Epistemic knowledge considered by secondary school students involved in the examination of a real alimentary emergency

This study examines the epistemic disciplinary knowledge that students consider when addressing a real food emergency that requires their engagement in inquiry and argumentation practices. The study comprised two phases: 1) designing an experiment to study the emergency and 2) evaluating the real outcome of the emergency. The participants were 10th and 11th grade students (15-17 years old) working in small groups in the subject of Biology. Their conversations were examined through discourse analysis, for which two rubrics were developed, one for each phase of the task. The design phase related to the scientific practice of inquiry while the evaluation phase related to the scientific practices of inquiry and argumentation. The results suggest that not all the epistemic disciplinary knowledge promoted by the task was taken into consideration by students, especially in relation to the reproducibility of experiments and its feasibility to solve socio-scientific issues. This implies that epistemic disciplinary knowledge must be addressed in the classroom through an explicit-reflexive approach. Further directions and implications for biology teaching are provided.

Keywords: food safety; epistemic knowledge; inquiry; argumentation; secondary school

Introduction

This study aims to examine how do secondary school students take into account the epistemic knowledge of science when examining a real alimentary emergency that requires their engagement in inquiry and argumentation practices.

The study is framed in the approach of learning science through students' engagement in scientific practices, understood as the practices used to establish, extend and refine scientific knowledge (NRC, 2012). These practices are grouped under three interconnected spheres of activity involving different operations: investigation (inquiry), evaluation (argumentation) and developing explanations (modelling) (Osborne, 2014; NRC, 2012). In this study we focus on inquiry that involves planning, designing and

conducting investigations (NRC, 2013) and on argumentation that involves connecting evidence to claims through justifications (Jiménez-Aleixandre and Erduran, 2007).

The context of the study is food safety, considered a relevant concern for society since it is related to controlling microbiological contamination and reducing the risk of contracting a foodborne illness. In educational settings, food safety can be addressed as a socioscientific issue to be promoted in Biology lessons since it involves knowledges such as the foodborne diseases caused by microbial pathogens, considered as a public health problem. The choice of the context of the study is motivated by the scarcity of educational interventions related to the area of food safety in the secondary school classroom, as most studies conducted seem to be reporting on the attitudes and awareness of young adults. There are studies that relate an improvement in food safety skills with a better response to food emergencies (FAO/WHO, 2011), an indication of the importance of transferring these issues to the science classroom, since it is the mass media that play the most important role in educating citizens in this area (Ergönül, 2013). Additionally, the study conducted by Ellis, Sebranek and Sneed (2004) on the attitudes of secondary school students towards food-borne diseases exposes the need to consider knowledges related to the risks associated with food-borne diseases or inappropriate food handling in educational programmes. Barrett, Feng and Wang (2020) address the same issue, adding the difficulties that teachers experience in dealing with subjects that are less related to the school curriculum. It has been described that food contamination generates both social and economic burden on communities and their health systems (Korel, Ergönül, and Gökgöz, 2003) which shows the need to address these issues from an early age to try to influence as soon as possible in better hygiene and food handling practices, which absence results in the appearance of foodborne diseases. The biology course provides the ideal opportunity to deal with these topics,

due to its close relationship with the area of microorganisms, the transmission of diseases or the management of problems in public health and preventive medicine.

The focus is on the epistemic knowledge that secondary school students apply when they engage in the scientific practices of inquiry and argumentation for examining a real alimentary emergency. To do so, they have to apply theoretical knowledge from Biology, epistemic and procedural knowledge.

Epistemic knowledge is relevant in science education due to its relation to students' approaches to learning Science, as well as to their performances of scientific reasoning (Yang et al., 2018). By epistemic knowledge we refer to the understanding of the role of the specific constructs that are involved in the production of knowledge and of the essential features of the knowledge-building processes (Duschl, 2008). In Science Education, epistemic knowledge can be characterized in three different ways: disciplinary, personal, and social (Kelly, McDonald and Wickman, 2012). This article is framed in the disciplinary perspective, which focuses on knowledge within practicing scientific communities (such as the nature of evidence, the criteria for theory choice in science or the role of theory-dependence in scientific research methodology). This knowledge is a key aspect in the approach of learning through the engagement in scientific practices because it is required for understanding, how scientific claims are supported by data and reasoning in science, how measurement error affects the degree of confidence in scientific knowledge or the use and role of physical, system and abstract models and their limits (OECD, 2016). Moreover, considering the epistemic disciplinary knowledge involved in the scientific practices enables a meaningful engagement of students in these practices (Berland et al., 2016). Some specific examples of the epistemic disciplinary knowledge that would provide a meaningful engagement in inquiry would be considering systematicity as a feature of the scientific

