

Exploring the characteristics of argumentation in secondary school students: A study of reasoning, structure, and communication skills

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Abstract

This study examines the characteristics of students' arguments when they are confronted with scientific claims. A qualitative single-case study was conducted to investigate the problem. Data were collected through observations and interviews, using the convenient sampling method in a tenth-grade (n=9) class in Norway. Audio recordings captured the students while they were solving argumentation-based tasks in small groups. Interviews were also conducted with two of the students afterward. A constant comparative analysis approach was used to analyze the students' conversations, and a thematic analysis was used to analyze the interviews. The results indicated that the students used short statements to express both support and opposition to each other's arguments. Additionally, different types of content were used when students built their arguments, including ethical considerations, examples, fantasy based on their imagination, and assessments of the probability of socio-scientific issues. There were certain variations among the groups regarding group dynamics, and based on this, argumentation could be an activity that involves social risk for students. It can be said that this aspect also improved the effectiveness of the argumentation process within most groups, encouraging authentic discussions about challenging issues.

Keywords: Argumentation-based learning, Argumentation, Science education, Secondary school, Socio scientific issues, Critical thinking.

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Contribution of this paper to the literature

This study contributes to the field by providing insights and the characteristics of argumentation based learning in science classroom. This study investigates students' discussion styles, it also sheds light on the issues that teachers should consider when making argumentation-based science teaching.

1. Introduction

1.1. *A Study of the Characteristics of Argumentation in Secondary School Students*

Assessing knowledge in today's information society has become more important than ever. In our digital everyday life, we have information literally at our fingertips, and each of us has an almost unlimited ability to spread information to other people. Living together in an information society demands a lot from us as humans. During their school years, students need to acquire academic competence, but they should also learn skills that prepare them to live in a society that enables them to tackle more complex issues. According to [Evagorou and Dillon \(2020\)](#) in recent years, schools have shifted focus to a greater extent to provide students with content that fosters responsible citizenship. This shift involves making science more relevant to students, based on the idea that, as a society, we have a shared benefit from understanding science. The Core Curriculum ([The Norwegian Directorate for Education and Training, 2017](#)) also emphasizes this. An analysis of "The School of the Future - Renewal of Subjects and Competencies" ([Ministry of Education and Research, 2015](#)) reveals that in addition to being academically competent, students should be self-regulated, competent communicators, critical and problem-solver, creative and innovative, and democratically and socially responsible ([Riese, Hilt, & Søreide, 2020](#)). On this basis, the following research question was chosen: What characterizes students' arguments when faced with scientific claims? The research question is narrowed down to the following three sub-questions:

1. How do students support each other's arguments?
2. How do students express opposition when faced with each other's arguments?
3. How do students substantiate their claims they argue a socio-scientific issue?

2. Theoretical Framework

2.1. *What is Argumentation?*

Acquiring knowledge within the field of natural sciences requires scientific formulations, but many students find the scientific language difficult ([Mork, 2006](#)). A report from the 2019 TIMMS survey ([Lehre, 2021](#)) addresses students' abilities to argue scientifically on TIMMS tasks. The results of the argumentation tasks show that a relatively large proportion of 9th-grade students use everyday conceptions rather than scientific discourse ([Lehre, 2021](#)). Wallace describes a "gap" between students' everyday language and the scientific language, and as a teacher, one often wishes to bridge this gap for the students. The theoretical framework developed by [Wallace \(2004\)](#) is intended to serve as a model for scientific literacy and the use of language in the science classroom.. According to [Wallace \(2004\)](#) students' language is central to their exploration. Wallace employs the term scientific literacy, which includes the ability to think metacognitively, read, and write scientific text, as well as to use aspects of scientific arguments.

Argumentation is a term frequently used in our daily lives. Philosopher Stephen Toulmin defines argumentation briefly as a claim accompanied by justifications ([Toulmin, 2003](#)). [Costello and Mitchell \(1995\)](#) and see it as a tool to promote a view or position in favor of others.

In science and science education, argumentation often aims to reach some kind of conclusion or to lead to the development of science. [Tippett \(2009\)](#) points out that scientific knowledge is a socially constructed concept that is negotiated, validated, and communicated in a social context. [Driver, Newton, and Osborne \(2000\)](#) define argumentation as "a central feature of the resolution of scientific controversies ([Fuller, 1997; Taylor, 1996](#)) it is somewhat surprising that science teaching has paid so little attention to a practice that lies at the heart of science." According to [Erduran and Jiménez-Aleixandre \(2007\)](#) argumentation involves justifying knowledge claims and persuading others.

Toulmin's argumentation model [Toulmin \(2003\)](#) has gained an important place in argumentation theory and has become a well-known framework for argumentation in practice, and in research where the goal is to highlight the various components of an argument and their functions.

According to Toulmin, an argument has a logical structure where claims interact to support a claim, data, warrant, backing, qualifier, and rebuttal ([Breivega, 2018](#)). [Mork \(2006\)](#) have simplified the model in their research to include claims, facts, justifications, and conditions as often the main parts of an argument; but an argument can also consist of just a claim with justification.

