Malin Lavett Lagerström achieved her Licentiate degree in Science Education at Stockholm University with a thesis project on context-based teaching in secondary school science. She works now as Director of Education at the Swedish National Agency for Education.

Jesús Piqueras is Associate Professor in Science Education at Stockholm University. His research focuses on Science teaching and learning in informal learning environments as museums, science centers, botanical gardens and aquariums.

Ola Palm is a Lecturer and teacher trainer at Stockholm University.

MALIN LAVETT LAGERSTRÖM
Department of Mathematics and Science Education, Stockholm University, Sweden
malin.lavett.lagerstrom@mnd.su.se

JESÚS PIQUERAS
Department of Mathematics and Science Education, Stockholm University, Sweden
jesus.piqueras@mnd.su.se

OLA PALM
Department of Mathematics and Science Education, Stockholm University, Sweden
ola.palm@mnd.su.se

"Should we be afraid of Ebola?" A study of students' learning progressions in context-based science teaching

Abstract

In this study, we explored how learning progressions were established in a context-based science teaching unit. A science class in secondary school was followed during a teaching unit in Biology, in which the Ebola disease was used as context. Teaching was planned using the didactical model *organizing purposes*. ***Learning progressions were studied as continuity between teaching purposes, the science content and the context in four sequential lessons. The analysis of teaching evidenced a considerable variation in how learning progressions were constituted within lessons and showed how learning progressions could develop between lessons through the combination of different teaching activities. By consistently mentioning and referring to Ebola, the teacher had a pivotal role in establishing relations between teaching purposes, the content and the context. Furthermore, our results evidence the important role of the context in supporting students' learning of science content. Finally, we discuss concrete actions in the planning of the unit to improve lessons that evidenced a weaker connection to the context.***

INTRODUCTION

Context-based science teaching

From an educational policy perspective, it is often claimed that there is a need of well-educated students in science and technology to meet future challenges that require competencies in these subjects (Fensham, 2009; Tytler, 2007). However, students often describe science subjects as abstract, transmissive and difficult to understand (Lyon, 2006; Oskarsson, 2011), which make science appear as a foreign culture where the connection to "the real world" is missing (Aikenhead, 2006; Lyon, 2006). In the last decades, context-based teaching approaches have been developed in science education as an effort to meet challenges linked to science teaching in school. To use a context-based teaching approach as an alternative to more conventional forms of science teaching has been seen as a possible way to increase the number of students interested to study science at a higher level and further, to make learning of science more meaningful for students (Fensham, 2009; King, 2012). Also, a context-based teaching approach in science education has been suggested to meet the need of educating todays' students to responsible citizens in the future (Bennett, Campbell, Hogarth & Lubben, 2005; King, 2012). However, there is not a unique definition of context-based teaching or, as sometimes denoted, context-based learning (King, 2012). Usually, it refers to instructional methods in which learning, in a social-constructivist perspective, occurs through contexts in the social environment of an individual (Baran & Sozbilir, 2017). Thus, using a context-based learning method implies that a scenario including a real-life context is presented for the students. The scenario – sometimes a problem or a situation that needs a solution – leads the students towards a process of hypothesising and thus, promote the development of the students own learning needs (Baran & Sozbilir, 2017). In this process, the joint activity in the group is a crucial element in context-based learning, as it leads to a discourse that directs the students towards a solution (Baran & Sozbilir, 2017; Trimmer, Laracy & Love-Gray, 2009). In science education, context-based teaching is often an essential component in problem-based learning (PBL), science-technology-society (STS), project-based science (PBS) and socio-scientific issues (SSI) approaches (Broman, 2015; King, 2012). Common for the different instructional approaches is the context as an important element and that there is an aim to encourage students to link the scientific content with the real-world context (King, 2012).

Context-based teaching in science education has been discussed both as a general approach in science teaching as well as in relation with the teaching of the science subjects Biology, Chemistry and Physics (Bennett, Hogarth & Lubben, 2007; Broman, 2015). Different ways of embedding science teaching and learning in contexts have been explored, for instance in school projects in Chemistry and Physics (Fensham, 2009; King, 2012). Context-based teaching can also be related to the discussion of Scientific Literacy (SL), where it shows most similarities with Roberts (2007) description of Vision II. Roberts set out two visions of scientific literacy: Vision I (science literacy), that corresponds to a conventional way of science teaching with a focus on canonical science and the products and processes of science itself, and Vision II (scientific literacy) that focuses on literacy concerning situations in everyday life where scientific knowledge is important. Yet, Wickman and Ligozat (2011) highlight that Scientific Literacy has not to be viewed as a dichotomy between the two Visions but argue for an approach viewing Scientific Literacy as competent action. Further, the authors emphasize that it is important to use a problem or situation that the students can see the purpose of as starting-point in teaching, instead of using a context or everyday situation in general. Then, the students have the possibility to act in a purposeful way in the classroom.