methodology that leads to valued forms of knowledge (Sandoval and Reiser, 2004) acknowledging that the outcome of a single experiment is rarely sufficient to establish a knowledge claim (Osborne et al., 2003) or that it is important to conduct a clear, honest and accurate data collection (Georgia Department of Education, 2016). Regarding the argumentation practice, students should consider that a claim must answer the question and be supported by the evidence (Chenn, Brand and Park, 2016), that the quality of claim and evidence is important for establishing a convincing argument (McNeill et al., 2006; Sampson, Grooms and Walker, 2011) or that authority is less persuasive than evidence (Kittleson, 2011; Sandoval and Çam, 2011).

In our study, the specific disciplinary epistemic knowledge addressed is related to the design of an experiment and to the evaluation of a set of measures taken to examine the alimentary emergency. More specifically, the research questions that guide this investigation are:

1) Which epistemic disciplinary knowledge do secondary students use for designing an experiment to identify the cause of an alimentary emergency?

2) Which epistemic disciplinary knowledge do secondary students consider for evaluating the measures taken during the alimentary emergency?

Methods

This study is framed in qualitative research, which focuses on processes and meanings that are not experimentally examined or measured in terms of quantity, intensity, or frequency (Denzin and Lincoln, 2000). According to Yin (2011), qualitative research needs to consider contextual conditions and aim to provide an insight on existing or emerging concepts that explain social behaviour. The educational processes that constitute this study, namely the creation of an experimental design based on concrete

data and its subsequent evaluation, occur through the social interaction of the participants. This implies that these processes must be studied in depth to make sense of them. Assuming that knowledge is established through subjective experiences, consideration of the context in which they occur is essential to understand the participants' meanings (Merriam and Tisdell, 2016). For all these reasons, this piece of research is situated within the qualitative approach.

Our research focuses specifically on discourse analysis, an approach that considers language not only to represent what a person is thinking, but also the construction of social reality, especially within the social context of what is said (Yin, 2011). The basis of this approach are the specific details of speech considered relevant for that context and for the analysis (Gee, 2011).

Participants and context

The task analysed in this paper was part of a larger study about the epistemic knowledge necessary for an adequate students' performance in inquiry and argumentation practices, in the context of food safety (Authors, 2020).

In this task, the participants were 13 10th grade students (15-16 years old) and 10 11th grade students (16-17 years old) attending Biology and Geology lessons. The participants worked in six small groups consisting of 3-5 students for one 50-minute session. Groups A, B and C belonged to 11th grade and groups D, E and F belonged to 10th grade. The participants had biology instruction in their previous years of secondary school but were not familiar with inquiry or argumentative-based tasks.

The school was located in an urban environment but received students from urban and rural environments and of diverse socio-economic status.

Ethical issues

Both the students and their parents were previously informed of the goals of the study and how we intended to use the collected data. All the students agreed to participate, and their parents signed an informed consent form. In order to protect their anonymity, all of the students were identified by pseudonyms.

Description of the intervention

The task analysed in this paper is framed in the field of food-borne diseases and consisted of two distinct parts. First, in the design phase, students needed to design an experiment in order to find the cause of a real food emergency presented through a chronology of the events following the outbreak of the disease. This design included the selection of the samples for the experiment (food-related), the selection of an adequate human sample among six available options (blood, saliva, stool, sweat, urine, and others) and the prediction of which strain of E. coli bacteria was causing the emergency. Students were indicated to provide a justification for each choice and to do so, besides the chronology, they were provided with a complete medical report on a patient experiencing the symptoms of the disease and information on the pathogenic strains of E. coli bacteria, specifically the cells they can affect, the symptoms they can cause, the most common areas where the associated diseases are detected and the specific population profile most affected by the disease, if it exists at all. Students were also asked to indicate whether it is necessary to design an experiment before carrying it out and why. Second, in the evaluation phase, students received a second part of the chronology, that collected the actual events after the discovery of the cause of the outbreak as well as the WHO protocol for alimentary emergencies. They had to assess if the government' measures and course of action were correct and why, and whether

there were differences with the WHO protocol steps. Figure 1 summarises the course of the task, focusing on the information provided for each stage.