2.2. *Argumentation in the Science Classroom*

Researchers claim that the use of argumentation in science education has gained wide recognition among educators ([Allchin & Zemplén, 2020; Erduran & Jiménez-Aleixandre, 2007](#)). Argumentation has been viewed as an important part of science education. Nevertheless, the concept of argumentation is not extensively used in the formulation of competency goals in science. Therefore, it may be challenging for teachers to justify why argumentation should have a place in science education in Norwegian schools. However, the competency goals in science include the concepts of critical thinking, exploration, and research. At the same time, the scientific way of thinking is consistently reflected in the science curriculum ([Norwegian Directorate for Education and Training, 2019](#)). According to [Mork \(2006\)](#) argumentation can be used as a learning strategy to acquire knowledge and to learn subject matter and concepts. Activities that involve argumentation can lead to learning or high academic achievement ([Hattie, 2009; Ural & Gençoğlu, 2019](#)). [Mercer, Wegerif, and Dawes \(2004\)](#) research on exploratory dialogue in group discussions states something different, namely that group tasks encouraging students to argue lead to longer retention of subject matter compared to tasks that do not include argumentation ([Asterhan & Schwarz, 2013](#)). [Hattie \(2009\)](#) shows good results for students learning scientific methods and thinking. The second point concerns students' foundation for participation in democratic processes. [Kolsto \(2006\)](#) emphasizes that

knowledge of the nature of science is important for democratic participation, and the focus should be on methods, procedures, concepts of risk and probability, and competence in argumentation and analysis. He also points out that more complex tasks, such as assessing socio-scientific controversies, require students to develop autonomy and experience, which is important for their preparation for democratic participation.

2.3. Critical Thinking

Elementary school students need to develop critical thinking skills, as future challenges will require them to see multiple perspectives and reflect on complex issues. The curriculum emphasizes that schools should promote curiosity and critical reflection (The Norwegian Directorate for Education and Training, 2017). Mork (2006) points out that argumentation activities are rare in Norwegian schools, and Scheie et al. (2022) find few references to critical thinking in the curriculum, where cognitive skills and the knowledge dimension dominate. Exploration, which is closely linked to critical thinking, involves students asking questions, designing and conducting investigations, interpreting data, forming arguments, and communicating findings. This can increase students' interest and understanding of science (Bailin, 2002; Hand et al., 2018). Teaching that promotes critical thinking is characterized by exploring authentic problems, creating dialogue, providing critical thinking training and modelling by teachers (Abrami et al., 2008).

3. Method

3.1. A Qualitative Case Study

A single case study was conducted with observations and interviews of students in a selected class at a specific school. The purpose was to understand the context and create local knowledge related to the class and the school (Postholm & Jacobsen, 2018). The framework for the case is defined according to Merriam (1998). Data collection took place in the classroom over two school hours on two separate days. The findings are specific to this class, teaching plan and students' prior knowledge.

3.2. Participants

The data was collected in a 10th-grade class at a larger school in a village in Western Norway which is called Voss Secondary School. The students had been in the same class for two and a half years when the data collection took place. The sample was chosen based on availability, as the school was known through the researcher's network. The researcher also had a teaching role in the class for a short period before the data collection. Convenience sampling is the most common sampling method. This is when the sample is not random. This will also be the case in this study, whereby any findings will be tied to the available case.

3.2.1. Selection of Participants for Observation and Interview

Nine students participated in the observation of group discussions. The selection for observation was based on which of the students consented to be audio recorded. The students who discussed in the same group were thus strategically placed with others who also consented to participate in the audio recording.

Two students from this class were also selected for an interview, and these two students were in the same group on both days. The predetermined criteria for selection for the interview were that there should be one student of each gender and that the two selected should have different levels of academic engagement in science.

3.3. Data Collection

Data collection was conducted in the autumn of 2022. The observation lasted over two days, with audio recordings each day. On the last day, an interview was also conducted in the following class period, with a break in between. The students were given argumentation tasks and discussed in groups of three. The topic was evolution, as the students had recently learned about it and thus had good prior knowledge. The researcher's previous role as a teacher in the class before the data collection meant that they were well acquainted with the student's prior knowledge and expectations, which may have influenced the study (Bornstein et al., 2013).

3.3.1. The Teaching Plan

The teaching plan was designed to facilitate student activity, especially through oral argument, based on the teacher's assertions. The time was divided between a common start, group discussions, and a joint review. Before distributing the tasks, there was a conversation about what it means to argue, the characteristics of good arguments, and how to listen to others. The guidelines for good argumentation according to Kolstø (2006) were used as follow:

1. Share ideas and listen to each other.
2. Speak one at a time.
3. Respect each other's opinions.
4. Explain and justify the ideas.
5. In case of disagreement, ask why.
6. Try to agree in the end.

3.3.2. Selection of Statements

The students worked on six statements over two days, as shown in Table 1. On day 1, statements 1, 2 and 3, which were academic and required prior knowledge of evolution and adaptation, were addressed. On day 2, statements 4, 5 and 6, which were socioscientific and related to values and society, were addressed.

Table 1. Claims distributed on day 1 and day 2.

Day 1	Both your father and your grandfather are among the greatest ski talents in Norway. Therefore, it is highly likely that you will become one as well. Organisms evolve through evolution with the goal of always becoming larger. One can be religious and still believe in the theory of evolution..
Day 2	CRISPR technology can be a helpful tool for creating a more efficient society. It should be legal to change the genes of one's children using CRISPR, both when it comes to diseases, appearance, and personality. That human breed animals is unethical.

Note: Overview of the six statements given in the argumentative task.

The students had been through an introduction to what evolution is, and had previously looked a lot at animal adaptations in nature. They have also learned about how humans can help change the genes of plants, animals and humans through breeding, and had a school assignment where they had to find information about gene editing with CRISPR technology. The students' science teacher expressed that the students were not used to being faced with statements, but rather various types of discussion tasks.

3.4. Data Processing and Analysis

In the analysis of the observation, codes, subcategories and main categories were developed. In line with Postholm and Jacobsen (2018) open coding, axial coding and selective coding were used as three steps in a constant comparative analysis: in the open coding phase, the main categories are developed, in the axial coding phase, the subcategories are developed, and in the selective coding phase, the pieces are put together into a whole to answer the research question.