Challenges in context-based science teaching

Previous studies have shown positive results concerning affective factors using context-based teaching and learning in science education (Aikenhead, 2006; Bennett et al., 2007; King, 2012). For instance, context-based teaching has been shown to increase students' interest for science subjects (King, 2012; Parchman, Gräsel, Baer, Nentwig, Demuth & Ralle, 2006) and students' retention of knowledge (Baran & Sozbilir, 2017). Moreover, previous studies indicate that students participating in context-based Chemistry courses do not achieve lower learning outcomes regarding concept learning than students participating in more conventional forms of teaching (Bennett et al., 2007; King, 2012). However, context-based teaching also involves challenges and teachers used to more traditional science education may experience difficulties to adopt a new teaching approach (Fensham, 2009; Tytler, 2007; Wickman, 2014). A challenge identified in context-based teaching regards the treatment of the science content in relation to the context. For instance, in a study of Parchman et al. (2006), the authors found a positive effect concerning students' interest and motivation during the context-based project, but the students also experienced a feeling of 'getting lost in context' and of missing the learning goals of science. In another study – aimed to strength the link between context and science content in chemistry education – the results revealed that a need-to-know that legitimize the learning of the science subject content has to be built progressively between different steps in teaching (Bulte, Westbroek, de Jong & Pilot, 2006; Bulte, 2007). Accordingly, the context has to provide a sort of necessity so that the students can realise the meaning of learning specific content or concepts, to answer a specific question or solve a problem (Bulte et al., 2006; Wickman, 2014). In another study, King and Ritchie (2013) explored how students made links between context and content in a context-based Chemistry course. The authors use the term *fluid transitions* to describe the students' movement from concepts to context in dialogues. The study shows that when students were allowed to interact in group work, the number of fluid transitions between concepts and context increased. King and Ritchie (2013) use the term *resonance* to describe a situation when the canonical science and real-world science is blended and the distinction between them is blurred (King & Henderson, 2018). The authors emphasize the need of further research to study the relationships between concepts and context in context-based teaching.

Studies such as those summarized above illustrate that context-based teaching does not automatically result in learning progressions among students and that such an approach raises new demands on teachers. There is a strong evidence that, to support students' learning progressions, it is important to establish continuity between the context and the scientific knowledge intended to be learned, and the role of the teacher in this process is pivotal (Johansson & Wickman, 2011). However, there is limited research about how learning progressions can be constituted in context-based teaching (Lavett Lagerström, Piqueras & Palm, 2018). In the present study, we explored students' learning progressions when they participate in a context-based teaching unit in Biology. In particular, we focused in the intricate relationship between the science content and the context. Our specific research questions are as follows:

> How were students' learning progressions established in the different lessons, and between lessons, in the context-based teaching unit?
>
> How were the science content and the context embedded and continuous in students' learning progressions in the teaching unit?

Theoretical framework

In the present study, we have used the didactical model *organizing purposes* (Johansson & Wickman, 2011; Wickman & Ligozat, 2011) to study how students' learning progressions were established during teaching the unit. According to the model, planning for learning progressions in a particular activity in the classroom implies, for the teacher, to establish continuity between different purposes: ultimate and proximate purposes. Whereas the *ultimate purposes* represent more overarching goals for teaching – for example the teachers' learning objectives for a particular lesson or curricular aims in science education – the *proximate purposes* are more student-orientated and have a closer connection to students' previous experiences and language. In a teaching activity, students' previous experiences are reconstructed and transformed in the new situation, resulting in consequences for the learning process. This conforms to Dewey's principle of continuity (Dewey, 1938/1997). The *proximate purposes* – such as teacher's instructions or questions – typically characterized by the intention to guide the students' actions, can be planned in advance, but they can also develop spontaneously during the teaching activities (Hamza & Wickman, 2009; Johansson, 2014). If a *proximate purpose* is functional, it becomes an *end-in-view* which directs the united action of students and teacher during the lesson (Johansson & Wickman, 2011). The term *end-in-view* refers to Dewey's description of purposes which function as the students, by using their everyday language and previous experiences, can participate in an activity in a purposeful way (Dewey, 1925/2013). Consequently, to support fruitful learning progressions, the teacher has a two-fold crucial role; firstly, to design activities that have the possibility to function as *ends-in-view* for students, and secondly, to actively work to establish continuity between *organizing purposes* in teaching (Johansson & Wickman, 2011, 2018).

