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Co-operative Learning on the Internet Using the Ball Bearing Method (Inside-Outside Circle)

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ABSTRACT *This paper presents three different lesson plans from lower secondary chemistry classes in Germany. These lessons use a combination of a guided search for information on the Internet with the ball bearing method. The ball bearing method is a form of co-operative learning. The method is based on working out two different parts of a topic in groups with different tasks. The working phase is followed by a presentation and explanation of the evaluated information in structured face-to-face-situations. A description of the method and three examples are given. Experiences from the teachers' perspective and feedback from written students' questionnaires are discussed.*

KEY WORDS: *cooperative learning, learning on the Internet, ball-bearing method*

Learning on the Internet

The use of modern technologies and new media has been repeatedly demanded for science classrooms (Valanides & Angeli, 2002). One of the possible applications is searching for information on the Internet (Pickergill, 2003). But, only at first sight is finding information on the Internet an easy task. Maybe it is quite easy if the question is clear and detailed, e.g., to look up the boiling point of ethanol. It is also not very difficult, if the user is experienced enough or an expert in the field the information is relevant for. She or he will be able to find appropriate information, judge whether it is relevant and well founded, or decide how much information is necessary to answer the question.

Unfortunately, this is not the case for students learning science in school. Although students are more and more familiar with computers, their experiences from outside the classroom differ completely from those needed for learning science in a structured way. Their everyday life experiences with the Internet comes from areas they are really experts in, e.g., pop music or video games. But within the science classroom, they have to deal with information in a domain-specific context, such as science and technology. As novices in science, they are not able to judge the relevance or reliability of scientific information. And they do not know what depth of information is required for their learning.

Thus finding relevant information for learning science needs additional competencies (*see also* Pickersgill, 2003). Students have to learn, for example, to:

- Develop a strategy how to find and evaluate relevant scientific information from the Internet.
- Understand what kind of information is expected by the teacher or is useful

and relevant for their learning process.
- Decide how much information is necessary or required.
- Select information from the wide range on offer on the Internet.
- Decide in which way the results have to be documented.

All these decisions can be made by the teacher or the whole group before the search on the Internet. But, a central issue of education is to teach the students to learn autonomously. This means enabling the students to make their own decisions about learning at the moment problems arise. From this perspective, it may be more valuable if the students find their own ways of learning on the Internet. Only if science teaching allows students to find – at least to some degree - their own way, can learning become an individual construction of knowledge. Only this process will offer them experiences to improve their competencies in using computers and the internet in learning science and technology – or in general (*see discussion in, e.g.*, Valanides, 2003). Nevertheless an introduction and the offer of some help from the teacher may be necessary.

But, how can an Internet search be structured and how can the students become aware of the required information? Because this is a difficult task, it may be better to ask the students to find their way not individually but in small groups. Additionally a good help may be a frame that allows the students to become clear about the Internet search and its objectives. This can be given by a short introductory text and/or respective control questions. Both can be offered by using methods of co-operative learning and appropriate materials. The task of explaining the topic later on individually to a classmate offers a clear objective and a predictable frame.

Following Saljo (1999), a second argument for combining the learning on the Internet with co-operative learning can be derived from a Vygotskian perspective on learning (Vygotsky, 1978). From this perspective, it is crucial for the internalisation to reorganize and reconstruct the information in a social context. Thus, Saljo (1999) argues for an active participation of the learner in ongoing conversations on the topic. Technology cannot replace this communication. But, technology can be used as a source of information to start up and promote communication among the learners about science topics. This communication can be structured by co-operative learning methods.

In general, co-operative learning is considered as a frame to help students to become clear about their strategy, work, and objectives. Co-operative learning, e.g., in the jigsaw classroom (Aronson, Blaney, Stephin, Sikes, & Snapp, 1978), is based on teaching each other about different topics worked while assigning different roles to different students. Thus, it is based on interaction and communication. The task of explaining the topic later on to each other can be a clear objective and motivation for the students. It can also promote understanding and learning through the process of actively reorganizing and restructuring the previously learned content.

