

## LEARNING TO TALK CHEMISTRY: 14-15-YEAR-OLD STUDENTS' EXPERIENCES OF GROUP DISCUSSIONS

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### ABSTRACT

*This study is based on an action research project, aiming at developing teaching methods in chemistry towards dialogic teaching. We investigate the use and impact of small group discussions and explore the students' experiences of the group discussions concerning participation, learning, understanding, and interest in chemistry. Data was collected in an 8<sup>th</sup> grade class of 17 students in 2018-2019 in Finland. Most of the students experienced that the group discussions helped them improve their understanding of chemistry. The students emphasized the importance of everybody participating and concentrating on the given task for the discussion to feel meaningful. Some students reported that their interest in the subject also grew when their understanding of chemistry increased.*

### INTRODUCTION

Since the inception of the Programme for International Student Assessment (PISA) evaluations in 2000, Finland has consistently performed above average in science. Nevertheless, the evaluation has also shown that Finnish students' interest in science has decreased and is now below average in the OECD countries (OECD, 2016). A national follow-up investigation of 9<sup>th</sup> grade students' science knowledge (Kärnä et al., 2012) shows that although students regard chemistry as a useful subject, they show a negative attitude towards chemistry. Further, the study shows that students' subject knowledge and how much they like the subject are correlated to the working methods and procedures used by the teacher (Kärnä et al., 2012). The current national core curriculum, which has been gradually implemented since the autumn of 2017, attempts to address the recent challenges in the field by stressing the importance of meaningful and active learning and interaction between students and teachers. It also states that students should take a greater responsibility for their own learning and learn to reflect upon their learning (Finnish National Board of Education [FNBE], 2016).

There has been a growing interest in the use of small group discussions in science education to both motivate students and enhance learning both in Finland and in other countries (e.g., Lehesvuori, 2013; Mercer & Howe, 2012; Howe, 2014). Despite the movement towards dialogic teaching, very little is known about students' attitudes regarding group discussions (Bennett et al., 2010).

During the past twenty years, Finland has invested in research in chemistry teacher education and the professional development of chemistry teachers (e.g., Juuti et al., 2021; Pernaa & Aksela, 2021). LUMA Centre Finland (n.d.) offers valuable support for teachers to improve the methods relevant for students' learning and interest in chemistry. However, research in authentic classrooms and, in particular, students' reactions to changes is sparse. This is also the case in the international research field.

This paper contributes to the field by focusing on the students' experiences of group discussions concerning participation, learning, understanding, and interest in chemistry. It is part of an action research study with the aim of developing teaching methods in chemistry towards dialogic teaching in lower secondary education and investigating the use and impact of small group discussions. This paper aims to answer the following research question:

- How do the students experience their participation in small group discussions?

## **THEORETICAL BACKGROUND AND EARLIER RESEARCH**

### **Theoretical framework**

The perspective on learning in this study lies in the sociocultural theory. Learners are viewed as active participants in a process that is mediated through interaction (Säljö, 2014). According to Wenger's (1998) social theory of learning, learning is about engaging in and contributing to the practices of people's communities. In this study, learning can be defined as increasing participation in the chemistry classroom practices. How we communicate and use language is essential from a sociocultural perspective and learning science means "learning to communicate in the language of science and act as a member of the community of people who do so" (Lemke, 1990, p.16). When participating in a community of practice, we do it with different emotions (Wenger, 1998), and in this paper we focus on students' interest in chemistry. Interest can be described as a phenomenon that emerges from an individual's interaction with the environment (Hidi & Renninger, 2006), and it is related to specific topics, tasks, or activities (Krapp & Prenzel, 2011). In educational research, two types of interest have been the primary focus: situational and individual interest (Hidi & Renninger, 2006). Situational interest is triggered in the moment due to environmental factors, e.g., an activity, whereas individual interest refers to a more stable predisposition to engage in certain activities, it is developed over time and is often associated with increased knowledge (Hidi & Renninger, 2006).

### **Small group discussions**

Findings from systematic reviews of the use and effect of small group discussions in high school science teaching during 1980-2005 have been reported in Bennett et al. (2010). The term *small group discussion* was used to describe groups of 2-6 students who discussed a specific topic for at least two minutes. In the review, only four percent of the studies were from chemistry lessons. Bennett et al. (2010) reported benefits from the use of small group discussions regarding the development of understanding but reported also challenges with engaging students. Moreover, Howe and Abedin (2013) have examined research concerning classroom dialogue in compulsory school during the last 40 years. They report that the findings give more information about the organization of the dialogues in the classrooms than the effects of different teaching methods on enhanced learning.

