information. Generally the students appreciated the possibility of working with fellow students from another country; they showed good ability to work autonomously, collaborate, and communicate about science issues. The ICT tool that were most popular among the students were Google docs and Skype. The complex learning situations created within the project enabled the students to interact regardless of physical borders and to train in important key competences such as using scientific methods, developing digital skills, and communicating in the mother tongue as well as in foreign languages.

Keywords: Science education, cross-border collaboration, ICT, communication, designed learning situation, key competences
Introduction

The use of ICT in teaching and learning is increasing worldwide. The Nordic schools are among the most well equipped in the world regarding ICT infrastructure, and the teachers’ and students’ access to ICT at school is generally high (Wastiau, Blamire, Kearney, Quittre, Van de Gaer & Monseur, 2013). However, the use of ICTs varies among different subjects, and in subjects such as science and mathematics, the use of ICT is generally quite low (Skolverket, 2013; Hatlevik, Egeberg, Björk Guðmundsdóttir, Loftsgarden & Loi, 2013). In this paper we report about a number of complex learning situations addressing a range of collaborative science tasks using various ICT tools engaging Swedish and Danish students in synchronous and asynchronous cross-border communication. Our aim is to observe how the ICTs in general and the shared documents in particular are used by teachers and students to collaborate and communicate about science and to evaluate the pros and cons with the different ICTs used for science teaching and learning.

The GNU-Project

The GNU-project, the abbreviation for Gränsöverskridande Nordisk Undervisning (Cross-Border Nordic Education), is a cross-border action-research-inspired project where teachers and researchers co-design collaborative pedagogical teaching models using digital technology for Swedish, Danish, and Norwegian students. A keystone in the project is that the cross-border teaching models that are developed within the project should be user-driven, practice-based, and co-designed by practitioners and researchers. Within the project, novel teaching models in the four school subjects of native language, mathematics, social sciences, and natural sciences have been developed and tested during 2012–2014. Nordic curricula share similarities in these subjects, thus creating structural possibilities for the teachers to plan and implement cross-border collaboration lessons without great problems (Pareto, Gynther, Lindhart, Spante, Vejbeæk & Wølner, 2013; Spante, Karlsen, Nortvig & Christiansen, 2013; Johansson-Svensson, Rustand, Steffensen & Sofkova Hashemi, 2013; Svedäng, Kinnerup, Andersson, Eriksen & Braaten 2015, http://projektgnu.eu/). In the GNU-project, the teachers, students, and researchers have communicated in their own languages: Swedish, Danish, and Norwegian. Thus one of the big challenges for all participants in the project has been to understand each other’s related, yet quite different, languages. In this paper we focus on the science cross-border activities that took place within the GNU-project during 2012–2014, when students in two Swedish classes cooperated in a cross-border environment with two Danish classes.

Cross-Border Science

Digital technology has the potential to reduce the physical boundaries in science education and to facilitate the individual’s participation in extended networks and interactive learning experiences online. Examples of ICT-mediated cross-border science work include digital collaborative learning environments enabling students to collaborate and perform experiments in remote laboratories (van Joolingen,
Jong, Lazonder, Savelsbergh & Manlove, 2004), to conduct asynchronous interactions online in asynchronous learning networks (Zion, Michalsky & Mevarech 2005), and to participate in virtual learning communities set up on Wikispaces (Chia & Pritchard 2014), as well as to implement video-channel educational tools in combination with online spaces for shared multimedia (Torres-Ramirez, García-Domingo, Aguilera & de la Casa, 2014).

The findings from the different ICT-based cross-border science learning situations referred to above are mainly positive. For instance, Chia and Pritchard (2014) reported from the cross-border scientific research collaboration between 16-year-old students from Singapore and the United States that the students participating in the project found the virtual learning community useful for their collaboration and that the exchanges on the platform positively impacted them in cognitive, intellectual, and interpersonal aspects. Zion and colleagues (2005) found that students from different schools in Israel who used asynchronous learning networks when studying biology developed better scientific enquiry skills and understanding than students discussing and solving problems face-to-face. They concluded that this result probably was due to the fact that written communication was used in the interaction, which gave opportunities for the students to review the written parts of the communication and thus engage in metacognitive activities (Zion et al 2005).

