

## A chemistry lesson for citizenship

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**DOI**

[10.3390/educsci9020100](https://doi.org/10.3390/educsci9020100)

**Publication date**

2019

**Document Version**

Final published version

**Published in**

Education Sciences

**Citation (APA)**

Bayram-Jacobs, D., Wieske, G., & Henze, I. (2019). A chemistry lesson for citizenship: Students' use of different perspectives in decision-making about the use and sale of laughing gas. *Education Sciences*, 9(2), Article 100. <https://doi.org/10.3390/educsci9020100>

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Article

# A Chemistry Lesson for Citizenship: Students' Use of Different Perspectives in Decision-Making about the Use and Sale of Laughing Gas

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Received: 31 March 2019; Accepted: 1 May 2019; Published: 10 May 2019



**Abstract:** The aim of this study was to explore how the design of this chemistry lesson for citizenship influences students' use of different perspectives in decision-making about 'the use and sale of laughing gas'. In this study, 'the use and sale of laughing gas among youth' was chosen as a socio-scientific issue. This chemistry lesson for citizenship was designed according to the 5E instructional approach, and activating pedagogical methods and tools (i.e., group discussion, reading the information cards, taking notes, watching instructional videos) were used. Both the types of perspectives used and the effectiveness of the pedagogies implemented were explored. Twenty-three students from two classes participated in the study. The data were collected through five tools (four worksheets and a questionnaire). The students mainly used 'scientist' perspective by focusing on what research says about the possible consequences of inhaling laughing gas. The students also focused on 'health'; principally, they referred to the relation between the amount of laughing gas used and the damage it may cause. As to the influential pedagogical elements of the lesson, the 'videos' were found to be the most effective and informative. In addition, the 'group discussion' was also found to be an influential activity of the lesson on making decisions about the use and sale of laughing gas. Therefore, our results suggest that the lesson design supported the students to recognize and use different perspectives to make informed decisions about the sale and use of laughing gas.

**Keywords:** chemistry lesson for citizenship; informed decision-making; using different perspectives; socio-scientific issues

## 1. Introduction

Currently, science education does not only aim to educate future scientists and technicians, but also the whole student population to become scientifically literate and responsible citizens. That means they can understand concepts, principles, and processes of science [1]. For the development of responsible citizenship, citizenship education and competencies are crucial for today's society [2,3]. Regarding this, to connect science and citizens, and to support communication between science and society, the European Commission (EC) launched several action plans such as Science and Society (2001), Science in Society (2007), and Responsible Research and Innovation (2010) [4].

In the local context, since 2006, Dutch schools are legally obliged to pay attention to 'active citizenship' in the lessons. Citizenship education is not a separate subject, but different school subjects are expected to contribute to this. School education should provide young people with the basic

knowledge, skills, and attitudes they need to be able to participate actively in today's multiform and democratic society [5]. Children should also learn to be active citizens based on their own ideas, values, and norms to develop the capacity to contribute to society [6].

In the Dutch education system, citizenship competencies are included in the objectives of the upper secondary education, and citizenship knowledge and skills can be assessed on the central exam. For example, in the final examination of the science subjects 'informed decision-making' is included as an important aspect of critical-democratic citizenship [7]. The common goal is to enable young people to critically deal with scientific questions when they face them now or later in their life, and to be able to make a decision, or at least be able to follow discussions about it [8–10].

Moreover, the national report of the International Civic and Citizenship Education Study addresses that citizenship competencies of Dutch pupils are lower on many components than in comparable European countries [11]. Dutch schools do not appear to have clear plans concerning citizenship education, and their efforts are only limited to achieving concrete goals [12]. In response to this, the Minister for Primary and Secondary Education endorses the urgency of strengthening citizenship education and further supports for schools and teachers [13]. Moreover, the Minister submitted a bill to clarify citizenship assignments in education [14].

Although teachers want to organize their lessons with citizenship education, they lack the tools, materials, and guidelines to achieve this aim within their limited available time [15]. Moreover, this is also related to the uncertainty about citizenship assignments. In such lessons, pupils can learn to give a reasoned opinion about current social issues, such as: 'genetically modified food: Is it a risk to your health?' However, with the high workload in education, teachers prefer to stay with the regular and familiar teaching program instead of investing their time in innovation in their lessons.

Particularly in the case of science subjects, the teaching materials for citizenship are limited. Nevertheless, there are numerous current social themes with a science component that pupils can ponder. The question is not only which theme you prefer as a teacher, but also which approach do you follow in the lesson? How many lessons do you spend on the theme? How do you assess students and how do you follow their development?

In order to promote citizenship competencies, incorporating socio-scientific issues (SSI) in science education is not a new idea [16–19]. Because of their controversial nature, while discussing SSI, students may encounter opposing opinions of different actors [3]. To deal with this, they need to develop the sub-competency of 'being able to recognize and consider different perspectives', which is the focus of the present study.

On the other hand, it is known that science teachers have a strong need for professional development and educational materials regarding teaching SSI. They particularly need support for teaching informed decision-making about SSI, and to develop effective lessons for this purpose. However, there are only few teaching materials for citizenship education in the Dutch language for science subjects. In addition, the societal subjects in these materials become out-of-date quickly, and they are not the focus of the current societal discussions any more. Given that science teachers need support to be able to design lessons for citizenship, this study aims to explore effective ways to support students and, through this, support teachers in teaching science for responsible citizenship.