Various terms are used to describe teaching based on discussions. *Dialogic teaching* refers to teaching based on communication and the use of language as a tool for promoting understanding and deepening thinking (Alexander, 2006; Sedova et al., 2014). Another term used is *exploratory talk*, where the students share ideas, comment on each other's ideas, work together and strive for a mutual understanding (Barnes, 2008; Mercer & Howe, 2012). Several studies have reported that qualitative discussions promote learning for both the group and the individual (e.g., Mercer et al., 2004; Littleton & Howe, 2010; Gillies, 2014). However, research has also shown that it is difficult to reach the requirements for dialogic teaching and that exploratory talk seldom occurs (Kumpulainen & Lipponen, 2010; Mercer, 2008; Sedova 2014).

For dialogic teaching to work as an effective way for students to learn and understand science, both teachers and students need to become aware of the educational value of talk (Bennett et al., 2010; Mercer & Howe, 2012; Lehesvuori, 2013; Sedova et al., 2014). Mercer et al. (2009) suggest more specific teaching in the effective use of talk for learning in teacher training and professional development. They also suggest that students need to be aware of how discussions can promote learning (Mercer & Howe, 2012). The classroom climate is also important for students to be able to feel comfortable engaging in discussions with each other (Pimentel & McNeill, 2016; Nieminen, 2016).

### **Participation, learning, and interest**

Research on students' participation in class discussions in science (Pimentel & McNeill, 2016) has shown that the extent to which students felt comfortable interacting with others in the class influenced their participation in class discussions. In addition, students who contributed more frequently in discussion referred to their own contribution as being beneficial to their own learning as well as the learning of other students, whereas students that tended not to participate

in discussion suggested that their contributions were unnecessary or would interfere with the learning of others. How students participate in dialogic classroom discussions will have implications on their individual learning (Clarke et al., 2016). Research suggests that there is a minimum level of engagement needed for learning to occur (Chi, 2009), and the students who explain to others in small groups seem to benefit most in terms of learning (Howe et al., 2007). Research from language arts lessons confirmed a strong link between students' individual participation and achievement (Sedova et al., 2019). However, cognitive engagement, even if the student is silent, may also be productive for learning (Clarke et al., 2016).

Learning science is not only about cognition but also about emotions (see e.g., Krapp & Prenzel, 2011). As Wenger points out, participation involves our whole person including body, mind, emotions, and social relations (Wenger, 1998). A review of the literature on attitudes towards science has revealed great concern about the situation worldwide (Osborne et al., 2003). A student's interest has a strong influence on learning (Hidi & Renninger, 2006; Schraw et al., 2001). When developing teaching, it is important to include the students' perspective. Interest is not likely to develop in isolation but requires support, e.g., from the teacher or peers (Hidi & Renninger, 2006). The choice of teaching method can influence the students' interest in the subject (Kärnä et al., 2012; Kousa et al., 2018), and a learning environment that includes group work has been found to trigger situational interest (Hidi & Renninger, 2006; Kousa et al., 2018). Background knowledge also affects interest, and an increase in knowledge has been reported to increase interest (Schraw et al., 2001). A study on low-achieving students' attitudes towards learning chemistry suggests that teaching methods preferred by the students could lead to more positive attitudes (Kousa et al., 2018). Situational interest is important in catching students' attention (Schraw et al., 2001) but capturing students' interest in today's schools is a challenge (Sahlström et al., 2019).

## **METHODS AND ANALYSIS**

### **Context of the study**

This paper is part of an action research project conducted in the teacher's own chemistry class in a Swedish-speaking school in Finland. The teacher wanted to change how the talking was distributed in the classroom by making room for the students' discussions and by limiting her own talk. The aims of action research are to change practices, people's understandings of their practices, and the conditions under which they practice (Kemmis et al., 2014). In this development process, the teacher observed, reflected on, and deepened her understanding of the practice.

