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## USE OF THE INTERNET IN THE TEACHING OF CHEMISTRY IN FINNISH SCHOOLS: A CASE STUDY

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**ABSTRACT:** The Internet provides several services that can be used in the teaching of chemistry. Electronic discussion has been used for some years and now teachers have started to use the Web for planning lessons and for finding teaching materials or exercises. In this study, 17 secondary school pupils used the Web in three different lessons for searching and reviewing information about ozone, and for discussing it. The aim of the first lesson was to search for and evaluate information about ozone and the aim of the second and the third lesson was to discuss it. The pupils' work was analysed quantitatively and qualitatively. During the first lesson the pupils sent 20 messages and during the discussion lessons over 100 messages. The pupils discovered several characteristics of the Web pages independently without any help. They also used the Web as the basis for several discussion topics and, especially in the final web-based discussion lesson, only one irrelevant message was sent. Both the pupils and the teacher enjoyed the lessons. This Web-based learning method was found to be a worthwhile tool in understanding pupils and how they think. The Internet-based method of teaching is flexible. In the future the teacher can give tasks to the pupils and they can complete them in their own time. [*Chem. Educ. Res. Pract. Eur.*: 2000, 1, 121-128]

**KEYWORDS:** *chemistry, ozone, teaching method, computer-mediated communication, Web-based discussion, Web-based reviewing*

### INTRODUCTION

Finnish teachers have started to use the Internet in teaching, particularly for planning lessons and for finding educational material or exercises. Some teachers use the Internet during their lessons by showing three-dimensional pictures or movies from the Web, or by creating small international projects between schools. Pupils have completed assignments using information found on the Internet.

Using electronic discussion in the classroom is a new way of teaching chemistry. E-mail discussion has been used for distance education (Liu, 1996) and chemistry conferences (Tissue, 1999). In Finnish schools, e-mail communication has been used in language teaching (Tella, 1992a, Tella, 1992b). The aim of this study was to find out how Finnish schools use the Internet in the teaching of chemistry. In this case study, the resources on the Internet were used in different ways: material search, e-mail use and Web-based discussion.

### METHODOLOGY

To find out how the Internet is used in Finnish schools for the teaching of chemistry, an e-mail questionnaire was administered. Four schools were selected on the basis of the questionnaire, and subsequently were visited in the spring of 1998.

In this study, the Internet was used during three chemistry lessons given in the upper stage of a Finnish comprehensive school. For a long time that school is considered as representative of a creative and international way of thinking. It has a broad language programme, and bilingual (Finnish/English) instruction is given in several subjects. The pupils, seven boys and ten girls aged 13 from the 7th grade, had used the Internet before in chemistry lessons: they had searched for information about the elements, and made a report in Finnish and in English. All the pupils had good marks in chemistry. The lessons investigated in this study were held in Finnish.

The three lessons, which had been planned by the teacher, dealt with ozone. The difference between the first and the other two lessons was the way the pupils handled the information. During the first lesson the pupils searched for information and during the discussion lessons they presented their knowledge. During the first lesson, the pupils were asked to find out and evaluate information about ozone using the WWW. The task was an open one: the pupils were free to choose the keywords and search engines they wanted to use. During the second and the third lesson the pupils discussed their findings. In the second lesson, the pupils practised discussion on the WWW, and in the third lesson, they discussed ozone on the Web using the information found there. Before this second discussion the pupils were divided into two groups: those who prepared questions and those who prepared answers. The teacher gave six special topics to those who prepared the answers. These topics were: 1) the substances that cause the ozone loss; 2) the damage caused by ozone to human beings, animals, plants and materials; 3) the protection of the ozone layer; 4) the formation of ozone in the atmosphere; 5) the importance of ozone depletion for Finland; and 6) the meaning of unfamiliar words. The second and third discussion lesson started with two messages written with the help of the teacher. All Web-page reviews and messages were sent using the guestbook created by Matt Wright (1999).

The questionnaires were given to the pupils and the teacher before the first lesson in order to find out how they had previously used the Internet. Three pupils and the teacher were interviewed after every lesson. All the lessons and interviews were tape-recorded.