The 'informed decision-making' competence can be divided into six sub-competencies: (1) The ability to correctly interpret scientific information; (2) dealing with conflicting information; (3) being able to recognize and consider different perspectives; (4) weighing of probability and risk; (5) (moral) argumentation; (6) dialogue skills and reflection on own values. These sub-competencies can each be transformed into various testable learning objectives [17,20].

Beyth-Marom and colleagues [21] (p. 19) argue, "Decision making is perceived as a higher-order, complex thinking skill which can be taught only after the more fundamental, lower-order skills have been acquired." Consistent with this, we believe that to develop the competency of 'informed decision-making', focus on the separate sub-competencies is first needed. Therefore, in this study, we aim to investigate the role of the sub-competency 'being able to recognize and consider different

perspectives'. By 'recognizing and using different perspectives in decision-making', we mean that students consider and understand the opinions of different actors in a given context about a given SSI. Ratcliffe [20] defines this as 'consideration of and respect for the viewpoints of others' (p. 180). She found that, when the students consider others' opinions and share theirs with them, they made a reasoned decision.

Although there are science education studies about informed decision-making [17,22,23], there is little known about the sub-competency of 'recognizing and using different perspectives'. Therefore, the present study aims to fill in this gap.

## 2. Theoretical Framework

As the theoretical base to promote citizenship competencies in science teaching, we benefited from the literature on 'science education for citizenship' [17] and 'teaching socio-scientific issues' [15,24]. Furthermore, as a main educational approach, we adopted the 5E learning cycle [25].

### 2.1. Science Education for Citizenship

No doubt there are interconnections between citizenship education for the responsible citizenry and scientific literacy; thus, science education. In this highly complex and rapidly changing society, scientific literacy is accepted as a basic skill that all citizens need to have [26]. There are several studies that discussed the role of science education in citizenship education. They mainly focused on educating scientifically literate students as responsible citizens [3,26]. Moreover, Ratcliffe and Grace [17] pointed out the common aim of citizenship education and science education as "... students will act as informed, responsible citizens when confronted with future scientific advancements." (p. 38).

Furthermore, Wellington [27,28] suggests that through science education for citizenship, it is possible to develop students' skills on (a) informed decision-making (based on evidence), (b) thinking (skills) including assessing risk and benefit, (c) searching and finding reliable data, (d) interrogating sources of information, (e) discussion, (f) communication, and (g) thinking about the consequences of their own behavior. It is argued that education should provide opportunities for students to practice these skills [29].

Responsible citizenship requires making informed decisions and having the necessary knowledge and skills to be active and responsible members of society. It is pointed out that in today's society, citizens need to deal with uncertain knowledge and complex issues. They often need to assess risk and probability to make informed decisions [28]. The 'Science Education for Responsible Citizenship' report by the European Commission [2] recommends that science education should be a part of all education levels (pre-school to adult education) to promote responsible and active citizenship. Particularly, the importance of science education in citizens' decision-making process regarding scientific reasoning is highlighted in the report.

To be responsible citizens, students need to be educated to gain scientific literacy and understanding of science so, while making decisions and forming their opinions, they can consider scientific evidence. Being scientifically literate, they can form opinions or make judgements for the benefit of society [30].

It is argued that SSI education contributes to the cognitive and moral development of students that are needed for 'functional scientific literacy' [24]. Moreover, teaching SSI is accepted as a useful approach in science education for citizenship to engage students in discussing the consequences of science on society and to be able to make informed decisions [31]. In addition, while discussing science education for citizenship, Kolsto [15] argues, "current controversial issues have to be taken into the science classroom." (p. 308). As a reason for that, he states that in today's society, we need to deal with science knowledge in a context, so we need to teach science in this way at schools to educate informed citizens.

## 2.2. Socio-Scientific Issues

Socio-scientific issues (SSI) are controversial and ill-defined problems based on science and have implications on society. Therefore, they have moral, economic, and political aspects. Moreover, usually, it is not expected that people reach a consensus or an agreement about them [32,33]. There is not necessarily one right answer for such complex issues. Genetically modified food, exterminating mosquitos, and human cloning are few examples of SSI.

According to Ratcliffe and Grace [17], SSI (a) have a basis in science; (b) require making decisions and forming opinions; (c) are reported by media; (d) deal with incomplete information; (e) address local, national, and global issues; (f) involve cost-benefit analysis and risk calculations; (g) may deal with sustainable development; and (h) involve moral and ethical reasoning.

There is a mechanism of mutual influence between scientific developments and the reaction of society to these developments. This means that on one side of the medallion, scientific developments influence society, and on the other side of the medallion, society influences scientific developments (i.e., future development of the scientific developments, their acceptance by society). It is known that to deal with these highly controversial issues, judgement and reasoning skills are needed [34]. It is proven that SSI is an effective context to develop students' reasoning skills. By evaluating and analyzing information from different perspectives and various sources, SSI education enables students to make informed decisions [35]. In SSI-based science lessons, students are engaged in discussion, debate, and argumentation activities where they need to base their opinions on evidence. Moreover, addressing SSI in science lessons fosters students' understanding of scientific knowledge by providing a meaningful context to them [36], through which they can link school knowledge with their daily life [37]. In this way, SSI lessons scaffold the development of students' informed decision making.