The teacher in the study teaches several classes in chemistry and two of these student classes also in mathematics. The teacher has had the role of both teacher

and researcher. The worksheets used for the students' discussion were continuously developed by the teacher. Experiences from previous lessons were reflected on and considered in the development of new worksheets. Feedback from the students was also considered in the development work.

Before the project, the students studied chemistry in the 7<sup>th</sup> grade once a week over a period of 12 weeks. The use of small group discussions in 8<sup>th</sup> grade as a way of teaching was a new approach for both the teacher and the students. The instruction used to be teacher-led, and group work only took place in laboratory work.

### **Data and participants**

The data was collected in a lower secondary school in Finland during 2018-2019 in an 8<sup>th</sup> grade class of 17 students. This class was chosen because they had chemistry as a whole class and the teacher taught mathematics to the same class. This gave opportunities for flexible arrangements when needed. All students in the class had permission to participate in the study, and both the students and their parents had signed a letter of consent. The class in this study started with chemistry in November and had 35 lessons until the end of May. For the group discussions, the teacher divided the students into four groups of 4–5 students. The grouping was made with the aim of making the students feel comfortable and promoting a good climate for discussions. The groups were heterogenous when it came to the students' knowledge but homogenous regarding gender, two groups with girls and two groups with boys.

The students filled in questionnaires, they wrote reflective journals, discussions were video recorded, and the students were interviewed in groups. The original material was in Swedish, one of two official languages in Finland.

This paper is based on the following empirical material:

- Video recordings of semi-structured interviews
- Students' reflective journals
- Questionnaires (pre and post) with 33 statements
- Post-questionnaire with 20 statements and open-ended questions about the group discussions

The pre-questionnaire consisted of 33 statements, and these same statements were repeated in the post-questionnaire. In the end, there were also four open-ended questions and 20 additional statements about small group discussions. The students responded to each statement on a 5-point Likert scale, ranging from 1 (totally disagree) to 5 (totally agree). The students received oral instructions from the teacher concerning the questionnaire.

The students wrote reflective journals at the end of 10 lessons throughout the period. The overall question to answer was: "What did you take with you from this lesson?" Sub-questions were also posed to make it easier to reflect on the lesson, e.g. "Have you learnt something new?", "Something fun/boring?" and "What have you worked on during this lesson?" The purpose of writing reflective journals was to get the students to reflect on their own learning, and in this study the idea was also to give the students a forum to express their thoughts and opinions during the teaching period. The teacher continuously read the students journals and used the feedback in planning and re-planning lessons.

The teacher conducted semi-structured interviews with the students in their working groups at the end of the teaching period. Group interviews were used to enable potential discussions to develop. The interviews were video recorded and transcribed. Each interview lasted twenty to thirty minutes. The students answered questions about their experiences of the group discussions from different aspects. Semi-structured interviews were used to address the same issues in all groups, but the teacher could also react to the students' answers and comments.

### Analysis

The collected data were analyzed by the teacher, in her role as researcher. The time elapsed between data collection and data analysis was two years, which helped the teacher to move into the role of researcher and distance herself from the data (cf. Kemmis et al., 2014).

The qualitative data were analyzed using thematic analysis (Braun & Clarke, 2006). The analysis involved several thorough readings of all the data. Keywords and phrases of importance were marked, primarily from the interviews and the reflective journals. Similarities were developed into sub-themes and based on these sub-themes three main themes were created (see Table 1) to answer the research question. The process of analysis and the creation of sub-themes and themes were carried out by the teacher. The results were then presented and discussed at an internal research seminar and finally discussed and agreed on by the second author.

Table 1. Sub-themes and themes created and used in the analysis of the collected data.

Sub-themes	Themes
Participation, comfort, composition	The group
Cognitive functions, focus, concentration, effect on memorizing	Learning and understanding
Topic, activity	Interest in chemistry

In this study, the qualitative analysis is complemented with descriptive statistics from the questionnaires to show how the students' opinions are distributed in

the class and thereby offer broader information about the students' experiences (Bryman, 2012). From the questionnaires, statements concerning the same themes that were created in the thematic analysis are presented as graphs. Authentic excerpts from the students are presented with pseudonyms used for the students. The analysis was conducted in Swedish. The excerpts were translated into English by the first author and the translations were checked by a native English speaker.