To analyze the interviews, a thematic analysis was conducted according to the method described by Braun, Clarke, and Braun (2022). This process included several steps: getting to know the data, coding the data, organizing by theme, developing and reviewing the themes, and finally distributing and defining the themes.

4. Results

4.1. How Do the Students Express Support for Each Other's Arguments?

The analysis has been summarized in Table 2, with excerpts showing interesting situations. The table shows the main categories and subcategories of the student statements, as well as their occurrence. The statements in Table 2 were all interpreted as backing up the argument that came straight after them

Table 2. Occurrence of statements expressing support for an argument.

Main categories	Sub-categories
Agreement	“Yes”
	repetition
Requests for insight	Asks for justification
	Challenges argument
Competition-driven talk	Acknowledges loss/Victory
	Agree to disagree

Note: The table shows the occurrence of statements placed in main categories and subcategories. All statements in Table 2 are interpreted as supportive of the argument made just before.

The main categories that felt under this research question are “Agreement”, “Requests for insight”, “Competitive talk” and “Acknowledgement of different opinions”.

4.1.1. Agreement and Repetition

When a statement was categorized as "agreement", the student responded to an argument by saying a short but supportive "yes", or the student repeated verbatim what the other student's argument contained, without adding anything to the argument. Simply saying "yes" was the most common form of support. Group 2's statements showed agreement, and here the students used repetition to show that they supported each other.

Sara: *For example. For example, a rabbit that molts to become white in the winter. If he gets much bigger, it's much easier for him to be seen. So, it's not always better.*

Lars: *But bigger is not always better.*

Sara: *Yes. Bigger is not always better.*

[...]

Lars: *If everyone develops to become bigger and bigger, then we'll run out of space.*

Sara: *Yes. Kari.*

Kari: *That's a discussion that I'm not allowed to discuss.*

Lars: *Quality over quantity, true.*

Sara: *Yes. Example of statements in the subcategories “agreement” and “repetition”.*

As it can be seen from the quotation the statement being repeated several times. Sara ended a long statement about rabbits and size with “so it’s not always better”. Then Lars said the same statement, as if to emphasize Sara’s point. Then Sara repeated the statement once more. In this group, the students support each other by both repeating each other and by supporting with a “yes”. When Sara said here that “bigger is not always better”, Lars repeated this almost before Sara finished her statement.

4.1.2. Request about Insight

During coding and categorizing student statements, it happened on several occasions that students asked each other questions where they requested insight into each other's arguments, both by asking for more basis, and by challenging each other's arguments. When these requests were characterized by a positive curiosity the statements

were categorized as supportive even though these statements challenged the argument, because they seemed to acknowledge and question it. This is because statements that help drive an argument forward are considered supportive. A statement about “requests for insight”:

Kris: But true, not just that breed, they're talking about everyone.
Sander: Yes.
Kris: So ...
Sander: Yes.
Line: Oh yeah. Everyone?
Kris: So ... yes. So, like.
Line: Well then, that's a challenge.
Kris: So, they're kind of getting better?
Sander: Yes, but they're the kind of Hondas that if you, if you breed Hondas, do you mean that humans are going to decide that they're going to have trouble breathing and stuff like that?
Kris: Oh yeah. No, they're not good.

In the conversation, it can be seen that Kris explained that “it applies to all dogs, not a specific breed”. Line asked to confirm what Kris meant and asked for insight into her thoughts. Based on this, Line considered that "then it's a challenge". Sander asked Kris for his ethical opinion: "do you mean that humans should somehow decide that they have difficulty breathing and so on?". Kris concluded that "that's not right" based on the insight from Sander. The quotation showed that the students request insight into each other's reasoning. Line and Kris show mutual interest in information that could support the claims, in a group dynamic that is friendly and harmonious. Sander's statement in the conversation, which read: "do you mean that humans should somehow decide that they have difficulty breathing and so on?", was loaded with an expectation of an ethical assessment from Kris.

4.1.3. Competitive talk to Support each other

Some groups made competitive statements. Statements that were seen as supportive and competitive are characterized by students acknowledging defeat or victory, or indicating that they agree to disagree. The quotation below shows an example of competitive talk that appears to support the opponent of the person making the statement.

Filip: Yes, if your parents like what they do. But that's because we're used to our parents complaining about ... (Filip says something unintelligible). If your parents like your job, and you get the same job.
Rutt: Yes, that's true. Not true.
Filip: Ooooooh, you admitted it then! We won, we won, we won, we won, we won, we won.
Rutt: You can win.

It can be seen that Filip presented an argument, and Rutt then said "yes, that's true." After Rutt agreed with Filip's argument, Filip said "you admitted it," and continues with a competitive statement that challenges Rutt. Rutt then acknowledged that they won the argument, and the statement could almost appear as a surrender. It was also relevant here how both Filip and Rutt choosed to express themselves. Both used words that indicate that Robert and Filip are on the "team," as Filip said "we won" and Rutt says "you guys win." This could suggested that statements about competition are about who was on the team against whom, and they thus appeared polarizing.

4.2. How do the Students Express Resistance to Each Other's Arguments?

In Table 3, the analysis was summarized, and the conversationsshowed interesting situations. The table displays the main and subcategories for student statements, as well as the occurrence of these statements. All statements in Table 3 are interpreted as resistance to the argument that was stated just before.

Table 3. Occurrence of statements expressing opposition to an argument.

Main Categories	Sub-categories
Disagreement	Expresses disagreement briefly
Critical evaluation	Challenges logic
	Corrects facts
	Questions source
	Questions relevance
Irrelevant talk	Speaks destructively
	Teases
	Points out grammatical errors
	Interrupts
Competition-driven talk	Points out loss/victory
	Talks about competition

Note: The table shows the occurrence of statements placed in main categories and subcategories. All statements in Table 3 are interpreted as opposition to the argument that is stated just before.