[Figure 1 near here]

Figure 1 shows the different materials that were provided to the students for the completion of the activity. The chronology (part 1) presents in an orderly fashion the different events that occurred right after the outbreak. It specifies exactly the timeline in which decisions were made and in which concrete information about the outbreak was obtained (e.g., that the Hamburg hygiene institute reported that E. coli was found in two cucumbers of Spanish origin and one Dutch). The medical report is based on real information about the disease, more specifically the symptomatology of the uremic-hemolytic syndrome. The data on the patient and the hospital are fictitious but are presented as a model medical report with data on admission, medication, and insights on the patient's condition. The information on the different strains of pathogenic E. coli indicated above makes it possible to relate this data to the information provided in the medical report. In the design phase, the chronology contributes mainly to the selection of the experimental samples (the different foods suspected to have caused the outbreak) while the medical report and the data on the pathogenic strains of E. coli contribute to the selection of the human sample where the bacteria could be found and to the prediction of the specific strain that caused the outbreak.

The chronology (part 2) focuses more specifically on the resolution of the outbreak, with the discovery of the true cause (soybean crops of German origin) and provides data on the total number of deaths and those affected by the disease. The WHO protocol provides information on the steps to be taken in the event of an outbreak of a public health emergency, including expert reports, necessary to take action on the outbreak or to disseminate public information. In the evaluation phase, the comparison

between the real events and the steps of the protocol allows students to make assessments as to whether there were any steps that could have been taken earlier or later, in relation to the actual evolution and consequences of the outbreak.

Tools for data collection and analysis

Data collection includes audio and video taping of the lessons, as well as the researcher field notes. For the data analysis, the audio recording of the session was later transcribed and coded in terms of the epistemic knowledge that students considered during their conversations while solving the task. Several iterative cycles of analysis were carried out by the two authors and two rubrics (one for each research question) were developed in interaction between data and literature. First, a review of the existing literature was conducted, followed by an exploration of the epistemic disciplinary knowledge promoted by the task. Subsequently, the data analysis was performed separately by both authors until reaching total coincidence in the categories presented in the rubrics. Students' interventions labelled as epistemic contributed to the identification of specific epistemic knowledge over several speaking turns.

The first rubric examines the epistemic disciplinary knowledge involved in the design phase, which are related to the inquiry practice. The rubric is reproduced in table 1, along with an explanation on how to identify the epistemic knowledge in the students' discourse.

[Table 1 near here]

The second rubric examines the epistemic disciplinary knowledge involved in the evaluation phase, which is related to inquiry and argumentation practices. The rubric is reproduced in table 2, along with an explanation on how to identify the epistemic knowledge in the students' discourse.

[Table 2 near here]

Results

Epistemic disciplinary knowledge used for designing an experiment to identify the cause of an alimentary emergency

The results, in terms of the frequency that a given epistemic knowledge is identified in this phase of the task, are summarised in table 3.

[Table 3 near here]

In general, there is not a pattern in students' use of epistemic disciplinary knowledge, since it is used differently in the groups.

In relation to frequency of the epistemic knowledge, “Considering the need of ensuring representativity of the samples selected in an investigation” was the most frequently used with 10 out of 36 instances, followed by “Identifying the need of conducting an experiment to answer the question being investigated” and “Referring to the relevance of the evidence in drawing conclusions”, with 7 out of 36 instances, each. In contrast, the epistemic knowledge “Considering the need of conducting a reproducible investigation” was not identified in any instance of the students’ discourse. Two of the questions in the design phase of the task focused on sample selection, so this may explain that the epistemic knowledge related to the representativity of the samples was the one identified a higher amount of times. In contrast, there was not a specific question alluding to reproductibility, so this could contribute to corroborate why this epistemic knowledge was not identified in the students’ conversations. In addition, students were not asked to make an explicit comparison of their experimental designs, but rather a joint sharing and comparison with a reference experimental design presented by the researcher. This may also have influenced the fact that the experiment was not perceived as something to be repeated in order to verify its results.