The content and the number of messages and words were analysed. The purpose of the message and word count was to find out how long the messages the pupils sent were, and if there were any differences between boys and girls during the second lesson when no special instructions were given by the teacher. Tella (1994) did not count the number of words in the messages, because, as he says, the length of a message depends on the idea to be expressed. In this study the words were counted, because the number of words shows clearly the lengths of the messages and also approximately the length of the time pupils took to write a message, which may have influenced their ability to follow the discussion. No interaction analysis was made, as this technique has been criticised (Tella 1994b) because it does not study the content of the messages closely enough. Gunawardena (1997) is also concerned about this. He claims that all messages are interaction, although each of them is sent to a certain person or persons in a group. In a discussion group (here a discussion forum) all the participants can see all the messages and can answer all of them as well. Interaction is not communication between two persons; it is communication within a group. The quotations presented in this study have been interpreted and translated by the researcher.

## RESULTS AND DISCUSSION

### Results from the questionnaires

Pupils also used the Internet at home, at the library, at a friend's home or at the work place of the parents or friends' parents. Usually they had received instruction in computer use at school, but some had also learnt from their friends or parents or at home by themselves. None of them had his own home page. The boys used the Internet more frequently than the girls; five boys out of seven but only one girl out of eight used the Internet more than once a week. Usually they used the Internet from half an hour to one hour at a time. The most frequently used Internet services were the WWW, e-mail and CHAT. The girls used communication tools more than the boys did. The most frequently used search engines were AltaVista and Yahoo.

### Results from the lessons recorded on tape

Table 1 presents the proportions of the different kinds of talk during the lessons. These show that the lessons were very intensive, especially the third one, in which the pupils were discussing ozone. After receiving instructions from the teacher, the pupils worked by themselves with only a little help from the teacher. The percentage of teacher talk was very small compared to conventional lessons in the Finnish secondary schools: Leiwo et al. (1987) showed that the teachers did 61 % of the talking (moves).

**TABLE 1.** *Percentage of talk during the lessons.\**

<i>Kinds of talk</i>	<i>1st lesson</i>	<i>2nd lesson</i>	<i>3rd lesson</i>
<i>Teacher's instruction</i>	20	10	14
<i>Silence in the classroom</i>	0	6	11
<i>Pupils talking**</i>	80	84	75

\* Data from tape recordings of the lesson. Percentages calculated from the number of turns.

\*\* The pupils were sometimes talking at the same time as the teacher.

### Results from the written messages

As the results from the questionnaires suggest, the girls had more experience in the use of communication tools, but these three lessons showed no differences between boys and girls. The boys sent most of the messages during the first and the second lesson, but the number of words in the messages of both sexes was about the same in all the lessons (see Table 2). In the first lesson, the pupils searched for information from the Web and evaluated the Web pages spontaneously with no special instructions given by the teacher. According to Bos (1997), pupils can learn a range of critical evaluation skills by writing reviews of WWW resources. He also states that the pupils must have well-developed "meta" level skills in evaluating resources and judging what is and is not relevant to their topic area. In this study, the pupils paid attention to the information and its presentation on the web pages. Related to the information, they explored the following characteristics: content, quality, quantity, actuality, and the organisational structure of the resource. As to presentation, they noted the following properties: general layout, links, language, appearance, technical matters, and the source of the published resource. Most of the pupils paid attention to the quality (good, basic,

**TABLE 2.** *Number of messages and words in messages sent during the lessons.*

Sex	1st lesson		2nd lesson		3rd lesson	
	Messages	Words/ message	Messages	Words/ message	Messages	Words/ message
	N=20	average	N=108**	average	N=105**	average
Boys (7, 5, 5)*	14	21	63	16	47	17
Girls (5, 6, 9)*	6	20	45	20	58	16

\* The number of computers available in the classroom.

\*\* Irrelevant messages from unidentified senders are not included.

essential or important) and quantity of information, the organisational structure of the resource (well explained, clear or complicated) and the appearance (pictures and colour) of the presentation.

During the second lesson (the first discussion lesson) the pupils practised discussion with the guestbook. They discussed the consequences of the depletion of the ozone layer (23 % of the messages) and what should be done to prevent it (37 % of the messages). One of the most interesting discussion subjects related to the latter question was how to add or produce ozone:

*Hello, hello. This is me. My opinion is that the ozone layer is getting too thin. Ozone is essential to limit dangerous UV radiation from the sun. My opinion is that ozone should be added somehow to the atmosphere. Comments please.*

Another pupil mentioned going to the moon:

*We could build up cities on the moon, if the earth is getting so damaged.*

The pupils also discussed other environmental issues, such as the greenhouse effect and pollution (4 % of the messages), or they were generally worried about the situation (20 % of the messages). A misunderstanding between one pupil and the teacher caused irrelevant messages (16 % of the messages). The boys sent most of the messages containing information, answers, comments, or statements, and the girls sent most of the questions. These findings are given in Table 3.