The model of *organizing purposes* has been used in previous studies to analyse learning progressions in the science classroom (Anderhag, Danielsson Thorell, Andersson, Holst & Norling, 2014; Lavett Lagerström et al., 2018; Johansson & Wickman, 2018). The results of these studies show how the teacher, by different actions, can direct the students towards the *ultimate purposes* of teaching. This guidance is visible in various ways, for instance by the teacher explicitly linking the *proximate purposes* to the *ultimate purposes*, successively introducing scientific concepts, and inviting the students to use their previous experiences in relation to the new content. The studies also exemplify how the teacher supports students' learning by helping them to distinguish what actions are adequate in relation to the lessons' *ultimate purposes*.

METHOD

The teaching unit

The interventional study was performed in a Swedish secondary school. A science class of 30 students aged 14–15 was followed during a context-based teaching unit in Biology. The unit consisted of ten lessons of different time span (75–150 min). The Ebola virus disease was used as a teaching context for the unit. The motive for choosing Ebola was the interest, questions and concern generated among the students by a large Ebola outbreak that stroke several West African countries at the time of the study. The interrogative name of the unit ("Should we be afraid of Ebola?") suggested its overarching goal, namely that the students would be able to answer this question in a more informed way, as they learned more about different infectious diseases (the science content) and developed argumentation skills. In the present study, we have studied four consecutive lessons of the unit that had the main focus in the curricular goals related to the science content. The teaching was planned jointly by the ordinary science teacher and the first author using the didactical model *organizing purposes* (Johansson & Wickman, 2011). In the first lesson, the question "Should we be afraid of Ebola?" was introduced to the class and the students were asked to formulate their own questions about Ebola. Based on the students' questions and the curricular goals – associated with the spread of infections, virus and bacteria diseases and the body's immune system – different *ultimate purposes* were formulated for the lessons of the unit (Table 1). From these planned *ultimate purposes*, more student-orientated *proximate purposes* were planned for each lesson. In this study, *proximate purposes* were, for instance, the teacher's instructions for different teaching activities or explicit questions to elicit the dialogue in the classroom (Table 1). However, some *proximate purposes*, in the form of follow-up questions, prompts and comments, were not planned in advance but developed spontaneously in the moment-by-moment interactions between the teacher and students in the classroom.

Table 1. Lessons 5, 6, 7 and 8 in the teaching unit "Should we be afraid of Ebola?"

Lesson	Ultimate purposes	Proximate purposes	Ebola*
#5: Modelling Ebola	How do Ebola and other infectious diseases spread?	- Simulation activity with the 'test tube model'. - "What similarities are there between Ebola and our test tube model?"	39
#6: Searching information in the textbook	How does virus work? What differences are there between viruses and bacteria?	- Searching, reading and discussing information about viruses and bacteria in the Biology textbook. - "What is a virus?"	0

#7: Searching information in internet	How can infectious diseases be prevented and treated?	- Searching information in internet of human diseases. - Reporting and systematizing the information in a table. - "How can bacteria be killed?"	2
#8: Concept map activity	To systematize the acquired knowledge about spread of infectious diseases.	- Construction of a concept map with terms used in the previous lessons. - "Incubation period, what was that?"	21

Note: Ultimate purposes articulated as questions. Proximate purposes are examples of activities and questions prompted during the lesson. *Number of times in which the term Ebola was used in teacher-students or students-students dialogues.

Lessons were recorded with four voice recorders and one video recorder. Field notes were used to support the video and audio recordings. One of the lessons consisted in a concept map activity carried out in groups of three students. In this activity, we audio-recorded the talk of four groups of students when they constructed the concept map. Talk from recordings was transcribed verbatim in their entirety and translated from Swedish to English trying to preserve the original meaning and nuances of words.

The study has followed the Swedish Research Council's rules and guidelines for research, regarding information, consent, confidentiality and utilization of research data (Swedish Research Council, 2017).

Analytical approach

In order to answer our research questions ("How were students' learning progressions established in the different lessons, and between lessons, in the context-based teaching unit?" and "How were the science content and the context embedded and continuous in students' learning progressions in the teaching unit?"), a more operational question was used to guide our analyses: How do the teacher and students establish continuity between organizing purposes, the science content and the context in the lessons of the unit?

In a first step in the analysis of transcripts, we identified the *proximate purposes* in interactions where the teacher stated explicit questions or gave instructions in the different teaching activities. Then, continuity between the proximate purposes, ultimate purposes, science content and the context was analysed using practical epistemology analysis (PEA) (Wickman, 2004; Wickman & Östman, 2002). The starting point in PEA is that learning is a process of meaning making in which the participants (in this study the students and the teacher) establish *relations* to words that *stand fast* to fill *gaps*. A *gap* is the analytical term that refers to something that is noticed by the students or the teacher, an explicit question or something that needs to be explained. The term *stand fast* has its origin in Wittgenstein's use of the word and is applied to words or expressions that are used without hesitating or questioning in the specific situation. Words that *stand fast* can be used to establish *relations* to something that is new for the students. In the following excerpt, we exemplify the use of the PEA to analyse a dialogue between the teacher and the students during lesson 5.