Furthermore, a very initial design was requested, in which the entirety of an experiment was not addressed.

Regarding the specific epistemic knowledges identified in the groups, three of them are identified in five different groups, one epistemic knowledge in four groups, another one in three groups and one in none of them, as stated earlier.

If we focus on specific groups, group C was the one with a higher number of instances that can be labelled as epistemic, with 10, followed by groups A, D and E, with 6 each. Group C was also the one where the more diverse epistemic knowledges were identified, with five different ones. The rest of the groups identified three and four. This indicates that students recognised several of the purposes that the design of experiments aims to fulfill instead of focusing on a specific feature of the experimental design during their conversations in this phase of the task.

This paper aims to provide an insight on discourse analysis so that an extract from the students' discourse is presented to depict epistemic knowledge belonging to this phase of the task. Specific contributions to the identification of particular epistemic disciplinary knowledge in the discourse are marked in bold.

Design Phase. Extract 1: epistemic knowledge "Recognising the need of conducting a reliable investigation", identified in group E

Turn	**Transcription**
277	*Elena*: **Why do you think an experiment has to be designed before it is carried out?**
278	*Eva*: In order to not waste time.
279	*Emma*: **Don't waste time doing things that don't make sense**.
280	*Eva*: Yes, because if the really…
281	*Emma*: **A protocol**!
282	*Eva*: **Because if they really do an investigation and it goes wrong, they are wasting time and there are people who are affected. This could go further, it could increase.**
296	[…] *Elena*: **To carry out specific and necessary steps for the verification of an event**
297	*Eva*: **And waste no time because the lives of these people are in our hands**.

In extract 1, Elena rephrased one of the questions of the task in turn 277, generating a series of answers to the question of why it is important to design an experiment before carrying it out. These answers were related to making the investigation reliable in several ways, for example, making it more efficient by not spending time that could be crucial (turn 279), establishing a protocol (turn 281), reflecting on the consequences of what could happen if the investigation goes wrong (turns 282 and 297), and establishing the need to verify what has happened through concrete steps (turn 296).

Design Phase. Extract 2: epistemic knowledge "Identifying the need of conducting an experiment to answer the question being investigated", identified in group C

Turn	Transcription
337	*Carmen:* **How can we be sure which food is causing the outbreak? By analysing it.**
338	*Carlos*: But, why?
339	*Carmen*: **And testing for the bacteria.**
340	*Carlos*: Why?
341	*Carmen*: What do you mean, why? **Because it [the bacteria] causes these symptoms, I think.**
342	*Carlos:* **Because it causes haemorrhagic diarrhoea and...**
343	*Carmen*: **And failure, kidney failure.**

In extract 2, in order to establish which food is causing the outbreak, Carmen suggested analysing the food (turn 337) and testing for the bacteria (turn 339), referring later to the symptoms that can be caused by it and thus expressing the need to conduct the experiment to clarify which specific food generated the emergency being examined.

Design Phase. Extract 3: epistemic knowledge "Acknowledging the role that evidence plays in an investigation", identified in group F

Turn	Transcription
546	*Fermín*: **Because the necessary information appears in the analyses.**
547	*Fernando*: Necessary.
548	*Fidel*: **Necessary for testing and figuring out the possible causes of... [the outbreak]**
549	*Fermín*: Shut up, shut up. Because the analysis reveals...
550	*Fidel*: Nothing, they don't reveal anything.
551	*Fernando*: **They reveal information that can't be seen with the naked eye.**
552	*Flora*: **Specific information.**

555	[…] *Fidel*: **No, generic information on the patient's health status.**

In extract 3, Fermín stated that the analyses contain important information (turn 546), referring to the medical report that is given to students in the design phase of the task. Fidel supported this by saying that this information could be used to discover the cause of the outbreak (turn 548). Subsequent interventions discussed the type of information the medical report provided. Overall, an appreciation of the role of the medical report in the investigation was made, which helped to move forward to reach the resolution of the emergency.