A risk of conducting a study in your own classroom is that the students might try to please the teacher with their answers. To increase the reliability of the study, different data sources were used; qualitative data from the interviews and reflective journals together with descriptive statistics from the questionnaires deepens the understanding of the students' experiences (cf. Bryman, 2012).

## RESULTS

The results are organized according to the themes created in the analysis (see Table 1). The first part consists of the sub-themes connected with the students' experiences of the group. The second part consists of the students' conceptions of learning and understanding while the third part deals with the students' perceived interest in chemistry.

### **The students' experiences of the group**

The students had various experiences of the group discussions. The most important issue for the students was that everyone in the group participated in the group discussion. According to the students, this whole group participation was a requirement for the discussions to become a discussion. Michael wrote: "When everyone participates in the discussion, then you learn" and Sarah said in the interview: "We've been a pretty good group... it depends on your group... we've still, like, been able to communicate and stuff like that."

As the following extract shows, some students feel that in a whole class discussion, it is easier to zoom out whereas in a small group your group members will notice if you do not participate.

"You might not always listen one hundred percent when a teacher speaks ... because you're sometimes kind of in your own ... but then if your whole [group] has a discussion then you participate more." [Emma/Interview]

More than three quarters of the students felt comfortable in their group and had the courage to express their opinions in the small group. They thought it was good that the teacher had divided the students into groups. Oliver said that it was easier to work in a group where you knew the others, and that might lead to better discussions, because otherwise you might not be comfortable to express what you think.

The students felt that they were more active during the group discussions than without discussions, and more than three quarters reported that they had been active, see Figure 1.

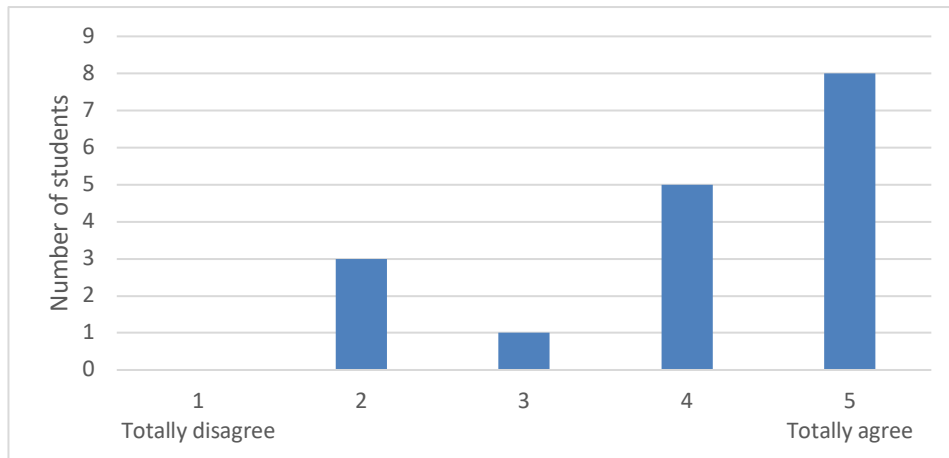


Figure 1. Distribution of answers to the statement, “I have actively participated in the discussions.”

According to the students’ answers, it is possible to be an active participant even if you do not participate equally in the discussion. Almost three quarters of the students reported that the talking was not divided equally in the group, but they still thought that they had been active participants.

Several students mentioned that it was easier to participate in the discussions if you knew something about the subject beforehand. The groups that were better at keeping to the topic had better experiences of the group discussions overall. The groups with girls were more conscious about the students’ differences in knowledge, and Emma said that they had been on different levels, but it was good in a strange way. Lily in the same group talked about different levels of knowledge and said that one can try to even out the differences.

Table 2 shows excerpts from four students about ways to participate in the group. All students thought it was good that they could explain to each other if someone did not understand. Still, Emma was hesitant to ask questions because she felt it was not her groupmates’ responsibility to teach her.

Table 2. Students’ views about different ways to participate.