This paper describes three different lesson plans using the ball bearing method (Witteck, Leerhoff, Most, & Eilks, 2004). The ball bearing method is related to the jigsaw classroom. It is based on working out different issues and explaining them in a series of different individual face-to-face-situations. The learning of different issues, in this case, is achieved by a guided search on the Internet carried out by pairs of students.

The Ball Bearing Method (Inside-Outside Circle)

The ball bearing method (in German *Kugellager*), *which is also named as* Inside Outside Circle (Kagan, Robertson, & Kagan 1995), is a form of co-operative learning with parallels to the jigsaw classroom (Aronson, et al., 1978). Up to now, it is discussed only rarely in the context of science education (e.g., Eilks & Bester, 2003, Witteck et al., 2004).

Within the Ball bearing method, the whole learning group in a first phase is divided into two groups of similar size. Both groups work out a specific issue. The work within the groups can be supported by appropriate materials and tasks. The work within the two groups with separate tasks should be organized as work in pairs of two students or small groups of 3 to 4 students. If this phase is based on an Internet search, pairs of students sharing one computer are the best solution. A ball bearing can also be based on texts, two pages from a textbook, or experimental work.

Both issues (e.g., in one of the examples described below, the formation and exploration of crude oil and respectively its refining and the products) - given to the two groups - are related to each other, but do not overlap. The central task for each group is to understand their issue and develop a small presentation of five minutes about their topic. With this presentation, each of the students should be able to present her or his piece information as an 'expert' individually to one of the students from the other group. Additionally, a set of control questions is available for the students. For the control questions, the teacher has a set of model answers, which the students may use, if they feel somehow insecure. Another very important task in this phase is to train explaining skills within the pairs or small groups of experts. Again, an exchange between the pairs or small groups who worked on the same topic should be guided by the teacher.

After working on the scientific topics, the students form two circles as shown in Figure 1. In these circles, two of the learners form pairs with one expert from each group. Both 'experts' present and explain their part of the topic individually. The 'non-experts' are asked to listen, to understand, and to make some notes. Depending on the students, their interest, motivation, and experience in co-operative learning, this phase takes between 10-20 minutes.

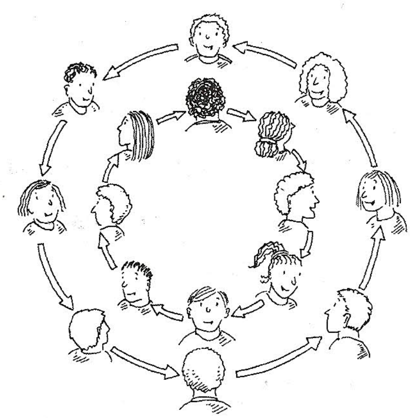

Figure. 1: Grouping the students within the "Ball-Bearing" (figure from Eilks & Witteck, 2003)

Now the circles are rotated. One circle is rotated clockwise, one counter clockwise by one or two chairs. Thus, new pairs of students are generated. The task in the second round is to repeat the explanation of the topic presented in the first round. The original 'experts' now listen, expand, and correct. This again takes some 10-15 minutes. In this second phase, all students also have the chance to ask comprehension questions, if they have the feeling that the explanation in the first round has not been sufficient. If so, all learners now have new partners who may be better at explaining their topic. Maybe they do it just in another way compared with the initial partner in the previous round. If required, a further rotation can be made to create new pairs of students.

After a final rotation of the ball bearing, both learners in each new pair are asked to look for parallels, differences, and relationships within the two topics. From its parallels to the jigsaw classroom, it can be assumed that similar effects take place within the ball bearing method. Those effects for different forms of co-operative learning have been extensively reviewed, (Lazarowitz, Hertz-Lazarowitz, & Baird, 1994; Lazarowitz, 1995; Lazarowitz & Hertz-Lazarowitz, 1998). Amongst others, these reviews show that forms of co-operative learning in most cases are very motivating for the students, leading to at least the same cognitive outcomes, and are beneficial for the students' non-cognitive skills and social behavior.

