RESEARCH ON LEARNING

Let's Talk Biology – Developing a Model for Incorporating English-Speaking Experts into the (Bilingual) Science Classroom

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Abstract

We present an instructional approach to incorporate into biology lessons an exchange of videos between international practicing scientists and secondary-school students. We validated the approach in German school settings in three curricular contexts: genetics, cell biology, and immunology. The participating students (n = 255) were native speakers of German with a background of English as a foreign language. The three participating scientists, English-speaking experts from the United Kingdom and Uganda, were rooted in different fields that were related to the respective curricular topics. We explain how the video exchange model was developed and evaluate students' comments and suggestions for improvement in a qualitative approach. This is followed by a discussion of implications for future applications. The video exchange was intended to promote English as the language of science in biology lessons. Through personal and genuine insight into science professions, students were able to experience the usefulness of English as a tool for international communication. We argue that the instructional model is applicable to a wide variety of educational contexts, including minority language students and native speakers of English.

Key Words: *Science language; bilingual science; content and language integrated learning (CLIL).*

○ Introduction

English is the dominant common medium for global communication in the natural sciences (Brumfit, 2004; Coleman, 2006). Therefore, solid proficiency in English and its linguistic conventions in the sciences can be considered a part of scientific literacy (cf. National Research Council, 1996) and is thus an essential goal of science education that applies to both English language learners (ELLs) and native English speakers (cf. Halliday, 2016). In non-English-speaking countries, this situation entails the responsibility to familiarize students with the use of English in scientific contexts. Combining language and content instruction to achieve learning outcomes in both regards is the basis for content and language integrated learning (CLIL). The umbrella term CLIL denotes "any dual-focused educational context in which an additional language [. . .] is used as a medium in the teaching and learning of non-language content" (Marsh, 2002, p. 15). In Germany, where this paper originates, CLIL programs are offered in numerous schools, but natural science subjects are often only marginally included (KMK, 2013).

With the instructional model presented here, we aim to promote the use of scientific English in the context of standard science courses. This model includes English-speaking partners to increase the learning situation's authenticity by creating a "genuine communicative purpose" (Breen, 1985, p. 62). A similar aspect is the authentic representation of scientific methods, scientists, and their work fields. Outreach programs of different research institutions are tailored toward providing students with genuine insight into their professions. They might involve scientists visiting a school (e.g., Glynn et al., 2017), or a group of students touring a lab (e.g., Itzek-Greulich et al., 2015) or a museum (e.g., Griffin, 2004). These programs aim at widening an often restricted and abstract view of scientists (cf. Finson, 2002) and are thus a valuable tool to demonstrate how extensive and diverse the world of natural sciences is. Woods-Townsend et al. (2015) argue that such encounters are likely to influence students' perspectives on science-related professions and their career choices. Due to their organizational requirements and time restrictions, the number of day trips to out-of-school learning sites is limited, and having scientists visit the schools may entail considerable travel expenditures. However, modern media such as real-time chat or video chats allow for encounters that are similarly direct but more economical and time-efficient. Basiliko and Gupta (2015) used live video chat to connect university students with scientists, and they report positive feedback by both students and experts. When transferring this approach to the secondary classroom, some major differences in comparison to higher education must be considered. For example, school schedules are often less flexible and class times more restricted. Also, younger students will need specific support and guidance to have a meaningful exchange of information. However, based on a feasible instructional model, such an exchange might be a unique way to demonstrate

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how useful the language of science is as a bridge to foreign people and cultures.

Against this background, we present an instructional approach to incorporate communication between international practicing scientists and secondary students into biology lessons. We worked with students who were native German speakers and connected with English-speaking experts from different fields through videos. The approach was tested in 10 classes at six different schools of two federal states in Germany.

Research Goal

Our research objective was twofold. First, we wanted to identify a practical concept to make English-language communication with external partners feasible in realistic school settings. We considered aspects of methodology, technology, and scheduling. A successful model would enable students to contribute meaningful questions and to extract relevant information from the experts' answers without experiencing major comprehension issues. Second, we wanted to gain qualitative insight into students' perception of the exchange and receive their suggestions for improvement. Accordingly, we present the rationale behind developing the new model and its validation studies. The concept was first realized in a preliminary case study in two German high school classes. After making some revisions, we examined its feasibility for a wider scope of grade levels, curricular topics tested, and number of students. The following research questions guided our studies:

(1) Is our instructional approach for an expert video exchange feasible in realistic school contexts? If so, what are the relevant factors for a successful implementation?