On the other hand, previous research states that students have difficulties in engaging societal discussions and making decisions. It has been claimed that one of the reasons for this is the students' "lack of personal experience in moral decision-making" [38] (p. 52). Regarding this, it is commonly agreed that SSI provides opportunities for students to gain personal experience in making informed decisions. In SSI lessons, they participate in activities that make them practice skills for responsible citizenship [39]. Informed decision-making, and connected to this, recognizing and considering different perspectives, are two important citizenship competencies that are in the focus of this study.

## 2.3. 5E Learning Cycle

One of the educational approaches to design a lesson is the 5E learning cycle. Bybee and colleagues [25] developed this constructivist instructional model for the biological science curriculum study (BSCS). According to constructivism, learner's prior knowledge is a crucial element of the learning process. The learner puts the new ideas against what she/he already knows, and in this way, constructs new knowledge. If there is an imbalance between the learner's prior knowledge and a new idea, the learner accommodates new ideas and constructs a new understanding of how the world works [38]. Therefore, in the learning process, the aim is to provide learners with opportunities to experience new ideas and allow them to reconsider their prior conceptions. In this way, learners "redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment" [25] (p. 176).

The 5E instructional model puts learners in the center of the learning process and provides them with an organized and structured way of learning. In this learning approach, students are engaged in the learning process from the beginning, they are the main actors of their learning process, and they are guided in the process of constructing new science knowledge and undergoing a conceptual change. The 5E learning cycle has often been used in science education for promoting conceptual change. There are several studies that proved the effectiveness of this model in various science subjects [40–44].

The cognitive stages of learning in the 5E learning cycle are:

*Engagement:* The main aim of this introductory step is to gather the attention of learners. At this stage, a teacher can discover students' prior knowledge, alternative ideas, or misconceptions.

The possible activities can be reading, demonstration, and brainstorming. The teacher poses problems or asks questions and students develop an interest, call up prior knowledge, experience disequilibrium, identify issues to be solved, decisions to be made, and conflicts to be solved.

*Exploration:* At this stage, students actively explore new objects and phenomena. Students are encouraged to start observing, questioning, collaborating, predicting, designing, planning, collecting data, building models, searching for possibilities, reflecting, and evaluating. Hands-on activities are used at this stage to promote students' exploration for conceptual understanding of the phenomena. A teacher provides resources and feedback and assesses students' understanding.

*Explanation:* This stage helps students to clarify their conceptual understanding, draw conclusions, and communicate their understanding in different forms. A teacher provides feedback, asks questions, enhances, and evaluates explanations. Students justify their understanding, share it with their peers, seek for new explanations, and employ different models for an explanation.

*Elaboration:* In this stage students apply science concepts in new contexts and expand their understanding. Teacher guides the process by providing resources and feedback. Students apply knowledge, make decisions, resolve conflicts, ask questions, and propose solutions.

*Evaluation:* At this stage, the teacher evaluates students' understanding of new concepts and their skills. In addition, students also evaluate their own understanding. Although this is the fifth stage of the learning cycle, evaluation takes place throughout the learning process, not only at the end. Teacher continuously observes and assesses to answer students' needs in time. Therefore, not only summative evaluation, but mostly formative evaluation is used in the 5E learning cycle.

The 5E's are used iteratively and cyclically (see Figure 1).

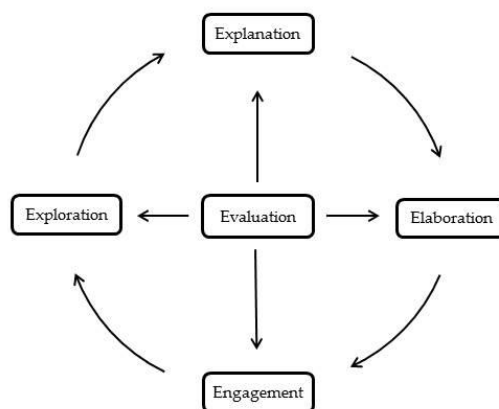


Figure 1. 5E Learning cycle.

Since it was designed by science educators to promote science learning and the effectiveness was tested and acknowledged by several researchers, the 5E learning cycle is an appropriate model that can be used in science education for citizenship.

### 3. Aim

The aim of this study was to investigate how certain pedagogical elements in the design of a chemistry lesson for citizenship contributed to the development of the sub-competency 'being able to recognize and consider different perspectives'. For this purpose, 'the use and sale of laughing gas' was chosen by the teacher as an SSI because of its popularity among young people as a party drug [45–47]. The lesson was designed according to the 5E learning cycle. We formulated the following research questions:

- (1) To what extent did the students recognize in the lesson the different perspectives about the use and sale of laughing gas among youths?
- (2) To what extent did the students use different perspectives in decision-making about the use and sale of laughing gas among youths?

- (3) Which pedagogical elements of the lesson design are more influential in using the different perspectives in decision-making about the use and sale of laughing gas among youths?

#### 4. Context of the Study

As mentioned before, in this chemistry lesson for citizenship, the 'use and sale of laughing gas among youth' was selected as an SSI. Known as laughing gas, nitrous oxide ( $N_2O$ ) is widely used in medicine for anesthesia, in the car and food industries [48], and recently for recreational purposes as a party drug. Nitrous oxide is defined as a colorless, non-irritating, sweet-smelling, and sweet-tasting gas. The Netherlands Institute for Mental Health and Addiction reported that the use of laughing gas has increased sharply in recent years. In addition, it is given in their report that the risks associated and the short-term and long-term consequences of inhaling laughing gas are not well studied. There are also many questions from municipalities regarding city ordinances about how to deal with nuisance [49].