Examples from the Chemistry Classroom

Wastewater treatment and the packaging of waste separation

Wastewater treatment is a typical issue for early chemistry teaching. Different methods of separating matter are applied and can be learned in the framework of this example (e.g., filtration, sedimentation, or distillation). Not that common but maybe nearly as important as wastewater treatment is the treatment of solid waste. In Germany, several years ago, a system of collecting and recycling packaging waste was established. All packaging waste now is collected and processed by a system called 'the green dot' (in German '*Der gruene Punkt*', information in German or English at *www.der-gruene-punkt.de*). Different processes for separating matter are also applied (e.g., separation by different densities or magnetic properties) in Wastewater treatment. In both processes, similar strategies are used. Nevertheless, many differences exist, making the topics suitable for ball bearing treatment.

Waste separation in Germany is regularly taught in grade 6 (or 7) science lessons (age range 11-13). For preparing the ball bearing, some Internet sites are offered as an entry into the search as indicated in Figure 2. On the given websites, all the appropriate information is available. But, the students are also asked to look for further information by using search engines, e.g., www.google.com. The tasks are:

- to work out a table which displays the stages and respective processes within the Wastewater treatment plant on the one hand, and the separation plant for packaging waste on the other hand,
- to prepare a 5-minute presentation about the main stages of the respective processes, the methods used for waste separation, and the substances removed from the waste water, and
- to exercise explaining skills using their task.

Waster water treatment
www.umweltministerium.bayern.de/aktiv/schule/13/klaeranl.htm
www.klaeranlage-online.de

Treatment of packaging waste
www.gruener-punkt.de/
www.bug-koeln.org/expo_src/pavillon_dsd/sources_pavillon_dsd/sortec/sortec2.htm

Formation and exploration of crude oil
www.bpaustria.at/content/pages/BP_Heizoel_DerRohstoffErdoel.php
www.aral-forschung.de/forschung/homepage/wissen/erdoel.html

Refining of crude oil
www.aral-forschung.de/forschung/homepage/wissen/dieraffinerie/
www.bpaustria.at/content/pages/BP_Heizoel_DerRohstoffErdoel.php

Production of beer
www.bier-keller.de/index.php?text=bierherstellung.html
www.foodnews.ch/x-plainmefood/produkte/Bier_Schema.html#stationen

Production of wine
www.winety.com/herstellung/weinherstellung/index.html
www.wein-aus-oesterreich.at/weinherstellung.shtml

Figure 2: Some web pages in German language used in the three examples. Examples in other languages may be found by appropriate search engines.

Some more aspects are mentioned in the tasks and are also included in the self-control questions offered to both groups (Eilks & Witteck, 2003; Eilks & Bester 2003):

- *Waste water treatment: How much fresh water does every German citizen use per day? For what purposes the water is needed? Through which three stages does the water have to flow in the wastewater treatment plant? Which methods are applied in the different stages? Which substances have to be removed from the water?*
- *Packaging waste treatment: How much waste is produced by every German citizen per year? How much packaging waste is collected by 'the green dot' per year in Germany? What substances are within the packaging waste, what substances can be recycled? What is made out of these substances? Which stages of processing are applied to the packaging waste in the packing waste treatment plant? Which methods are applied in the different stages? Which substances from the waste are recycled?*

After preparing themselves, the students are asked to explain to each other the two issues within the Ball-Bearing method. After the final rotation, the students should recognize the similarities and differences of applying physical and chemical methods of separating substances within the two applications.

Formation, exploration, and refining of crude oil

The chemistry of crude oil and its components is central for a lot of industrial applications. Dyes, pharmaceutical substances, or fuels are made from crude oil. Thus dealing with the formation, exploration, and refining of crude oil is an important issue for chemistry lessons.

Different oil companies are offering websites about their sources of crude oil and their technical processes. The examples used in this lesson plan come from the

Austrian section of BP and the German websites from ARAL. Similar pieces of information may be available in other languages on the websites of the national and multi-national oil companies.

The topic of crude oil formation and refining is taught regularly in grade 9 or 10 chemistry lessons (age range 14-16 in Germany). In this example, the students are asked to learn about the formation of and prospecting for crude oil, and on the other hand about the refining of crude oil and oil-based products. Some Internet pages are available as an entry as indicated in Figure 2. All the necessary data is available on the websites. But, the students also are asked to look for further information on the Internet. The tasks are:

- to evaluate all necessary information to explain the main aspects of crude oil formation and prospecting, respectively refining of crude oil,
- to prepare a 5-to-10-minute presentation about the central aspects of the respective topic, and
- to exercise explaining skills on their task.