Thus, ICTs can certainly serve as useful tools for communicating, teaching, and learning science. In this paper we report on a number of joint Swedish-Danish science learning sessions within the GNU-project involving complex learning contexts where many different skills, such as communication, collaboration, scientific method, ICT use, and the like, are taught simultaneously.

Aim

The aim of this study is to investigate how teachers and students involved in the project dealt with a number of designed learning situations, including autonomous practical and theoretical science work, use of different ICTs, and cross-border communication and collaboration. The focus of the study is to find out which ICT tools are chosen among the ICTs available to teach and learn science in the different sessions of the project. We also want to observe how the ICT tools are used, study which ICT tools are preferred by the participants in the project, and evaluate different learning outcomes.

Method

This study is a design and action-research-based case study (Majgaard, Misfeldt & Nielsen 2011) combining different qualitative research methods. Classroom observations of the cross-border communication and collaboration through different synchronous and asynchronous methods were combined with analysis of the students’ shared documents and shared presentations, and of the films they produced. This was done to enable the collection of data to provide the authors with a comprehensive understanding of how the teachers implemented assignments and
instructions for the students, and how the students used the different ICTs provided to communicate, collaborate, and solve the different science tasks assigned to them. To evaluate the collaboration and learning outcomes and to find out the students’ opinions about participating in the project, we gathered information from group interviews and written evaluations at the end of the different science sessions. The rationale for this multi-method approach was linked to the aim of the study, that is, to investigate and analyse how a designed learning situation based on cross-border collaboration and communication regarding different science topics could be implemented, and hopefully to enhance students’ motivation and scientific literacy. Because the GNU science project is action-research-influenced (Dick, Stringer & Huxham, 2009, Majgaard et al 2011), the teachers and researchers planned and developed the project collaboratively during the 2.5 years the project was running. They met each year to plan collectively which science topics would be addressed and to draw up general guidelines and goals for the teachers’ and students’ collaborations. The first and third meetings took place as actual face-to-face meetings in Sweden, while the second was organized as an online videoconference. During each of the three planning meetings, the teachers and the researchers discussed and compared the science curricula in Sweden and Denmark and decided on common topics covering typical goals for the science subject in the countries. Practical issues, teaching models, and ICT tools available were also discussed, and which forms of ICT would be used were collectively decided.

The first two classes participating in the project (a Swedish and a Danish eight-grade class, 14–15 years old) finished secondary school/ninth-grade in spring 2013 and were replaced by two new eighth-grade classes in fall 2013. From the Swedish school the same teacher participated during the entire project; in Denmark, the first teacher to join in the project retired in spring 2013 and was replaced by two new Danish teachers in fall 2013.

Results

The overall impression after the science part of the GNU-project was finished is that in spite of the project encountering quite a lot of technical and other problems, it certainly was successful in implementing several novel teaching and learning methods which involved different learning outcomes such as science content learning, increased communication and collaboration skills, increased ICT skills, and increased ability to communicate in native and foreign languages. The teachers and the students found it interesting and stimulating to meet and collaborate with friends from another country and to use ICTs to communicate.

Science Topics and ICT Tools

During the 2.5 years the project was running, five separate sessions with complex learning situations were set up, addressing a number of different science topics and using a variety of ICT tools (Table 1). Shared documents were used for asynchronous communication in most sessions of the project, enabling teachers and researchers to follow, give written instructions, and occasionally comment upon the students’ work with the different tasks.
<table>
<thead>
<tr>
<th>Session</th>
<th>Grade</th>
<th>Science Topic</th>
<th>ICT tools used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 2012</td>
<td>8</td>
<td>Meteorology</td>
<td>Blog, Film (link in the blog), Skype</td>
</tr>
<tr>
<td>Fall 2012</td>
<td>9</td>
<td>The Properties of Water</td>
<td>Search for information on the Internet, Google Docs, Film (link in the shared document), Skype</td>
</tr>
<tr>
<td>Spring 2013</td>
<td>9</td>
<td>Environment and Wastes</td>
<td>Search for information on the Internet, Google Docs, Google presentation, Share links to websites in shared documents, Adobe Connect</td>
</tr>
<tr>
<td>Fall 2013</td>
<td>8</td>
<td>Organic chemistry</td>
<td>Google Docs, Film (link in the shared document), Skype</td>
</tr>
<tr>
<td>Spring 2014</td>
<td>8</td>
<td>Soil analysis</td>
<td>Google Docs, Google presentation, Skype, Oral presentation via Skype</td>
</tr>
</tbody>
</table>

