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Argumentation about Antibiotic Resistance in Secondary School Biology: The Role of Skills, Knowledge and Learning Environments

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Abstract

Science education aims at preparing students to participate in the social discourse and make informed decisions. Austrian science teachers shall encourage students to justify their positions and argue professionally and consistently. This work deals with secondary school students' (n=24; 16-17 years old) argumentation about antibiotic resistance. Qualitative data were collected by audio taping eight 20-minute small group discussions in a standard biology lesson. The students were prepared for the discussion in twelve biology lessons. In groups of three the students had 20 minutes to deal with the claim "antibiotic resistance is increasing worldwide" and four possible explanations. They should reason with the help of four short facts given to them as well as their expertise gained in recent biology lessons. The discussions were audio taped, transcribed and qualitatively analysed. The results show that the argumentations are mostly shallow and consist of few elements. Also, they argue rather intuitively than rationally. The students spend a lot of time with clarifying the meaning of the given explanations and facts. Many students seem overwhelmed by the task and don't recognise it's purpose. They experience difficulties in connecting knowledge as well as recognising errors in the given explanations. Poorly developed language skills and a lacking conceptual understanding of the content may have influenced the quality of students' argumentation.

Keywords: *socioscientific issues, decision-making, reasoning, discourse, motivation*

1. Introduction

Science education aims at preparing students to participate in the social discourse and make informed decisions. In Austria, science teachers shall encourage students to justify their positions and argue professionally and consistently.

Argumentation is an important facet of science. Learning the language of science is an essential part of science education and so every science lesson should encourage students to improve these language skills. However, scientific language is a major obstacle for many students in studying science. Improving the quality of science education, both in terms of the experiences it offers students and their cognitive and affective outcomes, requires the promotion of language, literacy and scientific literacy. [e; c]

According to the Toulmin's Argumentation Pattern, argumentations can be subdivided into the elements claim, data, warrant, backing, qualifier, and rebuttal. The basic argument consists of a claim that is in such a way supported by data or examples that the claim is a conclusion (syllogism). However, claims can be relativised by terms such as some, likely, and possibly. Warrants create links between the claim and the data, which can be underpinned by backings. Rebuttals are statements that contradict data, explanations and support. This form of argumentation is descriptive, logically inferential, and contains no normative premises. [3; 4; 5]

This work deals with secondary school students' argumentation about antibiotic resistance. The research questions are: Which argumentation structures do secondary school students (n=24; 16-17 years old) use when discussing the reasons for the worldwide increase of antibiotic resistance?

2. Research design

Qualitative data was collected by audio taping eight 20-minute small group discussions in a standard biology lesson. It seems to be important to prepare students in terms of language and content [6]. Thus, students learned about the immune system, vaccines, public health protection, pathogens, symbiotic bacteria, antibiotics, antibiotic resistance and strategies to avoid antibiotic resistance in eight 50-minute biology lessons. In two biology lessons (100min) the teacher (first author) provided an argumentation training. The students practiced arguments, analysed argumentations and became acquainted with argumentation errors in general and specific in a biological context.

For the qualitative data collection the teacher developed a task similar to tasks used by other research groups [5; 10]. The task was designed to support students in recognising errors in the given explanations, reasoning with the help of lessons learnt in biology class as well as determining and discussing their own views and those of others. The students are expected to be able to argue well, because both in German lessons and in foreign language teaching argumentation skills are practiced in several grades.

In groups of three, students (n=24) were confronted with the statement “antibiotic resistance is increasing worldwide” and were offered four possible explanations. The students were asked to discuss these explanations. They should reason with their expertise gained in recent biology lessons and with the help of four short facts provided on a worksheet. The groups which finished their task very quickly or felt that they can’t get on with the discussion received two additional explanations. The students discussed for 20 minutes. After 10 minutes, they got four additional facts and were asked to reconsider their choice as well as to talk about why they reasoned for or against the four explanations. Finally, they were expected to adapt their choice and their reasons, if necessary.