The main categories that felt under this research question are "disagreement," "critical evaluation," "irrelevant talk," and "competitive talk."

4.2.1. Disagreement

The subcategory "disagreement" could consist of statements such as "no" or "I think that is wrong." Statements in the subcategory "expresses disagreement briefly" were thus made without providing any justification for the disagreement. The statement therefore was not necessarily had any depth in itself and did not need to be based on anything other than the fact that one disagrees. Such statements typically belonged in a context that may be relevant to highlight in order to understand what the disagreement means. A typical example of disagreement is shown in the following quotation:

Lars: *If you... if you... if you believe... if a person believes that God created everything, Kari, maybe they believe that the theory of evolution, that it is... it means that animals created themselves in a way, right. So, you can't believe in both.*

Kari: *Yes, you can.*

Lars: *No.*

Sara: *But then it's just wrong, so you just believe wrong, Kari.*

Lars presented an argument at the beginning of the excerpt, concluding that it was impossible to believe in both the theory of evolution and a religion, and Kari briefly disagreed without providing any reasoning. Lars then disagreed with Kari's disagreement, and Sara continued by stating, "then it's just wrong," almost asserting that Kari was incorrect. In the excerpt, both Kari, Lars, and Sara made statements that directly contradicted each other, with Kari and Lars doing so simply by saying "yes" and "no." The conversation as a whole was characterized by disagreement, but the three students seemed to support their arguments with personal experiences, examples, knowledge of the topic, and similar elements in their disagreements along the way. The excerpt followed a longer conversation that appeared constructive and based on relevant content. The excerpt was taken from the very end of the argument relating to the claim about religion. It seemed that the students had reached a point where the argument had come to a sort of standstill, with not much more to add to the arguments. Sara expressed something that might indicate this by saying, "But then it's just wrong, so you just believe wrong, Kari".

Group 2 in the conversation above did not have the highest occurrence of statements in the category "expresses disagreement directly." Group 1 had roughly twice the occurrence of the "expresses disagreement directly" category compared to Group 2, on both day 1 and day 2. Considering the context around the disagreement between the two groups, Group 2 differed from Group 1 by their disagreements being more mutual, with the friction that occurred within the group often not negatively charged. Their disagreements appeared more constructive than those of Group 1. In Group 1, the conversation seemed negatively charged, and the statements in the "expresses disagreement directly" category were frequent and often repetitive. The following excerpt provided an example of this:

Robert: *It's in your blood.*

Rutt: *That's what you say. Oh, yes. I don't think you inherit physical form.*

[...]

Rutt: *I don't think that ...*

Filip: *You're wrong.*

Rutt: *I don't think that*

Robert: *You're wrong.*

Rutt: *You think you ...*

Filip: *Wrong! Examples of statements in the subcategory "expresses disagreement directly".*

The students were discussing physical fitness, and Rutt asserted that she did not believe physical fitness could be inherited. She tried to continue speaking but was interrupted by Filip, who said "you are wrong." He repeated these two more times, with the final statement simply saying "Wrong!" The quotations contained examples of statements where the students expressed disagreement directly, without this leading to a discussion. It seemed that Robert and Filip's statements of disagreement towards Rutt undermined and interrupted Rutt's attempts to discuss. The group stood out on this point in the table, perhaps due to excessive disagreement, as illustrated by the last quotation

4.2.2. Critical Evaluation

The group that showed the most disagreement across these four subcategories was Group 2, and they had the highest occurrence of the subcategory "doubt source." An example of Group 2's discussion of sources can be seen in the following statements:

Lars: *Have you by any chance seen this on TikTok, Kari?*

Kari: *No, no, but I was in Armenia and I saw it!*

Lars and Kari: *[Laughs.]*

Lars: *You have seen it on TikTok.*

Kari: *And ... I do not want to ...*

Sara: *Kari. My little friend, now I'm going to tell you something. TikTok is not always a very good source.*

Kari: *I was not on TikTok. Okay? I have seen this.*

The dialogue started with Lars doubting Kari's source by asking if she saw it on TikTok. Kari responded that she had evidence for her argument, but the others continued to suggest TikTok as her source. Sara teased Kari, who again denied that TikTok was her source. The discussion in the conversation showed disagreement over Kari's use of sources. This exemplified a critical assessment that required reflection. Group 2 had the most instances of questioning sources, which could enhance argumentation, but here it was placed under resistance as it was not based on curiosity but rather criticism.

4.2.3. Irrelevant talk

The occurrence of irrelevant talk varied between the groups and days. Group 1 had the most frequent degrading talk, with 40 instances. This characterized their conversation, with little professional talk from anyone other than Rutt. She repeatedly attempted to speak professionally and invited academic engagement, but was often met with irrelevant talk, as shown in the following statements:

Rutt: *There are many who believe that the world has always been here and that humans have just arrived.*

Filip: *No.*

Robert: *That's pretty strange then.*

At the start of this dialogue, Rutt presented an argument, and Filip expressed disagreement with a simple "no" without further explanation. Robert followed up with a derogatory comment, "Da e ganske sløkte då," where "sløkte" meant dumb or idiotic. The conversation was generally negative and lacked constructive responses and

mutual humor. Derogatory talk also occurred in other groups, particularly in Group 2, where it was used 24 times. In 21 of those cases, the talk was teasing and received as a joke, as shown in the following quotation:

Lars: *Can you, who watches so much cross-country skiing, have something.*
Sara: *You should know, you who do cross-country skiing.*
Kari: *Yes. Every day, every night. Northug.*
Lars: *What... What first name?*
Kari: *Petter.*
Sara: *Yes, you know his children, Kari.*
Kari: *Yes?*
Sara: *He doesn't have children, haha, you don't watch cross-country skiing.*

In this dialog, humor and irony were evident in the conversation. The students had previously discussed Kari's knowledge of cross-country skiing, and Lars used this as an argument against her expertise. Lars's comment was interrupted, but Sara followed up with irony: "you should know, you who do cross-country skiing." Kari played along and responded, "Every day, every night. Northug." This excerpt showed teasing and irrelevant talk, but the group had good chemistry. Humor was used to build arguments, and the teasing was mutual. Kari's tone and laughter, especially with "Yes. Every day, every night. Northug," indicated a positive and friendly conversation.