Table 1. The science topics covered and the ICT tools used in the different sessions of the GNU science project.

The first science topic (spring 2012) addressed in the project was Meteorology. This was a pilot study to try out some ICT tools and enable the students to get to know one another. Student groups in the Swedish and the Danish class (14-15 years old) met online using Skype and shared meteorological data. The Swedish students produced a film presenting themselves and their school to the Danish students. The film was posted on the mutual blog.

In fall 2013 the student groups in the two classes (now in ninth-grade, 15-16 years old) studied different aspects of the properties of water, seeking out water experiments on the Internet and planning and exchanging ideas via Skype. Subsequently, the students executed and filmed the experiments they had selected, shared the films in the mutual blog, and reported and evaluated the experiments in shared documents and in Skype meetings.

In spring 2013 the two classes worked with environmental questions and waste management and sorting in Sweden and Denmark. The student groups posed questions to each other in the shared documents, discussed and compared waste management and sorting in the two countries, and made simple investigations about waste sorting/disposal habits by interviewing people at their schools. They answered each other’s questions and presented their joint results in shared Google presentations.

In fall 2013 two new classes—a Swedish and a Danish eighth-grade —joined the project because the two previous classes now had finished secondary school. The setup of the collaborative task assigned to the student groups was similar to the assignment realized in fall 2012—to seek out, plan, execute, film, and communicate
science experiments; this time the experiments selected illustrated properties of carbon and organic chemistry.

The student groups in these two classes also cooperated in spring 2014 making soil analyses in different environments in Sweden and Denmark (coniferous forest, deciduous forest, agricultural land, etc.) and presenting their results in shared Google presentations. Some of the results were also reported orally to all classmates in both classes via Skype.

**Teaching and Instruction**

The evolution of the teachers’ written instructions in the shared document during the project is shown in Table 2. Shared documents were used as a common platform for students, teachers, and researchers in all sessions in the GNU science project except in the pilot study, that is, from fall 2012. The sessions typically lasted for five weeks, with the students working with the project approximately two lessons per week. In general, the lessons were introduced by the teachers, who made a brief outline of the mission of the day, but after the introduction, the teacher assigned the students to work autonomously in their groups and was available only as a support when a group needed help during the rest of the lesson.

To use the shared documents as a platform for communication and instruction from the teacher to the students was a method that evolved during the project, and the instructions became more and more refined with time (Table 2.). The use of written instructions directly in the shared documents, as a complement to the oral instructions given when starting the lessons, was used from spring 2013. The last year the teachers also included the schedule in the shared documents, informing the students of the timetable for the project and when synchronous online meetings were planned. The teachers posed written evaluation questions in the shared documents, which the students answered by the end of each session (starting fall 2012).

<table>
<thead>
<tr>
<th>Session</th>
<th>Shared document</th>
<th>Instruction in shared document</th>
<th>Time schedule in shared document</th>
<th>Evaluation in shared document</th>
<th>Questions in both languages (Swedish and Danish)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 2012</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>Fall 2012</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Spring 2013</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fall 2013</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Spring 2014</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Table 2.** The evolution of the instructions from the teachers to the student groups in the shared documents.
The importance of frequent communication between the teachers and thorough planning cannot be underestimated in a complex project of this kind that involves teachers, students, and researchers in different countries. If the teachers had not agreed upon very distinct frames supporting the collaborative work between the student groups, the communication between the students encountered problems and sometimes failed. However, as the project evolved, the teachers realized the importance of very clear outlines and instructions in the project, and the planning and instructions to the students improved. As one of the teachers put it: The most important [part] for every project is that the teachers have planned well and that they give the same instructions to their students. (Teacher in written evaluation)