Design Phase. Extract 4: epistemic knowledge "Referring to the relevance of the evidence in drawing conclusions", identified in group B

Turn	Transcription
217	*Berta*: **How can be we sure what food is causing the outbreak?**
219	[…] *Brais*: **Analysing the stool will tell us which kind of food you ate.**
220	*Berta*: Of course, yes.
221	*Branca*: For sure!
222	*Brais*: **And then by looking around the house, comparing the food you have around the house, in the fridge, we can see which one is infected.**
223	*Berta*: What if she ate everything?
224	*Branca*: Well, **analysing what the patient consumed, let her tell you.**
225	*Brais*: Well, **with the packaging, which tells you where it [the food] comes from.**
226	*Branca*: I ate this, I ate that…
227	*Berta*: **Analysing what the patient consumed.**

In extract 4, specific actions were mentioned aiming to distinguish which specific food was causing the outbreak. Brais mentioned that the analysis of the stool of the patient would indicate the food consumed (turn 219) subsequently adding an analysis on the food around the house to confirm the origin of the infection (turn 222) and an exploration on the packaging of the food infected to determine where it came from and avoid further damage (turn 225). These ideas were well received by the rest of the group, which agreed that these were appropriate steps to draw conclusions on the origin of the outbreak.

Design Phase. Extract 5: epistemic knowledge "Considering the need of ensuring representativity of the samples selected in an investigation", identified in group A	
Turn	**Transcription**
156	*Alberto*: **But of course, you would have to take cucumbers from every country that exports them**.
157	*Ana*: **Of course, Spanish cucumber, Dutch cucumber.**
158	*Alberto*: **And German** because they say that they put...
159	*Ana*: **German too?**
160	*Alberto*: **It says nationally distributed products there**, in the end. Read the last one.

In extract 5, Alberto and Ana alternate in consecutive turns to choose the samples that would be representative for the experiment, mentioning quite rightly that cucumbers should be selected from all countries exporting this product to Germany (turns 156 and 157), as well as from nationally distributed products in Germany (turn 160), which ended up being singled out following further analysis after the outbreak.

Epistemic disciplinary knowledge used for evaluating the measures taken during the alimentary emergency

The results, in terms of the frequency that a given epistemic disciplinary knowledge is identified in this phase of the task, are summarised in table 4.

[Table 4 near here]

In relation to the frequency, the epistemic knowledge, "Recognising the role of investigation in decision-making to solve a scientific or socio-scientific issue" was the most frequent with 6 out of 11 instances, followed by "Considering the role of authority in justifying conclusions", with 3 out of 11 instances and "Referring to the relevance of the evidence in drawing conclusions", with 2. In contrast, the epistemic knowledge "Alluding to the feasibility of the design for solving a scientific or socio-scientific issue" was not identified in any instance of the students' discourse.

In this phase, the question posed to students about whether the German government acted in a scientifically appropriate manner is more open-ended than the questions in the previous section, as students were able to make assessments based on the German government's lack of evidence to draw conclusions about the nature of the outbreak, that established protocols with concrete steps were overlooked, or that the investigation was poorly designed in relation to, for example, the samples selected. In that sense it was somewhat unexpected that epistemic knowledge "Alluding to the feasibility of the design for solving a scientific or socio-scientific issue" did not appear, which was attributed to the fact that the specific experiment of the German health authorities was not broken down, making it difficult to make comparisons with the experimental design of the previous phase.

Regarding the epistemic knowledges identified in the groups, one epistemic knowledge was identified in four different groups, one epistemic knowledge in three groups, one in two groups and one in none of them, as stated earlier.

If we focus on specific groups, group C was the one with a higher number of instances that can be labelled as epistemic, with 5, followed by groups A and B, with 2 each. Group C was also the one where the more diverse epistemic knowledges are identified, with three different ones. In the rest of the groups two, one and even none were identified. This indicates that students mostly focused on specific knowledge when assessing the outcome of an emergency of this kind.

This paper aims to provide an insight on discourse analysis so that an extract from the students' discourse is presented to depict epistemic knowledge belonging to this phase of the task. Specific contributions to the identification of particular epistemic knowledge in the discourse are marked in bold.

Evaluation Phase. Extract 6: epistemic knowledge "Referring to the relevance of the evidence in drawing conclusions", identified in group D

Turn	Transcription
450	*Denís*: **Do you think the German government acted in a scientifically correct way?**
452	[…] *Denís*: **[The government] rectifies by saying that the E. coli bacteria found on cucumbers is not the same strain** (reading chronology).
453	*Darío*: Come on, Denís.
454	*Denís*: **From a scientific point of view, it is wrong because they do not have full reports.**
455	*Darío:* I was thinking the same.