4.2.4. Competitive talk to Express Opposition

Competitive talk often served as resistance to others' arguments and frequently involved winning or losing. When students pointed out their own win or someone else's loss, this was sometimes linked to the assigned roles. It was challenging to directly link competitive talk to role assignment, as clear evidence in the data was scarce. An example where competitive talk appeared to be a result of role assignment could be found in the following conversation.

Sander: *Actually. Yes. Should we just die there or what? Katching, katching, katching!*
Line: *But I can't... I agree, actually.*
Kris: *You! Can we switch roles now?*
Sander: *Do you want to be against it?*
Kris: *Yes!*
Line: *Yes, but I actually agree, so then they're a bit like.*
Sander: *Then you and I are for it, and we're going to crush Line.*

Sander asked if they should end the discussion, followed by a sound that was interpreted as a slot machine, expressing victory. The students further discussed the distribution of roles. Finally, Sander said: "Then you and I are in, and we are going to crush Line," indicating teamwork and engagement in the argument. This statement could be interpreted as part of the competition, as he encouraged Kris to cooperate in order to "crush" Line, which suggested a competitive conversational environment.

4.3. How do the Students Support Their Claims?

In Table 4 summarized the categories associated with students' argument construction. The table showed the categories in which student statements were placed and the frequency of the different categories. To answer the research question, students' use of content in arguments was examined, focusing on how they substantiated their claims and what types of facts they used to justify them.

Table 4. Occurrence of statements expressing different types of facts as support for an argument.

Main categories	Sub-categories
Ethical consideration	Etiske vurderinger
Examples	Examples
	Personal experience
Fantasy	Fantasy
	Exaggeration
Assessments	Degree
	Probability

Note: Summary of the occurrence of statements about the students' reasoning. The table shows all statements, regardless of whether the students support the same assertion or not.

The main categories in Table 4 showed what characterized the students' argumentation in general terms, and these were relevant findings in themselves. It could be shown that the students used varied justifications when they argued.

4.3.1. Ethical Considerations

Group 3 stood out the most in terms of the occurrence of statements in the "ethical considerations" category. These statements also had CRISPR and breeding as the theme of their claims, which may have contributed to the group having more cases in this category. An example of ethical considerations can be seen below:

Line: *Think of a child who becomes disabled, for example. How many resources would that save?*
Kris: *You have to love people even if they are disabled!!!*
Sander: *You love them, you can make it easier for them in this!*
Sander: *This is not about loving people and thinking they are wrong, they are.*
Kris: *But she started with parents ...*
Sander: *Yes, it is because it is easier for parents, it is better for parents if they have a child with a little challenge. Then they can practice.*
Line: *The parents can be mentally destroyed by spending so much resources and energy on them.*
Sander: *Then you stop ... they just ...*

Kris: You, the parents SHOULD spend a lot of resources on them.

Line: Yes, of course, of course, of course.

In this statement, Line discussed the use of CRISPR technology to save resources, and Kris responded by saying that we must love everyone, including the disabled. Line nuanced her stance and stated that technology could make people's lives easier. Kris, Sander, and Line then discussed the role of parents and ethical considerations. Kris believed that parents "SHOULD spend a lot of resources on them," which Line ultimately agreed with. This excerpt showed that the students included several ethical perspectives in their assessment of CRISPR technology, especially the question of whether it is right to "fix" people with technology. The discussion took place in a friendly and engaged tone, which was also evident from the audio recordings.

4.3.2. Examples

Examples were used frequently, and statements could be categorized as both "example" and other categories, such as knowledge. Examples provided insight into what knowledge students chose to highlight. In the following excerpt, different religions were shown as examples:

Lars: Yes. But there are other religions than Christianity.

Kari: In ten ... Yes, in addition to the other religion, for example Buddhism. Then you can still believe in the theory of evolution.

Sara: Eh, I don't know enough about all these different religions, so it will be difficult for me to answer. But in Christianity, the religion is built on the premise that God created everything. So then it will be a bit strange if they start believing in the theory of evolution.

Lars pointed out that there are other religions besides Christianity, and Kari mentioned Buddhism as an example. She said that one could still believe in the theory of evolution. Sara found this difficult to answer because she did not know enough about different religions but used Christianity as an example to argue that one could not believe in both the theory of evolution and a religion at the same time.

4.3.3. Fantasy and Exaggerations

The categories "imagination" and "exaggeration" were similar to each other, but were still slightly different in use in the students' conversations. The category of imagination was defined as an expression of imagination and creative thinking that went a little beyond the argument itself. Nevertheless, imagination was expressed in all groups, but with different frequency. The excerpt below showed an example from Group 1's statements that were categorized as "imagination":

Robert: You could have become Superman.

Filip: Yes. Superman, flyyyyy Kristin!

Rutt: No.

Robert: Yeah.

Filip: Can probably piss lasers.

Robert: We could have crossed gorilla DNA, then we would be super strong.

Robert and Filip talked in the conversation about "you could have become Superman". Filip further said that one "could probably piss lasers" and Robert continued with, "we could have crossed gorilla DNA and become really strong". These statements were categorized as fantasy because the statements were not used to prove a point but could be interpreted more as an outburst of enthusiasm.