**Learning outcomes**

Classroom observations and analysis of the student reports in the shared documents and of the films produced by the students made it obvious that many different skills were developed during the project. Different types of scientific literacy—such as searching for and evaluating information, planning and making decisions, conducting practical work and communicating science—were clearly a part of the exit learning outcomes. Students were also trained in digital literacy in the form of handling and producing digital information in combination with collaboration and communicating skills.

When evaluating their work in the different sessions in the GNU science project, the students mentioned a number of experienced learning outcomes such as learning to handle new ICT tools and communicating in another language. The Swedish student groups emphasized scientific knowledge as an important learning outcome in the project, whereas the Danish student groups (which did not answer this question to as great an extent as the Swedes) stressed training in ICT and collaborative skills.
Most of the student groups enjoyed participating in the project of learning science in an unusual way, involving collaborative work with fellow students in another country and using ICT. They especially appreciated the possibility of practicing cross-border communication and working autonomously with experiments. It has been fun to talk a bit with another country and with someone speaking another language….It has been fun to do research about new stuff and to learn about different areas. It has been fun to be able to work more freely and more in [a] group than usual. (Swedish student group in written evaluation)

I think it has been thrilling to work together with the Swedes, since it has been a challenge to understand each other and work together in another language. (Danish student group in written evaluation) However, some student groups found it uninteresting to participate in the project and would have preferred to have “ordinary” science lessons instead. It has been thrilling to speak with another country, to see if we are working in the same way, but we think that the GNU (project) has been more non-serious than we had believed. (Danish student group in written evaluation).

Evaluation of the ICTs Used

During the project, technical problems occurred frequently, mainly because of an overload of the local broadband. The students, however, were patient and often managed to solve communication problems by, for example, using the chat function or sign language if the sound was failing when communicating via Skype or Adobe
Connect. Due to technical problems especially when communicating synchronously, many student groups preferred to communicate asynchronously in the shared documents (Figure 2).

In spite of some contact problems when using Adobe Connect and Skype, it is obvious that the students appreciated the real-time meetings and the possibility of seeing each other while communicating. The Swedish students were especially positive about using Skype as a tool to cooperate and communicate (Figure 2).

![Figure 2. Positive experiences of ICT tools (y-axis: number of positive postings in the student groups’ evaluations in shared documents)](image)

Although the students were positive about the possibility of meeting and communicating with fellow students in another country, the technical problems understandably frustrated them at times. Thus, in spite of the student groups’ positive attitude to the use of Skype, Skype is at the same time the ICT tool that rendered the most negative comments (Figure 3.). As can be seen when comparing Figure 1 and Figure 2, there are many more positive comments from the students than negative when evaluating the ICT tools used during the project.
The students’ positive experiences with the different ICT tools used when learning and communicating science is consistent with the fact that the students stressed ICT learning as the most important learning outcome within the project (Figure 1).

Discussion

It is interesting to follow how the communication and the collaborative work evolved over time in the GNU science project. To launch a complex action-research-based project of this kind based on designed learning situations developed by teachers and researchers in collaboration, involving students from two different countries with similar, yet different languages, meeting online to work and learn together, is certainly a challenge for everyone involved. To successfully implement the different science learning sessions outlined in the project, it is crucial that the joint planning is thorough and clear and that the participants are committed and willing to reach out and communicate. The overall impression is that this was the case regarding both the teachers and the students involved in the project. Although encountering different obstacles during the 2.5 years the project was running, the students were positive and certainly made their best effort to communicate and solve their tasks.