In the present study, a lesson designed according to 5E instructional approach and activating pedagogical methods and tools were used. These can be regarded as scaffolds for providing the information as well as engaging the students in the desired learning activities (listening carefully, reading, taking notes, marking text, carrying out assignments, debating, informed decision-making). The following activating pedagogies were used in this lesson:

1. Videos: Three YouTube videos were selected to introduce the theme with four different perspectives:
  - (a). The user/victim, who approached laughing gas (nitrous oxide) from the risks encountered;
  - (b). The student, who experiences/sees laughing gas as fun;
  - (c). The scientist, who approached the use of laughing gas more scientifically. Multiple applications are considered. Risks are associated with the dose taken;
  - (d). The dentist, who highlights the useful medical applications of the laughing gas.

The links of the videos used are provided in Appendix A.

2. Expert method: The students were placed in the groups of three or four. Each student received and read one information card. There were three different information cards and each presented information from different resources. The information cards supported the different perspectives that were introduced in the videos. (The information cards are provided as supplementary material).
  - (a). Card 1: In this card, the scientist provided information about inhaling laughing gas from different aspects. This information concerns scientifically substantiated figures and information about user groups, short-term and long-term effects, and knowledge gaps. It contains information about recreational use, a maximum dose of 5–10 balloons of laughing gas at a time and at most once a month, and inhaling has no adverse health effects. More frequent use and a higher dose of more balloons at a time can lead to a lack of oxygen in the brain with associated effects. It also includes information about the short-term and long-term effects of inhaling  $N_2O$  [50];
  - (b). Card 2: In this card, the information about the sale and use of laughing gas was provided from the seller/vendor's point of view. This information card contains:
    - Relevant parts of a safety data sheet (SDS), which the seller must legally comply with;
    - Information from a conversation with three members of a well-known shop (a chain of shops in The Netherlands);
    - The decision of an online seller (a most commonly used online shop in The Netherlands) to remove laughing gas cartridges from the online shop [51].

- (c). Card 3: This card contains information from interviews and field research among young people. Useful tips are also included [52].

The activity of ‘expert method’ ends when each student within the group has informed the other group members about what has been read from the information cards.

3. Group discussion: Each group discussed the topic of ‘the use and sale of laughing gas among the youth’. The students shared their opinions and the corresponding reasoning with each other on this topic. It was also asked that the students eventually reach a group consensus together. A reasoned group opinion must emerge from the group consensus.
4. Group presentation: Each group presented the group decision with their reasoning about it. If no consensus was reached, this must also be made known and explained.

The learning methods used were examined for their usability in this research. Literature about pedagogical and activating methods was reviewed [52,53].

The chemistry teacher enacted the same lesson design about ‘the use and sale of laughing gas among youths’ in two different classes.

Within the 5E model, the above-mentioned pedagogical strategies were used for scaffolding the students’ learning. Table 1 presents how the 5E instructional model was implemented in this lesson.

**Table 1.** Implementation of the 5E learning cycle.

5E Stage	Work Form	Description	Worksheet
1. Engage	<ul style="list-style-type: none"> <li>■ YouTube videos</li> </ul>	<ul style="list-style-type: none"> <li>■ Introduction of the theme</li> <li>■ Checking the students’ prior knowledge (the students articulate their own opinion)</li> <li>■ Attracting attention (videos)</li> <li>■ Introducing various perspectives through the videos</li> </ul>	<ul style="list-style-type: none"> <li>■ Worksheet 0</li> <li>■ Worksheet 1</li> </ul>
2. Explore (Expert method)	<ul style="list-style-type: none"> <li>■ Information cards Card 1: Scientist Card 2: Seller/Vendor Card 3: Young people</li> </ul>	<ul style="list-style-type: none"> <li>■ Students read the information cards (deep learning phase)</li> </ul>	<ul style="list-style-type: none"> <li>■ Worksheet 2</li> </ul>
3. Explain (Expert method)	<ul style="list-style-type: none"> <li>■ Group interaction</li> </ul>	<ul style="list-style-type: none"> <li>■ Students exchange the information within the group</li> </ul>	
4. Elaborate	<ul style="list-style-type: none"> <li>■ Group discussion</li> </ul>	<ul style="list-style-type: none"> <li>■ Students discuss the problem/question in their group</li> </ul>	
5. Evaluate	<ul style="list-style-type: none"> <li>■ Group presentation</li> </ul>	<ul style="list-style-type: none"> <li>■ Students achieve a group consensus and present it</li> </ul>	<ul style="list-style-type: none"> <li>■ Worksheet 3</li> </ul>
After the lesson			
Reflect & Evaluate		<ul style="list-style-type: none"> <li>■ Students evaluate the lesson by responding to the questionnaire individually</li> </ul>	<ul style="list-style-type: none"> <li>■ Questionnaire</li> </ul>

In the *Engage* phase, the students’ prior knowledge was checked by worksheet 0. Then, the question for this lesson was introduced on the whiteboard: “Should there be regulations for the use and sale of laughing gas?” After this, as explained above, the students watched three videos. Each student must write down the different perspectives that were recognized on worksheet 1 individually, together with his/her reasoned opinion regarding the question posed in the lesson.