The subcategory "exaggerations" was defined as a distortion of reality in an extreme direction where the student who made the statement wanted to prove a point with the exaggeration. An example of this could be seen in the following conversation:

Lars: Laughs. It's ... It's obviously not practical if everything is just going to get bigger.

Sara: If Kari had gotten a lot bigger, then ... Say in the door, if you have to go through that door. When you went to school, you would have pulled through the road, because you were so big.

[...]

Lars: Where are we going ... If the rabbit had been gigantic, then it would have been really easy for bigger ... bigger animals like that to catch them.

Tarjei: Exactly.

Sara: And those.

Tarjei: If the rabbit had been gigantic then.

Sara: If you were hunting, Tarjei. Tarjei. For example, if I were to hunt a rabbit. It's a little ... Then it's a lot easier ... Imagine that. It's much easier to shoot a big rabbit than to shoot a small.

In this statement, Lars said that it was not practical if organisms became infinitely large. Sara exaggerated, mentioning problems such as walking through doors and stepping on roads. Lars mentioned that large rabbits could be easily caught, and Sara specified hunting. The students used exaggerations to illustrate the disadvantages of large organisms. To understand them, one had to interpret humorous statements and read between the lines.

4.3.4. Assessments

Students made statements that were categorized as "probability" and "degree." These categories indicated that students could use arguments containing a caveat about risk or chance that something would happen, and they used this as part of an evaluation of the claim. An example of this was shown in the following:

Sara: If you look at the statistics, it's very rare that there are three people in a row in the same family who are dead in cross-country skiing. It's quite a small... small probability.

Kari: Huh? No, I don't think so. Eskil is right... Take Eskil for example. He's good at cross-country skiing, right.

Lars: Yes.

Kari: He has strong parents, right.

In this statement, Sara said that it had happened a few times that three in a row in the same family had become “deadly” in cross-country skiing, and then pointed out that it was “quite unlikely”. Kari then responded to this by saying to bring up an example of a person who was fit himself, who also had fit parents. Here she did not directly assess probability, and the statement was not categorized under the main category “assessments”, but this was an example that responded to Sara’s assessment of probability. There were also examples of students’ assessments of risk and how could play a role. The example that dealt with assessment of probability and risk could be seen in the following conversation:

Trond: Trond: Yes, but they can still live a better life without gluten allergies.

Sara: But then we change them, so think for example now there is someone who is a doctor. So, you change those genes, and then you can maybe ... then they might change.

Trond: But you don't know ... whether the person actually gets a doctorate when they grow up. You don't change people when they are adults.

Sara: Yes, you change the person, Trond. Then they might not end up the way they really intended to end up.

Sara pointed out the risks of CRISPR, indicating that gene editing can have unforeseen consequences. Trond also considered the risk and the chance that something could go wrong. Sara highlighted that “it could happen,” which demonstrated awareness of possible problems with CRISPR. The students demonstrated the ability to weigh the risks and likelihood of unwanted consequences when using CRISPR.

5. Discussion

5.1. The Support among the Students is Frequent and Significant for the Group Dynamics

In light of Vygotsky's sociocultural learning theory (Säljö, 2013), the social framework surrounding any learning activity is considered important as it can provide students with supportive scaffolding. Agreement in itself can give argumentation value in the form of a simple but important support for the student who has presented an argument. It can be thought that such a statement comes under Mercer's (Kolstø, 2016) definition of supportive talk, as these are characterized by agreement, confirmation, repetitions, and elaborations. Nevertheless, it shows that the students are largely repetitive and confirming, without adding further value to the argumentation, which is an important principle in Vygotsky's theory (Säljö, 2013) of supportive scaffolding. Although the students largely show signs of also delving deeper into the argument in other categories than they do under “agreement” and “disagreement,” it is significant that these two are the most frequently used.

Though this does not necessarily contribute more depth to the conversation between the students, these statements of agreement can still have greater significance than one might think, as this can be thought to be an important part of the social interaction occurring in the groups. The PISA framework highlights that collaboration and criticism play an important role in the natural sciences. Vygotsky's sociocultural learning theory (Säljö, 2013) informs us about the important social process that is crucial in any learning situation (Kolstø & Ratcliffe, 2007; Säljö, 2013). This will also be applicable here. A “yes” can be significant in making a student feel heard and understood, for example, and a short “no” can feel just as unpleasant as a well-grounded counterargument.

The findings of the study show extensive use of ungrounded statements of agreement and disagreement, which may be influenced by the role distribution in the teaching setup. The students focused on agreeing with their partner and supporting their partner's opinions, which may have inhibited critical thinking. Group 1, in their conversations, stood out with few requests for insight and a low occurrence of justifications in their arguments. Many statements of agreement without justification could be due to their roles as “for” and “against” in the discussion. The element of argumentation may have led to a confrontational conversation, where two students support each other with short statements and little content. This may have given an artificially high occurrence of “requests for insight.”

Arguing largely involves weakening or strengthening a claim (Karlsen, 2018) and a short statement of agreement can help give an argument more weight. At the same time, more is required for an argument to survive; it depends on presenting evidence, articulating reasoning (Karlsen, 2018) and providing claims with justification (Breivega, 2018). For an argumentative conversation to move from supportive to exploratory (Kolstø, 2016) students must proceed to these components mentioned by Karlsen (2018) and Breivega (2018).