A detailed explanation, especially of processes like hydrogenation or reforming, is not required here. This is clearly stated to the students. The objective is to see the main aspects from an everyday-life oriented perspective. Details and a deeper handling of the chemistry behind the technical procedures may be appended in subsequent lessons. Some more aspects are mentioned within the tasks and are also included in the control questions offered to both groups (Witteck & Eilks, 2004a; Witteck et al., 2004).

- *Formation and prospecting: Which chemical substances form crude oil? What are the differences between crude oil, natural gas, and coal? When, how, and from what materials did crude oil evolve? In which regions of the world is crude oil explored? How much crude oil is explored per day resp. per year?*
- *Refining: Which chemical substances does crude oil consist of? What happens in the refinery? How does the process of refining crude oil work? What (not how!) happens in the processes of cracking, hydrogenation, and reforming? What are the most important products coming out of the refinery? What are the boiling ranges of the different products? How much crude oil is refined per day resp. per year in Germany?*

After preparing themselves, the students are asked to explain to each other the two issues within the Ball Bearing. After the final rotation, the students should recognize the relationship of both parts to the whole processing of crude oil.

Production of wine and beer

Dealing with ethanol is an interesting and important issue for students in lower secondary science education. This is the age where students often make their own first experiences in consuming alcoholic drinks. Here, it is important for the students not only to learn about different alcohols and their chemical properties. It is also important to learn about the physiological effects and dangers of misuse of alcohol.

The topic of ethanol is normally taught in Germany in grade 9 or 10 chemistry lessons (age range 14-16). In the ball bearing, the students are asked to learn about the two topics, wine making and beer brewing. Internet pages for both topics are offered as an entry as in Figure 2. Additional links are given to websites containing calculators for the blood alcohol concentration. The students are also asked to look for further information. The overall tasks are:

- to evaluate all necessary information on the production of wine or beer, respectively,
- to prepare a five-minute presentation about the central issues of their topic, and
- to exercise explaining skills on their task.

A detailed explanation, especially of the biological and chemical fundamentals of the process of fermentation, is not intended here. The objective is to see the main aspects from an everyday-life oriented perspective. Details and a deeper handling of the chemistry behind fermentation may be appended in subsequent lessons. Some more aspects from everyday life are mentioned in the given tasks and are also included in the control questions offered to both groups (Witteck & Eilks, 2004b):

- *Wine: Which substances are used to produce wine? Of which stages does the wine production consist of? Which chemical methods are used in the single stages? What dangers do occur in cellars where wine is stored? How much alcohol does a young female person of 55 kg weight have in her blood after two glasses of wine (0.2 L each)?*
- *Beer: Which substances are used to produce beer? What are the steps in beer production? Which chemical methods are used in the single steps? What is the German purity law of 1516 (in German: Reinheitsgebot) about? How much alcohol does a young male person of 65 kg weight have after three glasses of beer (0.3 L each)?*

After preparing themselves, the students are asked to explain to each other the different topics within the ball bearing method. After the final rotation the students should recognize the similarities and differences of both chemical processes of fermentation. They also should see the similarities in the physiological effects. But, they also can see the different amounts of alcohol in wine and beer, and the differences in the effects among males and females.

Teachers' Experiences and Students' Feedback

Teachers' experiences

The lesson plans had been developed within a project of Participatory Action Research at the University of Dortmund, Germany (Eilks & Ralle, 2002; Eilks, 2003). The tasks and materials have been pre-tested and optimized in different steps of an iterative and cyclical optimizing process of planning, testing, evaluation, and revision. All authors tried out the described lesson plans with different learning groups at middle (in Germany *Realschule*) and grammar schools (in Germany *Gymnasium*) in the North and West of Germany.

The unit on waste water treatment and separation of packaging waste (Eilks & Bester, 2003; Eilks & Witteck, 2003) was taught in different grade 7 chemistry classes (age range 12-13) at middle and grammar schools. The other lesson plans were applied in grade 9 and 10 chemistry lessons (age range 14-16) in different middle schools shown in Table 1. The teachers' feedback was monitored during discussions at regular meetings of the Participatory Action Research group.