In the *Explore* phase, each student in all groups received an information card that included different types of information regarding laughing gas (as explained in the ‘expert method’ above). The information cards contained assignments to support the students in summarizing the provided information by asking questions, marking, circling, etc. This was useful to reason their opinion in decision-making. Each student individually wrote his/her opinion about the questions on worksheet 2.



In the *Explain* phase, each student shared the information she/he read from the information card, with the other group members.

In the *Elaborate* phase, the students discussed the question of the lesson in their group. During the discussion, they shared their opinion and arguments about what they read.

In the *Evaluate* phase, the students within each group tried to arrive at a group consensus. The group decision and the personal decision were written down by each student on worksheet 3. Each group then presented the group decision with the reasoning behind it.

After the lesson, the students received an online questionnaire where they were asked to evaluate and give their opinions about the lesson design and the different lesson components.

## 5. Research Method

### 5.1. Participants

The participants of this study are 23 students from 2 upper secondary schools (14–17 years old), in 2 classes.

The teacher who enacted this lesson was a pre-service teacher in chemistry (author 2). He designed and enacted the lesson as an assignment (to practice design skills and research skills) for the education research course in which he was enrolled. The course lasted one semester at the end of his teacher education program. The focus of his lesson and research was ‘teaching and learning SSI in chemistry’.

### 5.2. Data Collection

The data were collected through 5 tools (4 worksheets and a questionnaire). The students filled the first worksheet (worksheet 0) at the beginning of the lesson (pre-knowledge), the second one (worksheet 1) was filled after watching the videos (5E—engage), the third one (worksheet 2) was filled after the expert method (5E—explain), and the fourth one (worksheet 3) after group discussion (5E—elaboration). Additionally, at the end of the lesson, the students responded to the questionnaire (evaluation of the lesson) (see Figure 2).

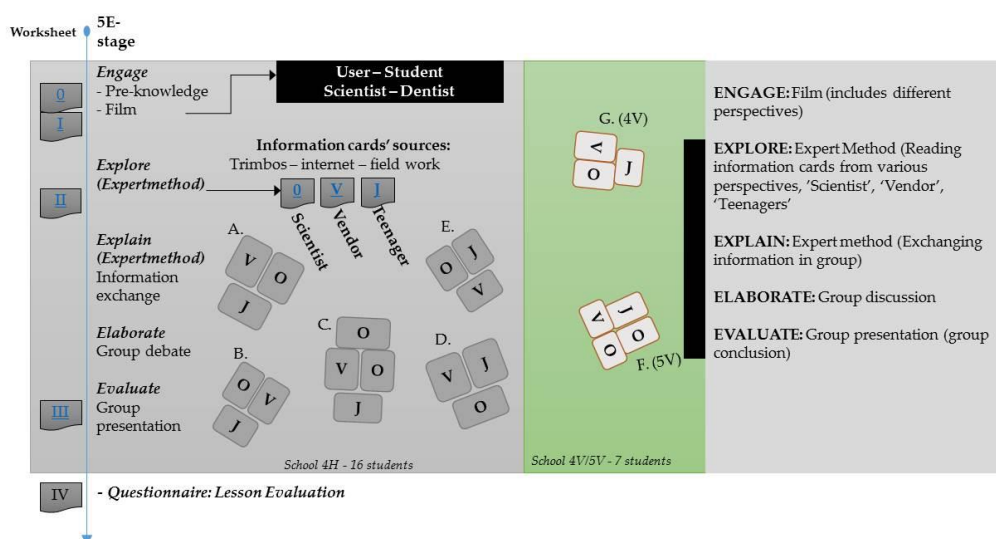


Figure 2. Lesson Design and classroom setup.

### 5.3. Data Analysis

A qualitative content analysis was performed using Atlas.ti software [54]. The data were coded in three cycles [55]. In the first cycle of coding, in-vivo and open coding were done. The statements about ‘recognizing’ and ‘using’ different perspectives, the ‘individual decision’ of a student about the sale and use of laughing gas, ‘group decision’ about the sale and use of laughing gas, and ‘the influential aspects

of the lesson' were the units of analysis. In the second cycle of coding, where necessary, the codes for identical concepts that differed only in students' wording were merged into one single code, and the codes were refined. Additionally, at this stage, the codes were grouped and categorized. Following this, in the third cycle, for each group of codes, the reasoning of the students in making decisions, both for individual and groups decisions, were studied.

## 6. Results

In this section, the results are presented per research question.

### 6.1. RQ1 (Recognizing the Different Perspectives)

After watching the videos, the students recognized the various perspectives. In total, 70% of the students could sufficiently distinguish different perspectives from the videos (at least three or more out of four perspectives) regarding the decision-making on the sale and use of laughing gas. For example, S7 mentioned four perspectives: "(a) Dentist: Calming, (b) Student: For the party, (c) Scientist: The excessive amount is dangerous, (d) User/victim: The physical consequences of the laughing gas".