In extract 6, Denís stated clearly that the German government's actions were incorrect since they did not have enough information for taking action that consisted of prohibiting the commercialization of certain products (turn 454), something that was done without proper analysis, and whose consequences, apart from the economic side, delayed the detection of the true origin of the outbreak. This implied that the government made a hasty conclusion about the outbreak that had insufficient evidence to support it.

Evaluation Phase. Extract 7: epistemic knowledge "Considering the role of authority in justifying conclusions", identified in group B

Turn	Transcription
337	*Berta*: And **there is a difference with the WHO protocol because the WHO protocol goes through many phases.**
338	*Bruno*: **The experts.**
339	*Berta*: So that... I don't know, to give an acceptable prediction.
340	*Branca*: So that's like…
341	*Berta*: Hmm… **[the government] failed to act in appropriately.**
344	[…] *Branca*: It didn't act appropriately…
345	*Berta*: **Because they did not make 100% sure before making the prediction**.

In extract 7, in contrast to the previous extract, the emphasis was on the WHO protocol for health emergencies (turn 337), and more specifically on the role of experts in drawing conclusions (turn 338), making a clear difference to what happened in this emergency, with the consequent rush of the German government in dealing with the outbreak (turn 345). The expert input mentioned in the WHO protocol for determining

the primary cause of the outbreak was perceived as the necessary authority to make such conclusions.

Evaluation Phase. Extract 8: epistemic knowledge "Recognising the role of investigation in decision-making to solve a scientific or socio-scientific issue", identified in group C

Turn	Transcription
426	*Carmen*: **By the time they [German authorities] found out it was too late.** It was. That's the first thing, that's in the chronology. **First, they thought it was cucumbers and then they saw it was soybeans.**
427	*Carlos*: Write there, bad intervention.
428	*Carmen*: No, I think it's fine.
429	*Carlos*: I disagree, and that's that.
430	*Carmen*: So, let's see.
431	*Carlos*: **I believe that before that [government's decision to retire products] you have to be very sure** in order to...
432	*Carmen*: Let's see, I think that if something is contaminated, well, we don't know.
433	*César*: On the one hand, good for health care, but on the other hand…
434	*Carmen*: They weren't going to let you eat it, otherwise…
436	[…] *Carlos*: **E. coli could be harmless or not. They didn´t know.**
437	*Carmen*: **As you don't know it, you put yourself in a bad situation.**
439	[…] *Carlos*: **They did not know it was bad.**
440	*Carmen*: **Or good.**
441	*Carlos*: **Why not? They should analyse.**

In extract 8, a review was made of the events narrated in the chronology, explaining the initial suspicion of cucumbers and the subsequent confirmation that the outbreak was caused by bacteria found in soybean sprouts (turn 426). The government actions were perceived once again as inadequate (turn 431) and the final conclusion expressed in the subsequent turns was that an analysis should had been carried out to establish the dangerousness of the E. coli bacteria initially found before any action was taken. This indicates recognition of the role that a well-planned investigation would have played in resolving the socio-scientific question posed by the task.

Conclusions and further implications

There are several studies addressing students' attitudes and knowledge on food safety

(Sanlier and Konaklioglu, 2012; Booth et al., 2013). However, most of these studies focus on establishing what these specific attitudes and knowledge are through tools such as the interview and specially the survey. In addition, most of these studies are conducted with university students, that is, young adults, although some interventions have been found targeting secondary school students, notably in relation to their attitudes towards food safety. In contrast, our study aims to provide a more comprehensive analysis of food safety issues through a concrete intervention in which students' conversations are examined through discourse analysis to determine what epistemic disciplinary knowledge they consider while examining and emergency in the area of food safety and what knowledge needs to be emphasised because of its scarce occurrence in students' discourse.

Given that food safety issues affect all citizens, we consider it more appropriate to address these issues at compulsory education stages, with secondary education providing the ideal opportunity to do so. However, it is recommended that this be addressed in upper secondary education, as the issue of food safety is complex and requires some knowledge of disease transmission, food-related pathogens and food-borne diseases.