Table 1
Source of Experiences and Data about Students' Feedback

Example	Age range	Learning groups	Learners
Waste water treatment - Packaging waste separation	Grade 7, age12-13	Two from grammar school, four from middle school	151
Formation of and prospecting crude oil –	One grade 9, age 14-15 Three grade 10, age 15-16	Four from middle school*	97
Refining crude oil			
Production of wine – Production of beer	Grade 10, age 15-16	Four from middle school*	81

*Three groups did both ball bearing lessons on crude oil and wine/beer within one school term

In preparing a lesson plan for the ball bearing method, the differences in the difficulty of the two different topics has to be thought about. Although the teacher should try to make both topics as similar as possible in workload and difficulty, in most cases at least some differences occur. These differences relate to the structure of the content of the two topics. They also may arise from the structure and content of the websites, which are available for both issues. For example, in the case of crude oil formation, prospecting, and refining, one issue (formation and exploration) was explained on the websites in a very comprehensive way. The explanation was illustrated by short animations, which helped the students to better understand their topic. The question of refining crude oil was more difficult to understand. On all available websites a lot of technical terms were used (e.g., cracking, hydrogenation, reforming, vacuum distillation), and the respective processes were explained in detail. The density of information made it more difficult for some students to work out this topic. It could be beneficial to select better students for the more difficult topic. The model solutions offered by the teacher were not used by most of the students. The students were motivated to solve their problems on their own, or within their group, and without additional help from the teacher.

The evaluation of information on the Internet in all groups was done in pairs with two students per computer. Here, the teachers for all groups described differences in the way of working and the speed of work. In some groups, the different capabilities in the use of the computer increased the usual differences in working speed and in others not. Generally, it helped to group students with little experiences in the use of computers with those who were more skilled.

The preparation of the presentation was a difficult task for a lot of students. Most students were not well acquainted with this kind of autonomous learning. Thus, among the younger and inexperienced students, a little help from the teacher was necessary. Especially, some of the students with lower motivation and achievement often did not take the task seriously enough to develop explanation skills within the groups of experts. They sometimes felt this task would not be too difficult. In those groups who did a second ball bearing on another topic, this went better. But, also in well-practised groups, some students still are reluctant about this aspect of the task.

During the ball bearing explanations, teachers were impressed how intense the content-focussed discussions within the pairs were. The students documented the explanation from their partners and the teacher as good and being much better than they would have expected. Nevertheless, in nearly all groups there were students who did not prepare themselves well or did not take their documentation with them. The shortcomings of individual students were pointed out by the classmates. This was very embarrassing for some of those students. The partners of those students can be assisted with the teacher's model solutions or they can join another couple of better-prepared students.

Although, there had been minor difficulties, all teachers confirmed that the students managed the independent work in this phase. The results were considered as good and detailed. Where the topics from the ball bearing had been used later on for other topics, the teachers reported that the students were able to remember a lot of information from the ball bearing and to make connections with the new content (e.g., Eilks & Bester, 2003).

From the teachers' perspective, the students' work was very intense and interesting. They concluded that the students liked to work within the ball bearing. They felt that the approach motivated the students to learn carefully. This was explicitly related to the tasks concerning the preparation of the presentation and the individual explanations. The task of explaining the learned content within the ball bearing method seemed to be a clear objective. This objective seemed to help the students to evaluate their work for themselves and to be successful. Teachers expressed the opinion that students took their responsibility for their classmates seriously and, especially in the face-to-face situation of the ball bearing, the students tried to avoid disgracing themselves due to an insufficient preparation.

But, this sense of responsibility is not present among all students at the first attempt. The teachers described the necessity to clearly point out the students' responsibility for their classmates in advance. In groups where co-operative learning with the ball bearing, the jigsaw classroom, and other related forms was repeatedly applied and the issue of responsibility was pointed out several times, the teachers described a considerable improvement in this area.