Key Competences

In the European Framework for Key Competences for Lifelong Learning, the EU council defines eight key competences considered to be required for personal fulfilment, active citizenship, and the like (Figel 2007). Among the key competences...
are, for instance, basic competences in science and technology, digital competence, learning to learn, and communication in the mother tongue and in foreign languages. These are all competences that certainly were well presented in the complex learning situations created within the GNU science project. Thus, while the collaborative tasks assigned to the students addressed different science topics, and the theoretical content they collectively produced in the project was exclusively about science, additional learning outcomes, some of them non-academic, constituted an important and desired goal in the project. The findings in this study coincide with the results of Chia and Pritchard (2014), who in their study of the cross-border collaboration by students from Singapore and the United States concluded that the use of a common online resource realized in Wikispaces impacted the students positively in both academic and non-academic domains.

Collaborating using ICT

The students participating in the project showed good ICT skills, and the technical problems that emerged were almost solely due to insufficient broadband capacity. As stated earlier, schools in Sweden and Denmark are among the most technically well-equipped in Europe (Wastiau et al. 2013), ICT tools are common in several school subjects (Undervisningsministeriet, 2008, Skolverket 2013), and Swedish students’ experience is that they are skilled at using ICTs (Skolverket 2013). Thus, a greater challenge to the students than handling the available ICTs was communicating and making themselves understood. Many student groups reported communication and language skills as learning outcomes in the project. Classroom observations revealed great willingness among the students to communicate, and they used many different modes of communication, such as body language, sign language, chat, and the like (Svedäng & Spante 2014).

Although the students greatly appreciated the possibility of meeting and communicating synchronously with each other, the shared documents were the most popular ICT tools among the students. This is understandable, because the shared documents were easy to use and did not suffer from technical problems. Chia and Pritchard (2014) reported that the students collaborating in the Singapore-US cross-border science project used the online working platform (the Wikispaces) for joint planning of the collaborative work, data collection, and analysis of experimental data, and for discussing and drawing conclusions, which is similar to how the students in the GNU science project used the shared documents. Zion and colleagues (2005) found that students from different schools in Israel who communicated asynchronously when studying biology developed better scientific enquiry skills and understanding than students discussing and solving problems face-to-face. They suggested that this result probably was due to the fact that written communication was used in the interaction, which gave students opportunities to review the written parts of the communication and thus engage in metacognitive activities. Thus, the use of asynchronous ICT communication tools such as Wikis and shared documents has many advantages, even though the synchronous communication is also important for the students to get to know each other and make friends.
Scientific Literacy and Attitudes

Attitudes towards science play an essential role in students’ scientific literacy (Bybee & McCrae 2011), and it is crucial to understand the factors that influence student attitudes, engagement, and interest in science in order to be able to improve science education and increase scientific literacy. The situation in many countries today, however, is that the interest among students is decreasing and many students find science ‘boring’ (Osborne, Simon & Collins 2003; Spall, Stanisstreet, Dickson & Boyes, 2004). Previous research shows that students favour learning situations that include practical work, high levels of student involvement, interpersonal interactions, diverse methods, and challenging material (Fouts & Myers 1992; Osborne et al., 2003; Raved & Assaraf 2010; Hampten-Thompson & Bennett 2011), indicating that the way science lessons are organized and implemented is important for students’ enjoyment of science and motivation to learn. The complex learning situations implemented in the GNU science project include many of these qualities—that is, the students have the opportunity to work autonomously, collaborate in groups, and use practical methods such as experiments and various types of ICT tools. Thus, we believe that this kind of designed learning situations may present the opportunity to improve the students’ attitudes towards science, increase their interest, and, hopefully, also their scientific literacy.

Conclusion

After following the teachers and students collaborating in the GNU science project, we conclude that the students’ learning outcomes, in addition to learning science content and methods, enabled the development of various highly useful skills such as ICT skills, communication skills, and collaboration skills. For successful implementation of the collaborative work between both teachers and students, thorough planning and clear instructions from the teachers to the students are essential.

The designed learning situations realized in the GNU science project can serve as an example of how science teaching and learning can be organized in a novel way, providing the opportunity for the students to train in many important skills as well as to improve their scientific literacy.
References


**Contact Email:** maria.svedang@hv.se