The pupils used several technical terms, such as ozone, atom, gas, radiation, freon,

**TABLE 3.** *Number of different categories in messages sent during the second lesson.*

Sex	Categories*				
	Information**	Questions	Answers	Comments***	Statements***
	N=18	N=42	N=18	N=58	N=46
Boys	16	13	15	33	31
Girls	2	29	3	25	15

\* One message may contain several categories.

\*\* Messages with informational content.

\*\*\* Comments were sent to a particular person and statements to the group in general.

smog, allotropic, oxidiser, methane, hydrogen, and oxygen, but not all of them necessarily understood their meaning. This became evident when one pupil asked: *What does synthesise mean?*

During the third lesson (the second discussion lesson) the pupils discussed ozone intensively: 51 questions, 39 answers, 10 informational messages, 6 statements, and 7 comments were sent. It is noteworthy that only one irrelevant message was sent. Table 4 shows the contents of the messages. Most messages were about the usefulness of ozone, its effects on human beings, the depletion of ozone, and the effects of the depletion. The following messages are examples of the pupils' questions and answers:

*What is the use of ozone? Ozone protects us from the UV radiation coming from the sun, but it is also harmful; for instance, it is said to cause a greenhouse effect. I mean the ozone which is in the lower atmosphere. Or am I wrong?*

*How does ozone affect human beings? Ozone causes lung trouble. The harmful UV radiation comes to the earth and causes skin cancer and eye diseases, for example keratitis. You should always protect your eyes against UV radiation.*

*Why is the ozone layer getting thinner? Freon gases and CFC gases are the main reasons for the ozone depletion. When ozone forms,  $O_2$  and  $O$  combine to form  $O_3$ , which is in turn decomposed by freon.*

*What happens when the amount of ozone on earth is too low? When the amount of ozone in the stratosphere is getting too low, the temperature will rise and the greenhouse effect increases. That causes wasteland.*

The messages show that pupils were able to link many ideas together:

*Oxygen is essential to all living beings. But if you get too much of it, it's a strong poison.*

*Maybe you mean that if the oxygen concentration is too high, everything is highly flammable.*

*No, I don't mean flammability. I mean complications in breathing (or something).*

They also discussed the subject between the lessons and during other lessons:

*What was the year when there was too little ozone? (You mentioned it after the biology lesson.) What did you say would happen?*

*Halons make up a group of compounds (CFC) which were used in old fire extinguishers. Nowadays carbon dioxide is used as a fire-extinguishing agent because it displaces air from fire. Take away oxygen and you will not have a fire, according to the Fire Triangle.*

One girl also referred to methane, which had been discussed in the previous lesson, and explained how it was related to ozone depletion.

**TABLE 4.** Number of different subjects in messages sent during the third lesson.

Subject of discussion	Categories*					Total
	Information* *	Questions	Answers	Com- ments***	Statements***	
	N=10	N=51	N=39	N=7	N=6	
<i>Usefulness of ozone</i>		7	6			13
<i>Statistics</i>		4	2			6
<i>Location of ozone</i>		2	5			7
<i>Recognition of ozone</i>		4				4
<i>Unfamiliar words</i>		4	3		1	8
<i>Questions concerning human beings</i>	4	9	7	1	1	22
<i>Formation of ozone</i>	1	2	2		1	6
<i>Depletion of ozone</i>	3	8	4	2	2	19
<i>Effects of ozone depletion</i>	2	10	9	4		25
<i>Doubts concerning ozone depletion</i>		1	1		1	3

\* One message may contain several categories.

\*\* Messages with informational content.

\*\*\* Comments were sent to a particular person and statements to the group in general.

Sometimes the pupils confused ideas; for example, air and oxygen or the different ozone layers: upper (stratosphere) and lower atmosphere (troposphere). A very important topic was the unfamiliar words. Pupils were assigned to answer these questions, but the study revealed that the questions were still too difficult for the pupils to answer. The teacher intended to ask somebody from the university to provide expert help on the subject, but after the first discussion lesson she gave up the idea because the pupils did not act the way she expected. Nevertheless, the pupils behaved so well during the second discussion lesson that the idea of using an expert might have been successful.