Students' feedback

Students' feedback has been evaluated by a combination of two written questionnaires. These questionnaires were slightly modified versions of questionnaires, which had been used in similar studies, e.g., learning at stations (Leerhoff & Eilks, 2003) or the jigsaw classroom (Eilks, 2004). The first questionnaire contained two open questions that examined which aspects of teaching and learning were most important to the students.

In the open questionnaire the students were asked the following:

- What do you think are the most important differences between the ball bearing lessons and the lessons you normally have in chemistry class?
- What is your opinion on working in a ball bearing? What did you like the most about it, and what could be improved?

The answers to both questions were analyzed together. They were examined to see which overall considerations of the lessons the students gave and whether students mentioned the promotion of co-operative skills, or improvements in independent working and/or communicative abilities. The analysis also examined whether or not the students judged the ball bearing method based on these aspects either in a positive or a negative way.

The second questionnaire contained 11 Likert-type statements. The students had to rate how much they agreed with each statement. The statements touched upon different aspects of learning, such as how the students liked the lessons, co-operative learning, and student activity. They could choose from four different answers on a scale from 'I agree' to 'I don't agree'. The questionnaires were filled out independently of each other. The open questionnaire was distributed first, so that the statements given in the second questionnaire did not directly influence the answers. The source of the data is given in Table 1.

Participatory Action Research is carried out with a qualitative and pragmatic understanding of educational research (Eilks & Ralle, 2002). Thus, the data in this case study is presented as qualitative data and discussed in an interpretative way. The analysis of both questionnaires led to similar results. Table 2 presents the data from the Likert-type questionnaire, and Table 3 presents similar data from three learning groups who worked on both units.

Table 2
Answers from the Likert-type Questionnaire

	I agree	I partially agree	I hardly agree	I do not agree
1. Because I had to explain and discuss the topic with my classmates I understood everything better.				
Waste	41.1 %	48.3 %	7.3 %	2.6 %
Crude Oil	39.2 %	52.6 %	6.2 %	2.1 %
Wine/Beer	49.9 %	43.2 %	3.7 %	0.0 %
Ø	**43.2 %**	**48.0 %**	**5.7 %**	**1.6 %**
2. We like it better if the topics are explained face to face than that the teachers discuss everything with the whole group.				
Waste	54.3 %	28.5 %	7.9 %	7.9 %
Crude Oil	38.1 %	27.8 %	22.7 %	11.3 %
Wine/Beer	49.4 %	21.1 %	11.1 %	4.9 %
Ø	**47.3 %**	**29.5 %**	**13.9 %**	**8.1 %**
3. The task to explain the topics to my classmate put too high demands on me.				
Waste	5.3 %	16.6 %	35.8 %	41.7 %
Crude Oil	5.2 %	32	35.1 %	30.9 %
Wine/Beer	6.2 %	9.9 %	27.8 %	49.4 %
Ø	**5.5 %**	**19.5 %**	**33.9 %**	**39.6 %**
4. Because of the task to explain the topics to my classmates later on I worked more carefully.				
Waste	33.1 %	42.4 %	12.6 %	11.3 %
Crude Oil	22.7 %	52.6 %	18.6 %	6.2 %
Wine/Beer	32.1 %	48.1 %	8.6 %	7.4 %
Ø	**29.3 %**	**47.7 %**	**13.3 %**	**8.3 %**
5. The task to work out the topic for such a long time without help from the teacher put too high demands on me.				
Waste	3.3 %	13.9 %	28.5 %	53.6 %
Crude Oil	7.2 %	14.4 %	33.0 %	45.4 %
Wine/Beer	3.7 %	13.6 %	18.5 %	61.7 %
Ø	**4.7 %**	**14.0 %**	**26.7 %**	**53.6 %**

Table 2 (continued)