Excerpt 1

1	T	Okay, what factors affect how fast an infection is spread?
2	S1	How often people meet and share their body fluids.

3	T	How often people meet [writes on the Smartboard]. Anyone else? Yes?
4	S2	In what way it spreads, if it spreads through fluids or through the air.
5	T	If the virus is airborne or not. What does it mean that a virus is airborne or not? What do you say?
6	S3	That it is like air…
7	T	If it is airborne, it is in the air, yes. //Ebola is not airborne, but flu is. What is the difference?

In the dialogue, the teacher (T) creates a *gap* by asking “What factors affect how fast an infection is spread?” (Turn 1). Student S1 establishes a *relation* to “how often people meet and share their body fluids”. The term body fluids *stands fast* for the students, since no one questions it and the conversation can proceed. Student S2 establishes further *relations* to “what way it spreads” and to the terms “fluids” and “air”. Then, the teacher creates a new *gap* by asking what is meant by an airborne virus (“What does it mean that a virus is airborne or not?”, Turn 5). Then, student S3 starts to establish a *relation* (“like air”), which is immediately used by the teacher to establish a new relation to another disease and the context of the unit (“Ebola is not airborne, but flu is”, Turn 7). In terms of the model *organizing purposes*, the questions used by the teacher (Turns 3, 5 and 7) are *proximate purposes* that work as *ends-in-view* for the students, that is, they support participation of the students using their language and previous experiences. In the dialogue, it is evidenced how the teacher and the students, through different *relations*, establish continuity between these *proximate purposes* and the *ultimate purpose* of the lesson (i.e. to learn about the spread of infectious diseases). The dialogue also evidences how the teacher establish continuity between the science content (i.e. “virus”, “body fluids”, “airborne” and “flue”) and students’ experiences, and how the teacher makes distinctions between Ebola and flue. In other words, we can see in this dialogue how the teacher and the students establish continuity between the organizing purposes of the lesson, the science content and, by explicitly mentioning Ebola, establish continuity with the context of the unit.

RESULTS

The analysis of teaching showed a considerable variation in how learning progressions were constituted during the sequence of these four lessons of the unit. In lesson 5, continuity between proximate and ultimate purposes was established. In the same lesson, both the context (Ebola) and the science content were embedded in the teaching purposes (Table 1). In lesson 6, continuity between proximate purposes and ultimate purposes of the lesson was not established and no explicit connection was made to the context (Table 1). During this lesson, the science content related to the ultimate purposes was scarcely treated. In lesson 7, continuity between the organizing purposes of the main activity was established and the classroom talk evidenced a relevant use of the science content, however the context was addressed very briefly on two occasions (Table 1). The analysis of lesson 8 revealed a similar outcome as lesson 5, that is, both the science content and the context were embedded in the students’ talk and continuous with the teaching purposes (Table 1). However, in lesson 8, it was the students – without the direct intervention of the teacher – that established continuity between purposes, context and content. Continuity between lessons was evidenced when the ultimate purpose of one of the lessons (lesson 5) was recalled and used by the students to handle successfully with the proximate purposes of a subsequent lesson (lesson 8). In the following sections, we exemplify these different outcomes with teaching situations from the four lessons of the unit.

Modelling Ebola

The ultimate purpose for lesson 5 was that the students should get a better understanding of how Ebola and other infectious diseases spread. The opening activity was the simulation of the spread of Ebola using a ‘test tube model’. This activity, that included several proximate purposes, such as teacher's instructions and the use of artefacts, was performed together with another science class and their teacher in the main hall of the school. Every student got a test tube with water (representing body fluids) except one student that got a transparent starch solution in the test tube (representing Ebola viruses). Then, the students mingled around and after a signal from the teachers the students mixed the content of their test tubes, simulating the spread of Ebola infection through the exchange of body fluids (Figure 1). This procedure was repeated three times. Then, the teachers used iodine to test – as in a check-point in an area affected by Ebola – the presence of starch in all the tubes, assessing in this way how many students got 'infected' with Ebola. Excerpt 2 shows how the teacher introduced the activity.