Excerpt
Sarah: The others can explain if you don’t understand
Lily: Some know more, and some know less, and then you can help each other and then it’s good
Emma: Sometimes I feel stupid when I don’t understand, and I don’t want to ask, because I feel it’s not my groupmates’ responsibility to teach me
Julia: Sometimes it was difficult when I understood something, and the rest of the group didn’t, and I had to explain a lot



When asked if the discussions had changed during the teaching period, some students said that they had not, and some said that maybe they had learnt to better keep to the topic, and the discussions lasted a bit longer because they got used to this way of working. After the teaching period there were more students who agreed with the statement, "I like to work in groups." Emma wrote in her reflective journal after the 8<sup>th</sup> lesson: "I've started to like chemistry more lately because we work in a good way with a good group, and I've learnt a lot and fast." The students' reflections in their journals gave the teacher valuable feedback; for example, one student wrote: "sometimes you talk quite a lot and then one gets tired of just listening."

### The students' conceptions of learning and understanding

The students experienced that the group discussions had helped them understand chemistry. Sarah wrote: "When we've worked in groups and discussed, then you understand a lot. The others can explain if you don't understand" and Julia said in the interview: "I learn the best when I figure out something by myself – that's why the discussions have helped me." Chloe reflected on her own learning and wrote after the 11<sup>th</sup> lesson: "I understand much of what we talked about, and I know more now than the last lesson."

Several students mentioned that if you do not understand a subject, then you can discuss it in the group, and explain to each other. Figure 2 shows that more than half of the students had experienced that the discussions had been valuable when it came to learning chemistry. Both asking questions and explaining to others had a positive impact on their own learning. The students were aware of differences in how much they knew about a subject and said that students with less knowledge learnt from the ones with more knowledge. One student said that when a student explains to another student it is more simplified than when the teacher explains.

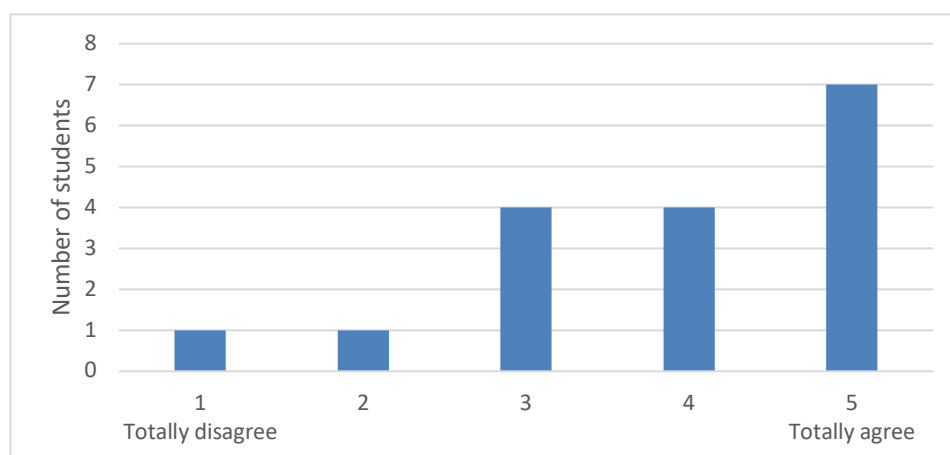


Figure 2. Distribution of answers to the statement, "The discussions have helped me understand chemistry."

Before the teaching period the students did not have experience of this type of group discussion. Many students chose the middle alternative on the Likert scale in Figure 3, but after the use of group discussions more students agreed with the statement that they learn well when they discuss with their classmates.

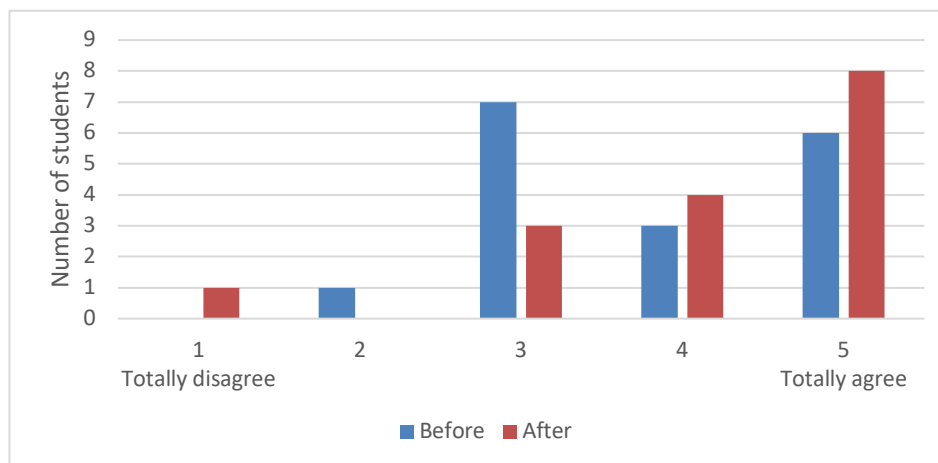


Figure 3. Distribution of answers to the statement, “I learn well when I discuss with my classmates.”