6. I like more if the teacher discusses everything with the whole group than to work in small groups.				
Waste	13.2 %	23.2 %	23.8 %	38.4 %
Crude Oil	24.7 %	28.7 %	22.7 %	23.7 %
Wine/Beer	11.1 %	27.2 %	27.2 %	32.1 %
Ø	**16.4 %**	**26.4 %**	**24.6 %**	**31.4 %**
7. I don't like this kind of working because my learning is too much dependent on my classmates.				
Waste	11.9 %	27.8 %	21.2 %	37.7 %
Crude Oil	22.7 %	34.0 %	23.7 %	17.4 %
Wine/Beer	6.2 %	30.9 %	21.0 %	39.5 %
Ø	**13.6 %**	**30.9 %**	**22.0 %**	**31.6 %**
8. Without the task to explain the topics to my classmates we would not have worked that carefully.				
Waste	33.8 %	37.1 %	14.6 %	13.9 %
Crude Oil	26.8 %	38.1 %	24.7 %	9.3 %
Wine/Beer	19.8 %	40.7 %	24.7 %	12.3 %
Ø	**26.8 %**	**38.7 %**	**21.3 %**	**11.8 %**
9. I liked learning with the face-to-face explanations because learned something from my classmates and together with them.				
Waste	48.3 %	31.8 %	12.6 %	7.3 %
Crude Oil	32.0 %	40.2 %	14.4 %	13.4 %
Wine/Beer	49.4 %	32.1 %	12.3 %	3.7 %
Ø	**43.2 %**	**34.7 %**	**13.1 %**	**8.1 %**
10. I don't like learning in this way because I like more if the whole group moves forward step by step.				
Waste	15.2 %	23.8 %	30.5 %	29.8 %
Crude Oil	29.9 %	25.8 %	32.0 %	12.4 %
Wine/Beer	14.8 %	19.8 %	45.7 %	17.3 %
Ø	**20.0 %**	**23.1 %**	**36.0 %**	**19.8 %**
11. Due to the use of alternative forms of working, teaching brings more fun and is less boring.				
Waste	69.5 %	23.2 %	4.6 %	1.3 %
Crude Oil	52.6 %	26.8 %	13.4 %	7.2 %
Wine/Beer	58.0 %	25.9 %	9.9 %	3.7 %
Ø	**60.0 %**	**25.3 %**	**9.3 %**	**4.1 %**

The considerations regarding the statements have parallels in all learning groups and in the different examples. In general, the students liked to work in the Ball-Bearing method. In the open and the Likert-questionnaire the students mentioned that they liked the lessons because of the chance to learn together with others in small groups. From the open questionnaire, it can be seen that the students liked it better, when explanations are given by classmates and in situations of pairs or small groups. Some of them mentioned the special importance of explaining newly learned topics for ones own understanding. Others mentioned having learned something about how difficult it can be to explain things to others. They also mentioned that they sometimes had the feeling of understanding, but then realized in explaining the topics that there were still inconsistencies in their explanations. This was considered to help their own understanding and lead to improvement of their explanations.

Criticisms in the open questionnaires – if mentioned at all - concerned uncertainty about the validity of information coming exclusively from classmates. The students were divided with regard to the situation of being very much dependent on the classmates for ones own learning. Some students missed direct feedback from the teacher after single steps of work and some of them considered the demands as being too high. These data are similar to those evaluated for the jigsaw classroom and learning on stations using similar questionnaires (Leerhoff & Eilks, 2003; Eilks, 2004).

The remarks from the open questionnaire are confirmed by data from the Likert-questionnaire. Also here, the students agreed that they liked to work in pairs and to explain the topics to each other in the face-to-face situation. They felt that explaining the topic helped them to understand it better. In the Likert-questionnaire the students also agreed that the task of preparing individual explanations for their classmates motivated them to work more carefully. Working out a task in this way was not considered too demanding by most of the students. Some of them documented this feeling also in the Likert-questionnaire. Working in small groups and using alternative methods in science teaching was considered positive.

The criticism from individual students in the open questionnaire is mirrored in the Likert-questionnaire. Although most students documented a positive attitude to the ball bearing a significant number (but less than half) of the students said that they preferred learning step by step with the whole group. This number is much higher than in parallel studies on the jigsaw-classroom and learning on stations using similar questionnaires (Leerhoff & Eilks; 2003; Eilks, 2004).

Table 3
Answers from Three Learning Groups Who Worked on Both Units: On Crude Oil (67 answers) and Wine/beer (61 answers) Within One School Term.