We also examined the nature of the students' recognition of different perspectives. The most mentioned viewpoint was that a person should make his/her own opinion about using or not using the laughing gas. Most of the students stated that if you do not use it in excessive amounts, it is not dangerous, which shows that they mainly used the information provided in the information card 1. However, they suggested that the effects of using laughing gas should be known and considered by a potential user. For example, S1 stated, "They should know it [using laughing gas] themselves, but they have to think about the effects."

Moreover, while talking from this perspective, the students also considered the research results and they were aware of the limited evidence about the effects of using laughing gas. For example, S21 said, "There is too little information to say that laughing gas is not dangerous."

In addition, the students also referred to a need for an extensive research about the effects of laughing gas. Regarding this, S20 expressed his opinion "As far as I am concerned, young people may use it [laughing gas], but I think that government should really do an extensive research to find out if long-term use can cause problems." Therefore, the students did not just mention an opinion from a particular perspective, but they expressed their reasoning about it.

The other mentioned perspectives were 'dentist', 'person who did not try it', 'vendor', 'journalist', and 'young people who have used laughing gas'. One student (S6) also brought up the perspective of 'law and regulations' by stating, "According to the law it is [using laughing gas] allowed, so I think it is ok. [to use it]." Therefore, some students also spoke about perspectives other than the ones introduced in the lesson.

It is noteworthy to mention that only one student recognized just one single perspective among the four perspectives.

### 6.2. RQ2 (Considering and Using Different Perspectives)

#### 6.2.1. Using/Inhaling Laughing Gas

While making their individual decisions about *using* laughing gas (inhaling nitrous oxide), the students considered and used several perspectives (Table 2). They mainly used the 'scientist' perspective by focusing on what research says about the possible consequences of inhaling laughing gas. They also focused on 'health'; principally the relation between the amount used and the damage it may cause was referred.

The most commonly made decision about using laughing gas was "If you do not use it too much then it is not dangerous". Regarding this, many students mentioned, for example "It is not bad for you if you do not use too much" (i.e., S9); "I think it can be used, but it should not become a habit" (S1);

“Controlled amount of usage is acceptable, but principally it is not necessary [to use it].” (S18); and “Personally, I think it [using laughing gas] should be possible, but young people should think more about the consequences of extreme use.” (S23).

**Table 2.** The perspectives used in individual decision-making.

Perspectives Picked	Frequency (Number of Times Mentioned)
Scientist	33
User	7
Dentist	2
Student	2
Total	44

While using the ‘scientist’ perspective, they also notified the damage it inflicts in a young person’s brain, which is still developing. For example, S17 stated “I am against it [using laughing gas]. It can be very dangerous for your brain. Young people’s brains are still developing, so in the future, it can cause a bad effect”.

On the other hand, the students also mentioned that it is acceptable to inhale laughing gas for medical purposes. For example, “For calming [by dentist] I find it good that it [laughing gas] can be used. For parties, people can quickly take too much and complain about the effects.” (S7).

Moreover, regarding a *group decision*, most of the groups decided that it could be used but not an excessive amount. They allowed inhaling laughing gas, but for them, the amount and how often it is inhaled were important aspects to consider. For example, some students mentioned the following as a decision made in their group “It is your own responsibility, try to do it in the right way and make sure you do not take an overdose” S06; “You can use it in the right way to ensure that you do not use it too much.” S05.

In addition, ‘It is user’s own responsibility’, ‘There should be a minimum age to allow using laughing gas’, and ‘Users should think about the consequences’ were reported as other group decisions. For example, one student said, “Everyone should know by himself/herself, but be careful, and think about the consequences.” S02.

### 6.2.2. Sale of Laughing Gas

Regarding the individual decisions about the *sale* of laughing gas, many students suggested that there should be stronger regulations for selling laughing gas. The majority of them suggested putting an age limit (for example, 18+ or 16+) for buying and selling laughing gas. For example, “More attention should be paid to in-store sales, and online sales should be cancelled” S10; “There are risks involved and, it should not be bought so easily.” S16; “I think it should be more strict, for example, 16+ because now children of 10 can also buy it and they certainly do not know what may happen to them.” S02.

However, some other students accepted it as not dangerous. Therefore, they suggested free sale. For example, “Laughing gas is not a drug or alcohol; it is a person’s own risk.” S15.

They thought that it is dangerous only if it is inhaled in a big amount. As an example, student 5 stated: “It is not bad for you, only with too much use.”

As a group decision, the most commonly made decision was putting a minimum age for the sale of laughing gas. For example, “You should be minimum 16 to be able to buy it.” S14.

The other decisions were ‘stopping online sale’ and ‘it is people’s own responsibility’.

It is noteworthy to mention that while making group decision, the students also considered the potential results of the decision they are going to make. For example, because of this, one group made a decision “It should be on free sale. Otherwise, people will buy it illegally.” Student 13 mentioned, “Everyone should be able to buy it because otherwise there will be an illegal sale.”

### 6.3. RQ3 (Influential Pedagogical Elements of the Lesson)

As detailed in Figure 3, the students reported that in the worksheets and the questionnaire, they were mostly influenced by the ‘film [videos]’ (11 students). They mostly found the videos very informative. Student 8 said, “The film [videos] was the most informative”. They also stated that it was useful to receive information from different perspectives through the videos. For example, the student 2 quoted “The film [was influential] because it presented the different perspectives.”