Several students mentioned that the group discussions had affected different types of cognitive functions, such as memory and attention. They said that the group discussions helped them remember the topic they had discussed; for example, Nancy says: “I think it has worked well. I learn better when we’ve discussed things and it’s easier to understand and remember what I’ve learnt.”

“I’d say that when we completely focus on the subject and really tell each other what we know, well then, we get to learn. If somebody knows some extra information about it, then you can learn from what that person says and put your heads together to come up with an answer if you have to answer a question or something.” [Oliver, interview]

Here Oliver summarizes well what they experienced as important: the need to focus on the subject to learn. Julia said in the interview: “We all focused quite a lot when we worked – it wasn’t like we talked about other stuff, so when we had the group discussions it was, like, about chemistry, not something else” and several students emphasized that they had to concentrate to participate in the group discussions, like Julia below:

“So, it was like, sometimes when you handed out those papers you think that you’ve really got to think again. And find the answers and all that, but it was still good anyway - you really learnt a lot from it, but it was pretty challenging.” [Julia, interview]

In their reflective journals, the students often wrote about learning. After the 22<sup>nd</sup> lesson Amy wrote: “I learnt about fossil fuels. I thought that I knew what it was. But I actually didn’t know anything about it,” and Julia answered an open question: “The carbon cycle felt relevant, and I learnt a lot that I didn’t know from

before, like about fossil fuels." They also wrote about topics they did not understand, and what they would do, like reading a chapter at home. A lack of understanding can also lead to a lack of energy, as Lily wrote: "I think it was a really difficult lesson today. Didn't manage so well since I didn't understand." Everyday matters that the students mentioned sometimes interfered with concentration were if they were tired or hungry.

### **The students' perceived interest in chemistry**

Some students said that their interest in chemistry had increased a little, because when you understand more of the subject it will become more interesting, as Nancy said in the interview: "Well, when I've understood more it has become ... just more interesting." Other students hesitated before answering and said that their interest had not changed in any way. The students seemed to be comfortable in the interview and replied according to their own experience, like Tom's reply to the same question: "No. If I can be totally honest. It has been rather fun, but it hasn't influenced me in any way." Oliver said that he realized that chemistry is more present in everyday life than he had thought of before, so that made chemistry more interesting. Students that had experienced an aha moment reported an increased interest at that moment. One student said that when she saw a chapter in the book it looked boring but when they started discussing it, it became more interesting. In their reflective journals several students wrote that a specific topic or happening during a lesson had been interesting, e.g., that different metals burn in different colors. The interest for different topics also had an influence on the discussion, as Oliver said: "For me it's easier to talk about things that interest me or if I know something about it from before. But it's also about being able to focus."

In the interview, Julia said that if the discussion concerned something that they had a connection to, that they had thought of before and wanted to know more about, then this made the discussion more interesting. A relevant topic such as climate change influenced the students' interest. According to the questionnaire the students' interest in chemistry did not change during the teaching period. When the students were asked about the importance of learning chemistry or the relevance of chemistry there was a slight increase during the period.

There is also a connection between interest and participation as Kevin expressed it:

"I think it's only interest that makes a group good or bad so if everyone is interested then there will be interesting discussions and stuff... but if half the group is interested and the other half isn't ... at the start you're interested but then gradually it just becomes boring because no one else ... it feels like no one cares." [Kevin, interview]

## DISCUSSION AND CONCLUSIONS

In the action research project, which this study is based on, the teacher wanted to change practices in the classroom by reducing the teacher-talk and giving the students opportunities to talk chemistry. In this paper we explore the students' experiences of their participation in small group discussions. The students accepted from the start a new way of working in the chemistry classroom, and most of the students engaged actively in the discussions. This exceeded the teacher's expectations because earlier research has indicated that students often demonstrate a low level of engagement in group discussions (Bennett et al., 2010). The single most important issue that the students pointed out was to have a group where everyone participated. If one or more students in the group did not participate, it was difficult to have a meaningful discussion which in turn would affect learning. According to Wenger (1998) participation is learning. Accordingly, in a group where everyone participated, the students experienced enhanced learning, and the discussions helped them learn chemistry and remember the topic discussed.