Excerpt 2

8	T	Today we are going to illustrate something. Imagine that you are 60 people living in an area in which a single person infected by Ebola arrives. We are going to make a sort of model of how that could develop and what way it could look like. You are not going to feel symptoms of Ebola at all, so you don't need to be worried. […] Ebola spreads through the body fluids. This [test tube with liquid] represents your body fluids. Everyone is going to get a test tube. […] You are going to mingle and talk to each other until we call out" Stop". Then you mix your body fluids with the person closest to you. […] In countries with Ebola they have check-points […]. They measure the body temperature to see if they are feverish. Fever is a symptom of Ebola […]. That represents our check-point where we are going to control who got infected […]. We have our analytical method, we use iodine. The test is positive if it turns blue. Then you might be infected and are quarantined.

During the first part of the teacher's monologue, it is evidenced how the teacher addresses explicitly the ultimate purpose of the activity ("to make a sort of model of how that could develop and how it could look like") and how, by mentioning Ebola, the teacher establishes a continuity with the context of the unit. Afterwards, the teacher used several proximate purposes and artefacts to guide the students' actions and, through different relations (this tube-represents your body fluids; control-check-points), establishes continuity with the ultimate purpose and the science content ("body fluids", "symptoms", "fever" and "infect").

The video recording from the first part of the lesson 5 shows that all students participated in the model activity and they could enact the instructions given by the teachers, playing their role with enthusiasm and sense of humour. On the basis of what the students actually did, it was visible that the sequence of different proximate purposes embedded in the model activity acted as ends-in-view for the students.

Figure 1. The students exchange "body fluids" using test tubes in the simulation of the spread of Ebola during lesson 5.

In the second part of lesson 5, the 'test tube model' was followed by a discussion in the classroom. The discussion was intended to explore similarities and differences between the model used in the previous activity and the spread of Ebola in the real circumstances. To stimulate students' participation, the teacher addressed questions (Excerpt 3).

Excerpt 3

9	T	Okay then… what similarities are there between <u>Ebola</u> and our test tube model? So, when you get infected… what situation represented the infection?
10	S1	When we mixed [The fluids of the tubes].
11	T	Yes. When you mixed the body fluids. There is a concept here which is about the time from when I get infected until symptoms are visible. What is it called?
12	S2	Incubation period.
13	T	Incubation period. Yes. It can vary a lot with different infections, but when it comes to <u>Ebola</u>, it is quite a big range between 3 to 21 days I think. So, you can be infected without knowing, absolutely. //
14	T	What is an exchange of body fluids in the way you did it with those test tubes? Can you find out some example?
15	S2	Well, if you eat a chocolate bar… And it's hot. The chocolate melts in your hands and you lick your fingers… and then you shake hands with someone.
16	S3	When you sneeze or when you cough, too.
17	T	So… if I sneeze right here, does it mean that I have exchanged body fluids with all of you?
18	Ss*	Yes … No?

19	T	Ok. What more is necessary?
20	S3	Well, you need that it gets in other people's body fluid.

*Ss [Several students]

In this dialogue, the initial questions (Turn 9) act as proximate purposes that allow the students to work towards the ultimate purpose of the lesson ("to get an initial understanding about how infectious diseases spread"). Further relations are used by the teacher to introduce a new scientific content ("incubation period", Turns 11-13), thereby making the context of the unit, Ebola, continuous and relevant for the ultimate purpose. In the dialogue, relations are established by the teacher and the students together and the students are able to participate using their language and experiences from the 'test tube model'. The proximate purpose (Turn 14) allows the students to use everyday experiences (eating a chocolate bar-licking fingers, S2; to sneeze, S3) to talk about disease transmission, i.e. the ultimate purpose. By using again "body fluid" and new proximate purposes (Turns 17 and 19), the teacher challenges the student to use the more specific scientific language to describe the pattern of infection that characterize the Ebola infection (Turn 20).

Our analyses of lesson 5 evidence that the proximate purposes used by the teacher worked effectively to support students' learning progressions. Within the same lesson, the teacher established a continuity between the organizing purposes of both activities (the simulation and the discussion) and the context of the unit (the term "Ebola" was mentioned 39 times during the discussion, Table 1). Furthermore, lesson 5 evidenced the only occasion, during the four studied lessons, in which the pivotal question "Should we be afraid of Ebola?" was explicitly recalled by the teacher (Turn 21).

Excerpt 4

21	T	So, when you ... So ... if we consider all we talked about the spread of infections. What do you think, should we be afraid?
22	Ss	No. // I don't know. //Maybe.

Searching information in the textbook

The ultimate purposes of lesson 6 were that students should learn about the function of viruses and the differences between viruses and bacteria. The planned proximate purposes of the lesson involved searching information in the Biology textbook about viruses and bacteria and thereafter participate in a whole class discussion. The discussion was led by the teacher that used various questions, also functioning as proximate purposes. The analysis of the dialogue between the teacher and the students shows that most of the students' questions revolved around different diseases, rather differences between viruses and bacteria, as it was intended.