Moreover, ‘group discussion’, in other words exchanging opinions, listening to the peers’ ideas, and having a discussion about them, was also found to be the influential activity of the lesson on making decisions about the use and sale of laughing gas. About this, student 9 expressed “Hearing about the opinions of the classmates. Then you find out what the others think about it.” Another student highlighted the importance of having a discussion on this subject by stating, “That the subject was discussed at all because almost nobody knows the risks of laughing gas.” S1.

Another influential element of the lesson was ‘sharing info in group’. In this activity, the students exchanged information about the use and sale of laughing gas that they had read from the information cards. Therefore, they read information from a particular perspective, and during this activity, they explained to the others what they read. Connected to this, some of the students also mentioned ‘reading and doing the corresponding assignments’ as an influential activity of the lesson. Moreover, ‘filling in the worksheets’ and ‘group presentation’, by a few students, were also mentioned as an influential pedagogical element of the lesson.

Furthermore, regarding the worksheets and the tools used during the activities, most of the students expressed their positive opinions like “Clearly formulated.” S7; and “It was well organized.” S10.

In addition, the students made some remarks about the teaching approach and the lesson design. They found the teaching approach straightforward. Regarding this, some quotations from the students are; “The way of teaching was very clear.” S6; “It was well explained what was going to happen.” S14. It is noteworthy to mention that in the questionnaire for the question “To what extent did this lesson help you to recognize different perspectives?”, the students expressed a ‘great extent’. At the end of the lesson, many of the students described the lesson as ‘informative’, ‘interesting’, and ‘enjoyable’.

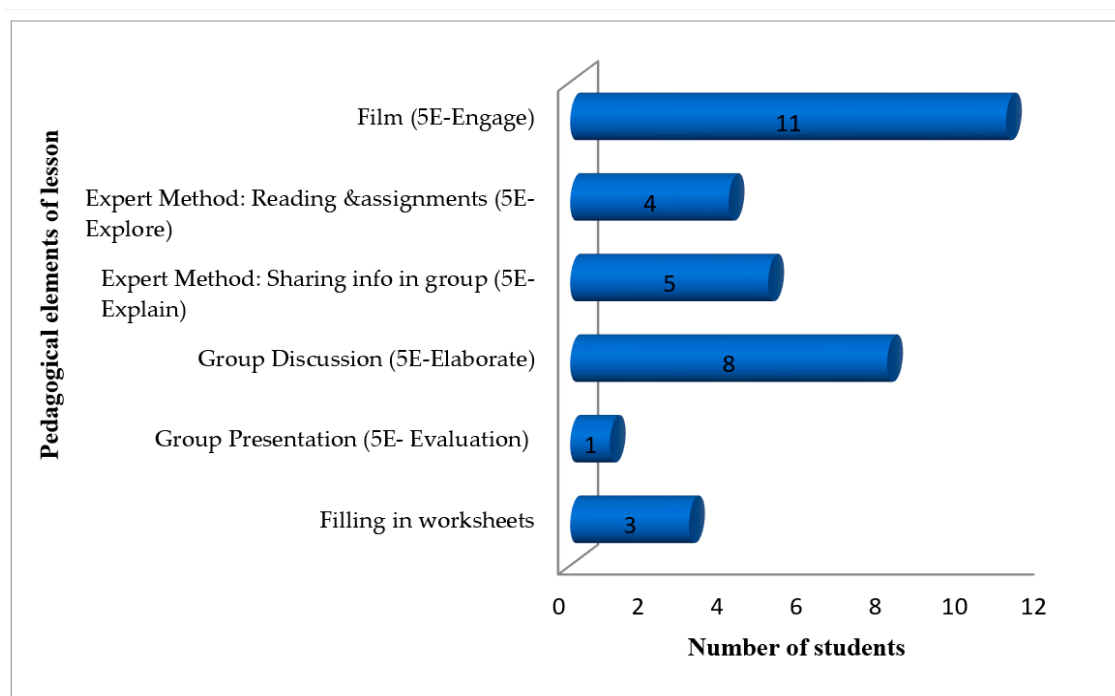


Figure 3. Influence of pedagogical elements of the lesson.

## 7. Discussion

It is known that teachers need support regarding teaching citizenship competencies in general and in informed decision-making in particular. It was pointed out that teachers need some guidelines for designing science lessons for citizenship [19]. However, on the one hand, the existing teaching materials are inadequate to support teachers, and on the other hand, the topics included in the materials become out-of-date quickly. Therefore, this study aims to contribute to finding out effective ways to support teachers in teaching science for responsible citizenship.

Following the prior studies in science education for citizenship [15,16,56], in this study, we also incorporated SSI in the chemistry lesson to promote citizenship competencies, specifically the sub-competency of 'being able to recognize and consider different perspectives' to make informed decisions. Because of its proved effectiveness, the 5E learning cycle instructional approach was followed in the chemistry lesson, which this study examines.

Our findings suggest that the lesson design supported the students to recognize and use different perspectives to make informed decisions about the sale and use of laughing gas. The students recognized the introduced perspectives and they could use some of these perspectives in their decision-making about the sale and use of laughing gas. The students not only stated their opinions about the issue, but they also explained their reasoning or their argument for their decisions. Therefore, we think that although some elements of the lesson design were more influential, on the whole, the complete lesson design could support students in learning about laughing gas, the potential consequences of using it, and consequently making an informed decision about the sale and use of laughing gas.