The pupils discussed chemistry. They had more time to think about the questions and the answers, as reported previously in a similar context by Tella (1992a). However, there were some excited oral discussions because the pupils could not write quickly enough. Everyone could participate in the discussion, which is not usual in a conventional classroom situation. As the teacher reported: *You don't see this in an ordinary lesson. They don't get a chance to talk so much.*

There was also clear evidence of interaction, although this was not analysed: when a question was sent to a certain pupil, two other pupils answered the question as well.

The pupils frequently used the names of many chemicals or compounds, concepts and symbols in their messages, although, as was previously mentioned, they did not fully understand the meaning. It was obvious that they copied the texts from the web sites or from their or other pupils' messages. This demonstrates how skilful they were at using a computer.

### Results from the interviews

All the pupils sent at least one message during the lessons. This means that all the pupils were paying attention. Guzdial (1999) also found that almost all pupils write messages in different discussion environments. He also stated that while we cannot determine whether individuals are learning or not at the aggregate level, we can determine whether some

mediating conditions for learning in a collaborative setting are being met. This study shows that all the pupils took the opportunity to express their knowledge and opinions and let their peers examine them. The following comments reveal this.

*Well, many of us could present opinions at the same time. If everybody tried to do that in the classroom, it wouldn't work at all.*

*So, you can express your own opinions and everybody hears or reads them all.*

*Everybody presented his or her own opinions, although there were some irrelevant ones.*

The pupils learned how to interact closely with each other. One boy said that he could not imagine another class doing what they did; i.e., that it was an unusual experience. They felt as if they had participated in a special and unique project. Yakimovicz and Murphy (1995) found that participants in an electronic discussion group worked together, shared adversities and successes, increased their self-concept, and expanded existing awareness. In this study, each pupil was able to present opinions, other pupils answered the messages, and it seemed that all the pupils experienced a feeling of success. The Internet also gives opportunities to make contacts. The pupils controlled each other. The Internet also expands the pupils' consciousness of knowledge:

*It (the discussion) was interesting. I couldn't do it before. I could indeed copy a text, but I didn't know that this kind of discussion exists where you can write down your own opinions.*

During the third lesson, the pupils discussed among themselves without interference from the teacher. She just observed the pupils and followed the discussion from the computer screen. During the discussion lessons, the teacher was not needed in the classroom, but this was considered a natural extension of the pupils' experience. The pupils' questions to the teacher were mainly of a technical nature. The researcher sent some e-mail messages between the lessons to the pupils, but they did not have time to answer it. The pupils could read their e-mail during the breaks, but 15 minutes and 12 computers were not enough, because everybody tried to use a computer at the same time.

## CONCLUSIONS AND IMPLICATIONS FOR INSTRUCTION

This case study shows some ways in which a Web-based teaching method can be used in the teaching of chemistry. Both the pupils and the teacher enjoyed the lessons. Both the girls and the boys sent approximately the same number of words during these three lessons. Computer-mediated communication can therefore be regarded as fairly democratic and contributing to gender equity (Tella, 1992a and Ruberg et al. 1996). Pupils' "meta" level skills were practised through WWW reviews, and their communication skills increased through the Web-based discussion. However, copying texts from the Web may be a chronic problem. Despite this, we might ask if this type of usage encourages pupils to use the language of chemistry.

The discussions on the Web in the classroom were found to be a good way of teaching. Both the teacher and the pupils liked it. It is a new way for the teacher to discover how the pupils think, and it seems to improve collaboration and the sense of social

community in the class. Several suggestions can be given for future classroom use. The discussion can be a closed session during one lesson: the information may be given beforehand, or the pupils can find out the information by themselves at their own pace. The discussion can be open and last longer, perhaps a month, half a semester or even through several school years (that is, a long-term project). The discussion group can consist of pupils in one school, several schools, schools abroad or of persons from a university, a company, a research centre or other professional groups. The discussion can connect different subjects, for example chemistry, biology, computer science, mathematics, languages, and geography. A good initial subject is a popular one that most pupils have an opinion about, such as a topic concerning the environment.

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