Because I had to explain and discuss the topic with my classmates I understood everything better.				
	I agree	**I partially agree**	**I hardly agree**	**I do not agree**
Crude Oil	32.8 %	56.7 %	7.4 %	3.0 %
Wine/Beer	45.9 %	49.2 %	4,9 %	0.0 %
I like it better if the topics are explained face to face than that the teachers discusses everything with the whole group.				
Crude Oil	35.8 %	28.4 %	23.9 %	12.0 %
Wine/Beer	50.8 %	29.5 %	14.8 %	6.6 %
The task to explain the topics to my classmate put too high demands on me.				
Crude Oil	7.5 %	35.8 %	31.3 %	25.4 %
Wine/Beer	4.9 %	9.8 %	32.8 %	52.5 %
Because of the task to explain the topics to my classmates later on I worked more carefully.				
Crude Oil	20.9 %	53.7 %	19.4 %	6.0 %
Wine/Beer	34.4 %	50.8 %	11.5 %	3.9 %
The task to work out the topic for such a long time without help from the teacher put too high demands on me.				
Crude Oil	9.0 %	16.4 %	37.3 %	17.3 %
Wine/Beer	4.9 %	14.8%	19.7 %	62.3 %
I like more if the teacher discusses everything with the whole group than to work in small groups.				
Crude Oil	28.4 %	28.4 %	17.9 %	25.4 %
Wine/Beer	14.8 %	29.5 %	24.6 %	32.8 %
I don't like this kind of working because my learning is too much dependent on my classmates.				
Crude Oil	20.9 %	35.8 %	25.4 %	14.9 %
Wine/Beer	8.2 %	31.1 %	23.0 %	39.3 %

Table 3 (continued)

Without the task to explain the topics to my classmates we would not have worked that carefully.				
Crude Oil	23.9 %	40.3 %	35.4 %	9.0 %
Wine/Beer	19. 7 %	41.0 %	29.5 %	11. 5%
I liked learning with the face-to-face explanations because learned something from my classmates and together with them.				
Crude Oil	26.9 %	43.3 %	14.9%	14.9 %
Wine/Beer	50.8 %	34.4 %	13.1 %	3.3 %
I don't like learning in this way because I like more if the whole group moves forward step by step.				
Crude Oil	31.3 %	26.9 %	31.3 %	10.4 %
Wine/Beer	19.7 %	21.3 %	42.6 %	18.0 %
Due to the use of alternative forms of working teaching brings more fun and is less boring.				
Crude Oil	47.8 %	29.9 %	16.4 %	6.0 %
Wine/Beer	57.4 %	27.9 %	11.5 %	4.9 %

The criticism is located especially in the items 7 to 10 and concentrates on the example of crude oil within three learning groups. Maybe these groups were not well experienced in open and co-operative forms of learning. This interpretation is suggested by the comparison with the students' attitude to a second example. These three learning groups did both units on crude oil and wine/beer within one school term but with about 4 months in between. In these three groups the criticism in items 7-10 decreased very much from one ball bearing to the second. This is also the case with the criticism on the demanding nature of this form of learning (items 3 and 5). In these three groups, an improvement in the positive attitudes to all questions took place and the general attitude to working within the Ball Bearing became more positive after doing it the second time (*Table* 3).

Conclusions

Using the Internet as a source for information is becoming more and more important. What is required is a stronger integration of learning on the Internet into domain specific school learning. Nevertheless, evaluating information from the Internet is not easy and if done in an unstructured way quite confusing and discouraging for the students. The combination of guided searches on the Internet with strategies of co-operative learning seems to be an interesting and motivating alternative. Using the ball bearing method seems to motivate the students and to help them become clear about what they have to do. But, their feedback tells us also that when using this method the evaluation of information is not an easy task. Students feel uncertain about dealing with information from the Internet. They also feel insecure with learning based on information coming exclusively from their classmates. Nevertheless, the students like to work this way and this case study suggests that insecurity will decrease if this kind of learning is applied repeatedly. The students seem to become more acquainted with the method and familiar with it when doing it more often. The teachers described a highly motivated and active atmosphere of learning and a high level of achievement. In addition, there is hope that this co-operative way of learning can help the students to improve their skills in autonomous learning, communication, and co-operation. All three issues are central for preparing the students for life-long learning.

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