5.2. Resistance in the Form of Short Statements, Irrelevant and Competitive Talk

Examining the various ways in which students resist each other reveals that brief, unfounded disagreement and irrelevant, competitive talk dominate. One exception is Group 2, which frequently criticizes each other's sources, and this may indicate a greater use of communication that is not primarily socially conditioned resistance. Kolstø and Ratcliffe (2007) point out in their research that reception can just as easily rest on social aspects as it does on critical thinking and assessment of arguments, and this may indicate that the students participating in the argumentation task also use the social aspects to a greater extent than they use critical thinking. As Kolstø and Ratcliffe (2007) point out, one never knows where a claim will end up, as it can depend entirely on other things than good arguments. The subcategory “disagreement” is similar to the subcategory “agreement” in subsection 5.1, in that disagreement can be separate from any further argumentation. Similarly to the subcategory “agreement,” it can also be thought that students might make this type of statement to be in disagreement because they have been instructed to disagree.

In students' conversations, disagreement has sometimes proved to facilitate further discussion, as the student meets the resistance by continuing to argue, but one can also see instances where students withdraw. An example of resistance becoming so strong that a student withdraws can be seen in Excerpt 9. Students engaging in such confrontational conversations (Kolstø, 2016) contribute to creating more disagreement, with opinions being presented without being constructive. Unless it is followed up by other statements, this is not a conversation that stimulates critical thinking.

In student conversations, disagreement marks the end of a longer conversation where multiple arguments have been presented, and acknowledges that agreement has not been achieved. The students' goal of confirming or

refuting the statement was not fulfilled, but they experience that different opinions are acceptable. In the natural sciences, it is important to be open to being wrong.

The main category "irrelevant talk" includes "speak destructively" and "teasing." In student discussions, one is joking with a positive tone, while the other is negative and destructive. This difference can have effects on argumentation as a social process.

Disagreeing is in itself a complex activity (Muller Mirza, Perret-Clermont, Tartas, & Iannaccone, 2009). Muller Mirza et al. (2009) highlight that students risk their relationships by participating in argumentation, and this will also be the case when destructive talk and teasing occur in the group. To avoid this, the teacher can ensure that there is not too much asymmetry in a group. Something that also influences the social risk students take in argumentation is the framework for the activity. Here, the roles "for" and "against" that the students have in the groups are relevant for interpreting the framework of argumentation taking place in the classroom.

It is interesting to look at students' competitive talk in relation to Mercer's ideas (Kolstø, 2016). A competitive conversation, according to Mercer's three types of discourse (Kolstø, 2016) can have characteristics of both confrontational conversation, supportive conversation, and exploratory conversations. In Excerpt 6, one can see how students argue that the conversation has features that fall under a "confrontational conversation." According to Kolstø, a confrontational conversation is competitive, and different opinions are presented to create disagreement rather than agreement. Kolstø (2016) emphasizes in his research that it should be a goal for students to agree in argumentation. The advantage of this, according to Kolstø, is that it creates exploratory conversation.

5.3. Students' Social Risk When Engaging in Argumentation

An argument will always be negotiated, validated, and communicated in a social context (Tippett, 2009). This argumentation assignment has given students roles, which may function to shift the pressure from the students themselves to the roles they play. The students, therefore, remove themselves and the personal risks associated with engaging in argumentation, as they are fulfilling a role and not their own personal opinion.

Muller Mirza et al. (2009) present four challenges to students' participation in argumentation. Argumentation is described as a demanding activity that involves different linguistic and cognitive processes, but it is also these aspects that add value to the argumentation. In interviews, students were asked about the importance of how well they knew the other students. The students themselves felt that having been in the same class for a considerable time is significant, both in terms of social risk and participation in the conversation. Rutt highlights that she believes it is important for oral participation that they have been together in the class since the beginning of the eighth grade. Filip chooses to mention a specific situation when asked about the importance of the class knowing each other well. His interpretation was that one can "tolerate" tougher confrontations better when they know each other beforehand. There have been tough confrontations, but this has happened most frequently in Group 1, where there has been a high occurrence of students, for example, speaking in a derogatory manner or similar.

In the student conversations, one can see how teasing is used in argumentation, which can be difficult for many students both to interpret, participate in, understand, and take a stance on. One can see signs that communication happens between the lines, and arguments are wrapped in humor. This can be a demanding social process for some to participate in. Nevertheless, the group dynamics appear to be good in Group 2, even though this is one of the groups that frequently uses teasing remarks.

In the conversations, one can see that the students talked about roles and showed resistance in the form of competitive talk at the same time, which makes it clearer that these two aspects may influence each other. The role assignments made by Sander and Kris, and the statement that they would "crush" the third participant is interesting. One can speculate on how such a statement is received, as it may point to social challenges that could result from such a quotation. Kolstø (2016) reflects on the idea that students should aim to agree if the goal is to facilitate an exploratory conversation, something that is not achieved with such competitive statements as resistance to argumentation. Nonetheless, one of the interviewees states that this disagreement through competition motivates her to "win".

5.4. Critical thinking and Ethical Assessment in the Argumentation

Elevenes "The students' positive curiosity towards each other often appears in their conversations. Unlike "agreement" and "disagreement," critical thinking requires more effort, especially when it comes to "requesting insights" and "critical evaluation," which require assessing information to form a well-founded opinion (Svartdal, 2022). In such situations, students seek to understand the content behind each other's statements, allowing them to present better-reasoned arguments.

The discussions within the group may have been influenced by competition resulting from the assigned roles of "pro" and "con," which can limit the students' ability to think critically (Kolstø, 2016). The role can train them to stick to their own viewpoints without being influenced by social factors such as charisma or persuasion abilities. This can be valuable but may also result in the discussion becoming more confrontational and less constructive.

Criticizing the sources used in arguments is an important part of the discussion (Karlsen, 2018). Ideally, this leads to exploratory conversations where students critically evaluate and challenge each other's ideas (Kolstø, 2016). An example from the conversation under "teasing" was when Lars and Sara asked Kari about the sources behind her claim, demonstrating their ability to question and ask for justifications, though the conversation could bear elements of humor and teasing.