Excerpt 5

23	T	Many questions concerning different kinds of diseases turned up ... about viral diseases and bacterial diseases and questions concerning cancer.
24	S1	Well, it is a tumour.
25	T	A cancer is a tumour. Yes. But is it a viral disease or a bacterial disease?
26	S1	Virus.
27	S2	It is in the book.
28	S3	What is the chance to get cancer? Is it around one of twenty or one of...?
29	T	Maybe ... can cancer infect?
30	S4	No.

31	T	Can you get cancer if I sneeze right here?
32	Ss	No. // Yes.
33	S4	It’s heritable.
34	T	So, it is neither a bacterial nor viral disease in that way.

In excerpt 5, virus and bacteria were mentioned by the teacher several times. However, these concepts did not become continuous with the lesson’s ultimate purpose, i.e. differences between viruses and bacteria. Cancer remained as a dominant content during the whole discussion; the students talked about cancer as a disease, what causes cancer and treatments of cancer diseases. Although the teacher tried to re-direct the dialogue to viruses and bacteria (Turn 25) on several occasions, it was difficult to establish a learning progression between students’ questions, students’ own experiences and knowledge about cancer, and the lessons’ ultimate purposes. Ebola, the context of the unit, was not mentioned in relation to the lessons’ purposes during the discussions (Table 1).

Searching information in internet

The ultimate purpose of lesson 7 focused in the characteristics of infectious diseases, in particular their origin, cures and prophylactical measures to avoid them. Working in pairs and using computers, the students were asked to search information in internet about human diseases, determine their cause and how they could be prevented and treated. Then, the student pairs reported their findings by filling a table that was displayed on an interactive board. Afterwards, the teacher started a whole class discussion going through the diseases on the table, what cause them (e.g. viruses or bacteria) and treatments. In excerpt 6 we present an example of the dialogue in the classroom.

Excerpt 6

35	T	Here, we have … shingles [reading the table].
36	S1	Unknown [treatment] because it is a virus.
37	T	Yes, shingles is a virus, then, no treatment. All of those [diseases] caused by viruses, it seems that they don’t have any treatment // Then ‘the Asian’, that’s a kind of flu, a virus, no treatment either. Cholera-bacteria-vaccine [reading the table].
38	S1	Vaccine? It can’t be right.
39	T	Well…yes…cholera-bacteria-vaccine [reading the table]. What’s wrong with it?
40	S2	You can vaccinate before you get it, but you can’t use vaccine when you have got it.
41	S1	Yes, I thought so at first, but now… I think you can.
42	S2	But vaccine is a small part ... which is innocuous and makes your body immune to it, so when you get it [vaccine], you don’t become ill. //
43	T	Cholera … are you sure that it’s a bacterial disease?
44	S1	Yes, bacteria.
45	T	How can bacteria be killed?
46	S1	We have penicillin there [referring to the table].
47	T	Yes, penicillin or, more general, antibiotics.

Retrieving information of diseases from internet and systematizing the information in the table were proximate purposes that worked as ends-in-view for all pairs of students. Excerpt 6 is an example that shows how the teacher, with the help of questions (new proximate purposes) directed the conversation towards the ultimate purpose of the lesson. Together, the teacher and students, established relations between the terms displayed in the table (diseases-viruses-no treatment; Asian-flu-virus-no treatment; Turn 37). Occasionally, the students noticed new gaps (Turn 38) and new relations were established to fill the gap (Turns 40 and 42). In this process the teacher took the opportunity to make distinctions and generalizations to introduce a new, specific, term related with science content ("… penicillin or, more general, antibiotics", Turn 47). As a whole, the proximate purposes of the lesson were continuous with the ultimate purpose during the entire lesson. However, the context Ebola was scarcely discussed during the class, it was only mentioned briefly by the teacher on two occasions (Table 1).

Concept map activity

The main activity in lesson 8 was the construction of a concept map in groups of three students. The proximate purposes for this activity were the instructions to build a concept map from 25 different terms included in a worksheet. The students were asked to discuss the terms and by drawing arrows with short written explanations, establish relationships between them. All the terms presented in the worksheet had been mentioned during previous lessons. However, "Ebola", perhaps the most important word of the unit, was unconsciously omitted in the concept map. The ultimate purpose of this activity was that the students used the terms in their reasoning and systematized the acquired knowledge about spread of infectious diseases. Our analyses of the students' talk during the work with the concept map show that the concept map activity functioned as an end-in-view for the students. In the groups, all of the students participated in the discussion, noticed all the terms on the map and managed to establish relations between them. Strikingly, considering that the term was not present in the worksheet, the word "Ebola" was mentioned 21 times in the conversations of the four groups (2, 11, 5, 3; Table 1). Excerpt 7 illustrates a fragment of one of the conversations when the students started discussing the terms "infection" and "incubation period".