Research suggest that many consumers believe that food-borne illness primarily arises from the practices of food manufacturers, whilst remaining oblivious to the fact that the home is a more likely place for potential food safety problems. In the European Union, 2019 data on the occurrence of strong-evidence foodborne diseases in a particular setting show that most cases are originated in a domestic setting (41.3%) followed by restaurants, pubs, street vendors, take-away, etc. (28.6%) and canteens or catering at workplace, school, hospital, etc. (13.0%) (EFSA and ECDC, 2021). Although our task would fall into the second category, since the outbreak occurred in a

restaurant and the soybean variety that caused the disease was grown on a farm, it is worth considering interventions in the home environment in the area of food safety. In relation to Biology, topics as diverse as the proliferation of pathogenic organisms in food, good hygiene and food handling practices and the differentiation between pathogenic and non-pathogenic organisms, with the consequent importance of the latter in the area of food and health, can be addressed.

The proposed task does not provide a very extensive scaffolding on its own, so some prior training in the area of food safety was required, as was tackled in our study through the analysis of population profiles and food safety terminology prior to this task. This is due to the fact that food safety is not a particularly well-known domain for students. Some experience is also recommended when approaching the scientific practices of inquiry and argumentation, although in this sense, the questions do provide some scaffolding, especially in the first phase of the task, the design of the experiment.

In relation with the scientific practice of inquiry, the epistemic disciplinary knowledge relates to the various ways in which an experiment becomes more reliable and adequate to investigate a certain situation, such as the emergency presented in this task through the chronology. Our research points out that the reproducibility of the experiment is not something that students initially choose to focus on when designing an experiment, so this needs to be addressed through questions aiming at state clear that all experiments should be repeatable to avoid any misinterpretations and to study the appropriateness of the experimental design in a particular case, thus bringing transparency to the process. This is especially relevant, as the scientific irreproducibility, also known as the inability, to repeat others' experiments and reach the same conclusion is a growing concern (Baker, 2016b) and the shortcomings in the experimental design are cited as the main cause of such irreproducibility (Baker,

2016a). Additionally, in the evaluation phase, the feasibility of the design was again not considered when assessing the outcome of the emergency generated by the German authorities' response. In this case, it is possible that this was done in an implicit way by judging the German government's performance as inadequate without drawing a concrete parallel to a good experimental design but taking this into account in order to reach the above-mentioned conclusion.

It is important to mention that the task does not address all the aspects that could be considered in an experimental design, such as the control of variables or instrumentation, but rather focuses on the proper selection of samples for comparison in order to provide the necessary information to solve a food emergency. This could be the reason why some of the epistemic knowledge relating to the scientific practice of inquiry considered in the rubrics is not identified in the students' discourse. Addressing a complete and more exhaustive experimental design would require an increase in the time dedicated to the task, and even without making a major modification, it would be advisable to dedicate additional time for the discussion between groups in relation to each of their experimental designs and possible modifications.

In relation to the scientific practice of argumentation, the epistemic knowledge relates to the consideration that evidence has to support a claim, and that the quality of those two generates a convincing argument. Epistemic knowledge is also related to argumentation in the sense that evidence must outweigh authority. The latter is of great importance in our task, which presents a situation in which the German authorities took a hasty decision, ignoring available evidence to make a decision on banning the consumption of certain foods that were believed to be linked to an outbreak, even though this was ultimately proven not to be the case. This shows the need to evaluate the role of the authority in matters that affect the citizens, especially with public health

issues, which can serve to introduce topics such as the importance of rigor in investigations or the seriousness of the consequences when this is not fulfilled.

Despite the fact that in this study epistemic disciplinary knowledge is fundamentally approached implicitly in order to detect particular knowledge that needs to be insisted on to a greater extent, it becomes evident that not all epistemic knowledge is considered in the same way by the students, which implies a greater effort to address knowledge related to the systematicity and reproducibility of investigations. Scaffolding through questions works to address aspects such as representativeness of samples, one of the most mentioned knowledge throughout the task.

However, an explicit-reflective approach is recommended, which implies that at the end of the tasks in question, it is necessary to dedicate some time to analyse the epistemic knowledge involved in the activity and the implications that these have in the construction of scientific knowledge or in addressing socio-scientific issues.

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