Afterwards, the students had 20 minutes to write about pro and cons of a chosen explanation. Previous research conducted in the same biology class allowed the interpretation, that these students might need a little bit of extrinsic motivation [7]. An attempt was made to motivate students to deepen their knowledge in the discussion and to use argumentation skills and knowledge to write the essay. It was also stressed that such tasks are relevant to their final exams.

Prior to the data collection, the students were asked for their consent and informed about in writing and verbally why and how data is collected, how anonymity and data security is ensured and that they can retract their consent any time. The audio-taped 20 minute long group discussions (n=8) were transcribed by the second author, who changed the names and did not transcribe personal information to ensure anonymity. Together, the authors analysed the students’ argumentations qualitatively by following the work of Riemeier and colleagues [5], which is based on Toulmins Argumentation Pattern [3;4].

3. Results

In general, the students argue rather intuitively than considerately and rationally. The argumentations are mostly shallow and consist of a few elements. Most argumentations consist of single claims, however, many students don’t give any facts or data to justify their claims. When students connect a claim with data, mostly this data is of poor quality. For example, a student chooses explanation number two because it just makes sense to her but gives no reasons for her choice. Warrants appear occasionally with very few students.

The students spend a lot of time with clarifying the meaning of the given explanations and facts or read the texts too fast and not careful enough. However, most students don’t understand the task, the explanations, and the facts properly. An ongoing discussion is rare, because students have difficulties in understanding the content or expressing their views verbally.

In general, most students seem to have misunderstandings, e.g. many students think the human body develops an antibiotic resistance instead of bacteria. Many appear to have a shallow understanding of the content. Some students show basic scientific knowledge, but can’t connect it with the task. Also, most students don‘t delve into the given explanations and facts deeply enough. Only few students recognise argumentation errors or incorrect argumentations. The facts offered in a extra work sheet are only used by very few students as data for their argumentation, instead most students discuss the content of the facts and try to understand them.

In the discussions most students don‘t focus on the correctness and logic when examining the arguments presented by their group members, but on fairness, e.g. by acknowledging the arguments of a classmate. Almost never students justify a counterclaim.

Many students seem overwhelmed by the task and/or don’t recognise the purpose of the task. Some even utter being bored or annoyed. In almost every group there is at least one student who just wants the discussion to come to an end no matter if a meaningful outcome is achieved or not. Few students state that this kind of task is a positive change in classroom routine or show signs of ambition and joy in problem solving. However, most students give up as soon as they experience difficulties in solving the task. Individual students show even signs of frustration when the teacher and the assisting pre-service teacher refuse to help them to solve the task.

4. Discussion

Poorly developed language skills, a lacking conceptual understanding of the content and de-motivating conditions in general may have influenced the quality of students' argumentation.

The fact that students' arguments consist of only a few elements and that students merely justify their arguments is consistent with other research findings [5; 8; 9; 10]. Language seems to be a major obstacle for most students in studying science [1]. However, students practiced argumentation in German lessons as well as in foreign language lessons in several grades. Perhaps, the content-specific knowledge and thus the causal relationship and the logic of arguments is less important in these subjects than in science classes. However, it is possible that the students do not realise that they shall transfer skills gained in other classes, even though the teacher emphasised the interdisciplinary importance of the task.

This research results as well as other research results suggest that it seems to be important to prepare students for argumentation in terms of language and content [6]. Students need to understand the content of tasks, assertions, facts, data and explanations in order to argue correctly and consistently and thus enter into a well-founded discourse. Possibly, the teacher didn't succeed in her attempt of promoting a conceptual understanding of antibiotic resistance, because the learning environment has not been crafted thoroughly enough. A few lessons might not be enough to help students understand biological phenomena as complex as antibiotic resistance and/or the argumentation training given by the teacher was too short. It is also possible, that the students were not interested in the reasons for antibiotic resistance, at least not to the extent that would have motivated them to make an effort. It might be that students did not consider it important to engage in an argumentative discourse because this is not common practice in science education [5] in Austria. The results raise the question if the prevailing school conditions, under which teachers and students may deal with socioscientific issues, support enhancing argumentation skills in biology lessons.

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