Excerpt 7

48	S1	Then, **infection** goes to an **incubation period.**
49	S2	Incubation period … what was that?
50	S1	Incubation period … it's the time before…
51	S2	The first **symptoms**?
52	S1	The first **symptoms** appear.
53	S2	Aha.
54	S1	Like <u>Ebola</u>. It has an incubation period of some weeks … something like that.
55	S2	If you become infected, then it's time before you become ill, sort of.
56	S1	Yeah, because <u>Ebola</u> has an **incubation period** of around one or two weeks.
57	S2	It would be different if it was three days, wouldn't it?
58	S1	Yeah. It can't be so easy to notice it if you can't see any **symptoms**.
59	S2	Mm.
60	S1	Then, infection goes to **diagnosis** and **symptom**.

When the students work with the terms, a gap is noticed ("Incubation period … what was that?", Turn 49) and relations are established to fill the gaps (Turns 50–56). In this process, the students are able to conceptualize the term "incubation period" (Turns 50–53) and to establish relationships between four different terms in the concept map; "infection" (Turn 48), "incubation period" (Turns 48 and 56), "symptom" (Turns 51, 58 and 60) and "diagnosis" (Turn 60). In other words, the students establish continuity between the proximate purpose (to construct a concept map) and the ultimate purpose of the lesson, making possible a learning progression. Both the science content (the terms) and the context (Ebola, Turns 54 and 56) were embedded in the students' talk and continuous with the teaching purposes. On multiple occasions, specific content related with Ebola from lesson 5 was recalled in lesson 8, almost in the exactly same words, to support their reasoning (compare "incubation period" in Excerpt 3, Turns 11–13). In terms of organizing purposes, this can be interpreted as the students establishing an 'inter-lesson continuity', in which the ultimate purpose of lesson 5 was the starting-point to cope successfully with the proximate purposes of lesson 8.

DISCUSSION

Learning progressions

The results of our study evidence a considerable variation in how learning progressions were constituted during the unit "Should we be afraid of Ebola". Two lessons (5 and 8) strongly supported students' learning progressions. In these two lessons - where the students simulated spread of infections and constructed concept maps - the teacher and students established continuity between the organizing purposes of the lessons, the science content and the context Ebola. Learning progressions were also constituted in lesson 7, at least in terms of continuity between the organizing purposes. However, in this lesson, Ebola did not work as a functional, embedded context.

One of the most exciting results of our study is the remarkable 'inter-lesson continuity' found between lesson 5 and 8. This continuity became discernible, when the students recalled and used science content introduced in the former lesson during the construction of concept maps. In lesson 5, in moment-to-moment interactions, the teacher actively guided the students towards the lessons' ultimate purpose. Then, this ultimate purpose was used by the students to cope with the proximate purposes in lesson 8. In other words, to systematize the knowledge about infectious diseases when constructing the concept map, the students needed the knowledge acquired both through the simulation and the discussion from lesson 5. The notion of using the ultimate purposes from one teaching activity as proximate purposes of the following teaching activities represent one of the most important features of the use of the organizing purposes as a model for planning for learning progressions (Johansson & Wickman, 2011). Our results show similarities with earlier studies about how continuity can be established between various purposes for teaching (Anderhag et al., 2014; Johansson & Wickman, 2018). These studies, demonstrate that the use of questions in science classroom discourses is one of the most powerful tools used by teachers to scaffold the students towards the learning goals, thereby supporting learning progressions (Scott, Mortimer & Aguiar, 2006). However, according to the results of the present study, we can also conclude that the combination of different activities in teaching sequences, involving i.e. modelling, questioning, discussions and concept mapping, can be a powerful approach for supporting learning progressions.

In contrast to lessons 5, 7 and 8, our results show that continuity between the ultimate and proximate purposes was not established during lesson 6. After searching for information in the textbook, the students could participate in the classroom dialogue, however, no explicit connections were established between the lessons' ultimate and proximate purposes. The teacher used a question about cancer as a starting-point, but the cause and treatment of this disease remained the main focus in the conversation. The concepts of virus and bacteria were mentioned several times by the teacher, but not in relation to the lessons' ultimate purposes. Other studies of using organizing purposes to study learning progressions in the classroom have described similar situations in which the students can deal with the proximate purposes but teacher actions are not sufficient to work towards the intended ultimate purposes (Johansson & Wickman, 2011). Furthermore, in the present study, the direction that the classroom dialogue took in lesson 6 can be seen in the light of how contingences and students' experiences can affect the direction of teaching and learning (Hamza & Wickman, 2009). The students had earlier experiences of cancer – from school and out of a school-context – and in the discussion, the teacher used this knowledge to redirect the discussion towards viral and bacterial diseases. However, even though cancer functioned well as a proximate purpose, it appears clear that the teacher could have done something more to guide the students towards the lessons' ultimate purpose, for instance to state explicit questions about the characteristics of viruses and bacteria or using the Biology book more actively during the discussion.