The students' ability to assess risk and probability is also important (Kolstø, 2006). In their discussions, students, for instance, critiqued other students' attitudes towards CRISPR. Assessing probability involves thinking about the chances that something might happen, the risks of different scenarios, and how often something has occurred in the past. Even though some statements may seem taken out of context and not always critically evaluated, discussions such as the one about the heritability of cross-country skiing talent show that students can perform thorough evaluations. Such discussions can be beneficial for strengthening students' academic language use (Wallace, 2004).

Through argumentation tasks, students handle challenging and complex claims, which often require ethical evaluations. Arguing for sociological controversies demands that students develop autonomy and experience (Muller Mirza et al., 2009). These controversies often evoke emotions and encourage conformity, but the roles of “pro” and “con” can provide students with protection by giving clear frameworks for argumentation. In their roles, they must argue for the viewpoints they have been assigned, which can help create a more organized discussion. Ethical evaluations in the data material are frequent, likely because CRISPR technology was the topic, naturally triggering such evaluations. Ethical evaluations are often laden with expectations based on ethics. Muller Mirza et al. (2009) point out that ethical issues have a social dimension that can influence argumentation. In the conversations, students countered the ethical argument by saying that “the most important thing” could override ethical evaluation, despite admitting it could be unethical. This shows that ethical arguments can be challenged, even though it may risk relationships and status within the group.

5.5. Argumentation as an Acquisition of New Knowledge

The students demonstrate a wide variety in the content they use when supporting their claims, indicating that they are capable of using arguments, providing evidence, and presenting a line of reasoning to support their claim. When students can do this, it means that they master argumentation well. A good argument should consist of a claim and a justification, which is shown to be prevalent in most groups (source).

When students engage in a social activity, as seen in the excerpts under sub-chapter 4, and bring up various facts, make assessments, and refer to knowledge, the scientific language will be used. New concepts are used and explained to fellow students. A concrete example of this can be found in sub-chapter 4.4.1, where one student asks what the word “unethical” means, and another responds by explaining the term. The students have relied on precise communication when arguing, as their conversations have proven to be nuanced and rich in content. In the relevant discussion, the students used the word “unethical” after establishing the meaning of the word. It can be argued here that the students are in the Zone of Proximal Development (Säljö, 2013) when they can learn and support each other with knowledge.

Halliday (2004) perspectives suggest that as a student, one can participate in learning processes with the acquisition of knowledge as a consequence, if one is able to use the language. Perhaps in this type of task, one also enters this “space” described by Wallace (2004). According to Wallace, participating in frequent and authentic discourses is necessary to acquire scientific language. There should be a conducive environment for communication through being listened to and evaluated, and new terms and expressions should be tried out.

Using examples is a simple way to incorporate various elements into the argumentation, but it is mostly used by Group 2. The prevalence is much higher here than in the other groups, and this is not surprising. Group 2 frequently uses statements that fall within the other categories. The use of examples often involves situations from the students’ own lives, which can be a harmless and everyday way for students to bring knowledge into the argumentation. Consequently, using knowledge can bring scientific language and learning, as Halliday (2004) and Mammino (2010) highlight social interaction and conversation as beneficial for learning scientific language. If this interaction is also authentic as Wallace (2004) emphasizes, the way students support each other academically can be good for their long-term learning outcomes and deep learning. Filip can also support this claim, as he pointed out in the interview that he felt he gained a deeper understanding from doing argumentation tasks.

5.6. Fantasy as a 'Bridge' to the Natural Scientific Language

Statements categorized as “fantasy” differ from other supporting arguments by relying on imagination instead of observations or scientific knowledge (Source). Fantasy can emerge when students feel secure enough to express their creativity. In the relevant conversation, Robert and Filip used fantasy to highlight absurdities in the discussion, based on knowledge of DNA and genetics. Exaggerations are used to twist real scenarios to extremes that prove a point, even if they are not entirely mature arguments. In the student conversation, the students demonstrated how exaggerations about size can strengthen the argumentation. Fantasy and exaggerations can bridge the gap between everyday language and scientific knowledge, providing students with a way to express themselves creatively (Wallace, 2004). Mork (2006) point out that scientific language can be difficult for students, and fantasy can serve as support. According to Lehre (2021) 9th-grade students often prefer everyday language, and fantasy and exaggerations can help them explore the language without risk.

6. Conclusion

The findings from the analysis of the observation show that students meet each other's arguments with both support and opposition. There has been a significant difference between groups in terms of group dynamics, which has impacted both the occurrence of supportive statements and statements of opposition. The assignment of roles may have also influenced the results in terms of support and opposition.

Students face a social risk when it comes to argumentation in the classroom. The value in argumentation comes from its authenticity and addressing real problems, which the students who participated in the interview also expressed positively. There have been significant differences in whether the students' discussions have been positively or negatively charged, and whether they have been characterized by destructive comments. Thus, from an external perspective, it may seem that students have faced a social risk by arguing. At the same time, it is expressed in the interview that it has been a positive experience. This ambiguity could be interesting to study further.

The students demonstrate that they are capable of justifying their arguments in various ways. The content of students' claims varies, and there are different justifications that arise, giving their arguments more substance. Students support their claims with ethical considerations, examples, imagination, as well as assessments of probability. Supporting their claims with this type of content has practiced the students in critical thinking through exploratory conversations about demanding and complex issues.

An interesting observation has been the use of imagination and exaggerations, which can be argued to have served as a “bridge” towards the use of a more academic language. Students have shown signs of using the

conversation to acquire new knowledge by using each other as academic support. It is likely that students take with them a richer language, as well as long-term learning outcomes and deep learning, from this argumentation task.

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