Different ways of participating in the discussion – by asking questions, by explaining, or by simply listening – was something the students reflected on. The students felt comfortable in their groups and they were aware of differences in the amount of each other's knowledge. Nevertheless, there were students who felt that they did not want to be the ones always asking questions. We suggest that even if the students do not take different roles in the discussion, they could still agree that everyone must ask questions. The students could also take turns in explaining to the others and agreeing that the others afterwards can complement with their explanations. When the small group is the learning community, problems arise if participation fails. As one student expressed it; if everyone is interested then there will be interesting discussions, but if some in the group is not interested, then your own interest wanes. In this case the group will need support from the teacher. The students mentioned that relevant topics increased their interest.

Most of the students answered that they had actively participated in the discussions, but at the same time they reported that they did not talk equally much. According to these answers the students participated in other ways than by talking, but as earlier research has suggested the ones who explain to the others are the ones that benefit the most in terms of learning (Howe et al., 2007; Sedova et al., 2019). Earlier research has shown that it is important to learn how to discuss topics in small groups (Mercer & Howe, 2012). According to the students, their discussions grew a bit longer over time and it was easier to keep to the subject, so their skills increased in how to work in small groups.

By using reflective journals, the students were encouraged to reflect upon their learning, in line with the current curriculum (FNBE, 2016). In addition, they contributed with feedback about how they experienced the lessons. The students participated seriously in the study, and their comments and feedback were constructive. It is likely that being part of the research study, answering questionnaires etc., together with writing journals, made the students more aware of their learning process than usual.

The choice of teaching method can influence students' interest in the subject (Kärnä et al., 2012; Kousa et al., 2018). Increase in knowledge has also been reported to increase interest (Schraw et al., 2001). Several students said in the interview that their interest had somewhat increased when they understood more about the topic; however, in the questionnaire before and after the teaching period the students' interest in chemistry stayed the same. When the statement was: "I am interested in chemistry" this was associated with an individual interest (Hidi & Renninger, 2006). There were no explicit questions about a situational interest. According to what the students wrote in their reflective journals, although they experienced situational interest during several lessons, the results indicate that the students' individual interest was not affected. When chemistry is introduced as a new subject in 7<sup>th</sup> grade, many students are enthusiastic about the new subject. As mentioned in the context of the study, these students have had 12 lessons of chemistry in 7<sup>th</sup> grade with a lot of practical work. The amount of theory increases from 7<sup>th</sup> to 8<sup>th</sup> grade, and many students experience the content in chemistry more difficult during 8<sup>th</sup> grade. This fact may also influence the students' interest in chemistry. The interest in science tends to decrease during secondary school, so if we succeed in keeping the interest at the same level it can be considered a good result. Most of the students in this study liked the new way of working in small groups, and their interest stayed the same during 8<sup>th</sup> grade even if the chemistry content was more difficult.

In whole-class discussions, only a few of the students usually participate in the discussion, and social comfort in the classroom influences the extent of student participation (Pimentel & McNeill, 2016; Clarke et al., 2016). This study shows that by introducing group discussions in the chemistry class, the students became more active than before, and more students got to talk chemistry during a lesson. Furthermore, it shows that even if the teacher is aware of the benefits of dialogic teaching, implementation is not easy (Lehesvuori, 2013).

The use of discussions in chemistry teacher education has recently been acknowledged (Pernaa & Aksela, 2021) and we think it should also be included in the professional development of in-service teachers. For the students it takes time to adopt a new way of working (e.g., Mercer & Howe, 2012), so this approach could preferably be introduced already in earlier grades.

This study fills the gap regarding a student perspective of classroom change and particularly gives an insight into how 14-15-year-old students experience small group discussions. By bringing the students' voices to research, we also wanted to contribute insight from an authentic chemistry classroom and thereby deepen the understanding of chemistry classroom practice. In our future research we will focus on the students' discussions, explore how they talk chemistry and how we can scaffold the students' chemistry learning. The role of the teacher and the teacher's perspective will also be explored.

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