Continuity between content and context

A challenge emphasized in earlier studies concerning context-based science teaching, is the relation between the context and content (Bulte et al., 2006; Parchman et al., 2006). Although the present study is limited to the experiences of one teacher and a class, our results show how the teacher, in concrete actions, can use effectively the context and the content to establish strong learning progressions in teaching. We found evidence of well-established links between the units' context Ebola, and the science content. For instance, in lesson 5, when students simulated spread of Ebola infection using test tubes, Ebola became an almost omnipresent element throughout the whole lesson. In the lesson, the teachers explicitly linked actions and artefacts used in the modelling activity to the real infection, thereby connecting the science content (spread of infections and related concepts) and the context. Similarly, a strong link between the science content and the context was also evidenced in students' talk during the concept map activity. Noteworthy, Ebola was spontaneously and frequently used by the students to establish relations between the concepts on the map, even though the term was not present in the original list of words of the task and the teacher did not participate in the dialogue. Seemingly, Ebola was an important resource for the students when they dealt with the terms in the concept map. Thus, our results show that the context was not only relevant, in terms of making the science teaching more interesting and motivating for the students, but it was also important for helping students to make meaning of the scientific content. The connection between the content and context seen in students' dialogues working with the concept maps show similarities with the implication of the terms *fluid transitions* and *resonance* used by King and Ritchie (2013) and King and Henderson (2018).

In contrast to lessons 5 and 8, Ebola was not a relevant context for lesson 6 and 7. During these lessons, the teacher did not establish explicit links between the science content and Ebola. As in more conventional forms of science teaching, context-based teaching is constrained by curricular goals and, consequently, focusing in viruses and bacteria as life forms in lessons 6 and 7 was clearly a didactical decision in the teacher's planning. Yet, it could be argued about the necessity to address explicitly the context (Ebola) in all lessons of the unit since lessons 6 and 7 also produced interesting discussions related with diseases. However, we cannot forget that these lessons were a part of a context-based project ("Should we be afraid of Ebola?") in which the ultimate purposes of the lessons were planned to help the students to answer the overall question at the end of the unit. Considering the rather fragmented school life of these students, in which they are expected to engage in different subjects in the same day, it is not difficult to understand that the context of a long unit can certainly fade from their attention. Therefore – bearing in mind the outcomes of lessons 5 and 8 – it would have been advisable for the learning progressions in the whole unit, to establish connections between the context and the science content also in lesson 6 and 7. This could be relatively easily done by including new proximate purposes in the lessons, for instance by using questions as "What is an Ebola virus?" "If I get Ebola, can I be treated?" in the classroom discussions.

In order to support students' learning progressions, it is important that the teaching activities function as ends-in-view for the students (Lavett Lagerström et al., 2018). Comparing the simulation of Ebola infection in lesson 5 and searching information in the Biology textbook in lesson 6, it can be concluded that there are clear differences in the affordances of these two activities. In the simulation, the students participate physically using artefacts and this setup was probably essential and decisive for a rich dialogue in the classroom. Understandably, the activity with the Biology textbook did not invite the students to joint participation in the same manner. One way of making lesson 6 more dialogical could be by using some guiding questions (i.e. proximate purposes), that the students could discuss while they work with the textbooks. Then, the teacher in the following whole class discussion, could refer to these questions and by using a more authoritative discourse (Scott et al., 2006) direct the dialogue towards the lessons' ultimate purposes.

Wickman and Ligozat (2011) have emphasized the importance of using problems or situations as starting-point in teaching in which the students can find a relevant purpose for learning. These authors have also stressed that students need both the canonical knowledge as well as competencies to use scientific knowledge in everyday situations or real-world. In the actual study, Ebola was a real and appealing context for the students. The overall question "Should we be afraid of Ebola" functioned as end-in-view that helped the students to participate in a meaningful way in the teaching. Also, the question addressed an authentic problem which created a need of scientific knowledge in the classroom. A similar situation, that shows the importance of relying in scientific knowledge to make informed decisions, has been dramatically highlighted by the pandemic caused by the Corona virus in the beginning of 2020. Here, our study suggests that working in the science classroom with contexts that are connected to real, even dramatic, problems can be a powerful approach to help the students in distinguishing facts and reliable information from prejudices and fears.

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