Since our results show that the students mainly considered the 'scientist' perspective in decision-making, we can conclude that this lesson guided them to make informed decisions based on scientific knowledge. The students considered what research says about the possible consequences of inhaling laughing gas. They were influenced by the research results that explain what may happen to a person's body after inhaling nitrous oxide. Moreover, the students also showed their attention to health issues and mentioned what may happen to a young person's brain by inhaling nitrous oxide.

While mentioning their opinions about inhaling laughing gas, many students pointed out that using or not using laughing gas should be a person's own responsibility. However, as presented in the results section, they emphasized that a potential user should know about the possible consequences of inhaling laughing gas, and what may happen to a person's body and brain. Therefore, the students indicated that a potential user should make an informed decision. We surmise that this also affirms that the students became aware of the importance of informed decision-making about these kinds of issues.

It appeared that the videos (5E—engage), and group discussion (5E—elaborate) are the most effective parts of the lesson according to the students. It is not surprising that videos engaged and influenced the students most. There are several studies that show the positive effect of videos on student learning, retention, and engagement [57–61]. In this regard, our study confirms the previous research about using videos as an effective pedagogical element of a lesson. It also should be mentioned that, nowadays, learning through watching videos (mostly informal learning) is a part of most young people's everyday life. In that sense, the students are familiar with learning in this way.

As to group discussion, the positive effect of it on fostering students' learning, and engagement has also been widely accepted [60–62]. In this chemistry lesson for citizenship, the small group discussion was chosen as an activity for the 'elaboration' phase of the 5E learning cycle, and our results confirm its effectiveness. Furthermore, we think that the context that was used in the lesson also has an influence on getting students to start a discussion. Since the SSI used in this lesson, the use and sale of laughing gas among the youth, is a current topic in society and also in students' everyday life, the students actively participated in the discussions and found the group discussion one of the most influential elements of the lesson. These findings support the study of Vesterinen and colleagues [3] where they claim that SSI can be used to foster students' interest in participating citizenship discussions. Moreover, Vesterinen and colleagues [3] also claim that lessons focusing on future scenarios could be useful in engaging students in science education. Our study extends their claim by proposing that not only

future scenarios but also discussing current topics such as current SSI (in this study the use and sale of laughing gas among the youth), are useful means to engage students in science education.

This study also has some limitations worth noting. The present study reports the results from analysis of data collected from Dutch students. Therefore, for the schools in other contexts, it would be useful to test the lesson and investigate the effectiveness of the pedagogical elements of the lesson. This could be suggested as a future study.

Another limitation is that this study focused only on one sub-competency of ‘informed decision-making’. Hence, the contribution of the present study for the research on informed decision-making is limited to one sub-competency. Therefore, future research could focus on other sub-competencies of ‘informed decision-making’ to advance our understanding of the development of this competency to better support science teachers and students.

## 8. Conclusions

Our results showed that the lesson design supported the students in ‘recognizing and considering different perspectives’ for making informed decisions. Regarding this, the present study pointed out the most influential pedagogical elements of the lesson. Thus, while designing science lessons for citizenship, the lesson design as a whole and the above-mentioned most effective elements can be considered. We conclude that science lessons that use the 5E instructional lesson design introduced in this study and the effective pedagogical elements of the lesson, could better support students in developing the sub-competency ‘to recognize and use different perspectives’ for informed decision-making.

Therefore, the lesson design and the pedagogical tools and strategies used in this study have the potential to support teachers for teaching science for citizenship. Moreover, our results suggest that designing a science lesson for citizenship can be included in pre-service teacher training programs.

**Supplementary Materials:** The following are available online at <http://www.mdpi.com/2227-7102/9/2/100/s1>, Information Card 1: The scientist, Information Card 2: The Seller, Information Card 3: The Young People, Worksheet 0: Entry, Worksheet 1: After videos, Worksheet 2: With expert method, Worksheet 3: After group consensus.

**Author Contributions:** D.B.-J. conceptualized the paper, collected resources, conceived and designed the analysis, contributed to the data collection and analysis tools, performed the analysis (2nd and 3rd cycles), and wrote the paper. G.W. conceived the presented idea, enacted the lessons, collected the data, performed the first cycle of data analysis, collected resources, contributed to the writing. I.H. contributed to the conceptualization, and writing of the paper, provided feedback and review. All authors discussed the results and contributes to the final manuscript.

**Funding:** This research received no external funding.

**Acknowledgments:** The authors wish to thank participated schools for their collaboration.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

Links video material laughing gas:

Video 1: Nieuwsuur Januari 6, 2018 (duration 1:12 min)

- [https://www.npostart.nl/nieuwsuur/06-01-2018/VPWON\\_1282888?utm\\_medium=refferal&utm\\_source=tvblik](https://www.npostart.nl/nieuwsuur/06-01-2018/VPWON_1282888?utm_medium=refferal&utm_source=tvblik) (minutes 13:43–14:55)

Video 2: DUB—Digitaal Universiteitsblad Utrecht (duration 2:29 min)

- <https://www.dub.uu.nl/nl/videos/2015/10/30/lachgas-ook-hype-onder-studenten.html> (minutes 00:10–02:39)

Video 3: Laughing gas dental sedation (duration 1:27 min)

- <https://www.youtube.com/watch?v=JQyb0FHTbXY> (minutes 00:00–01:27)

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