(2) What insight into their affective perception of the video exchange will students' comments provide?

○ Developing an Instructional Approach for Incorporating English-Speaking Experts into Biology Lessons

Goals & Purpose

Figure 1 provides an overview of the new expert video exchange model. With these guidelines, teachers can give their students the opportunity to interact with a real-life expert of the field they are learning about in class. For ELLs, the exchange model provides a secure environment to practice communicating scientific information in the foreign language. With this, we aim to increase students' motivation in class.

Recruiting Experts

Following Breen's (1985) call for authenticity, we wanted the students to communicate with professionals about scientific content related to their current curricular topic. Recruiting native English speakers was not a requirement, because English is often spoken between non-native speakers in academic and business communication. We contacted research institutions and social organizations to ask for their support in our project. The experts who agreed to participate were a British researching oncologist for our pilot unit on cancer, a British mitochondrial research associate for our unit on cell biology, and a Ugandan psychosocial specialist from an HIV support organization for our immunology unit. The latter case featured interdisciplinary elements, as the expert provided insights on medical issues from the perspective of the social sciences. Two of our experts were female and one of them was black – which, as Finson (2002) recommends, contradicts (and may thus help deconstruct) common stereotypes about scientists.

Technical Aspects

Working with international experts entails geographic distances as well as possibly differing time zones. We considered live video chats, but this raised logistical concerns as they are prone to connection errors. We therefore chose self-recorded videos as an equally appealing but more reliable medium that allowed the students and the expert to see and hear each other's faces and voices. At the same time, students and expert could record and replay their contributions as often as they liked, and the instructor could prepare language support materials.

Preparing the Expert Video Exchange in Class

Our participating German ELLs were to be familiarized with English in scientific contexts by conducting several weeks of bilingual lessons on curricular content prior to the exchange. These lessons included original English-language materials (texts, images, videos) for which we provided language and comprehension aids in the form of vocabulary help, guiding tasks, and practice exercises. We further included exemplifying aspects of the expert's field to provide students with the necessary background and confidence to formulate questions. When instructing the students about the exchange, no restrictions were made regarding the nature of questions that students could hand in (for examples, see Table 1). Topics such as cancer or HIV carry a potential for emotional and personal involvement, so the participating students could choose between asking questions related to school content and inquiring about personal concerns.

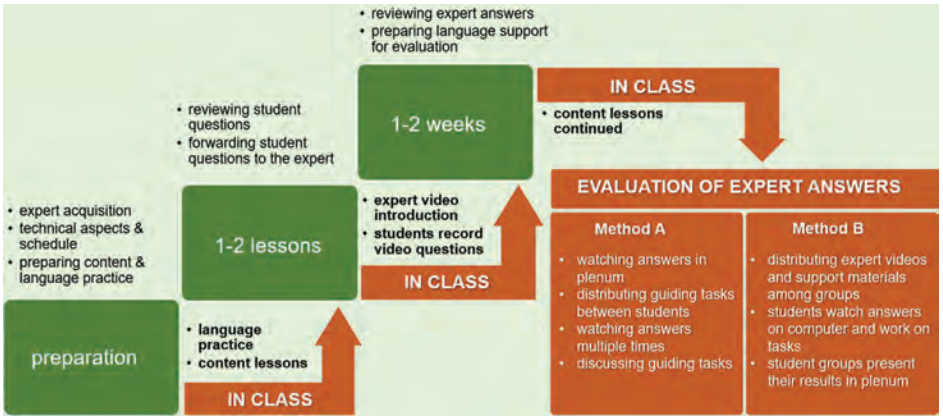

Figure 1. Overview of procedures and components of the new instructional model.

Evaluating the Experts' Answers

We mediated the exchange, a role that is fulfilled by the teacher in non-empirical settings. We reviewed all video contributions to decrease redundancies and potential misunderstandings. Also, we prepared language aids

Table 1. Sample of student questions to the experts in three curricular contexts.

Curricular Context	Expert's Field	Sample Student Questions
Genetics	Cancer research	• *What can you do that really helps to prevent cancer?* • *Do you think there will ever be a full cure for cancer?* • *Is it true that fried food causes cancer?* • *I heard that brain tumors are difficult to treat due to the blood-brain barrier. Is that true and why?*
Cell biology	Mitochondrial disease research	• *Can mitochondrial disease be healed?* • *What are the causes for mitochondrial disease?* • *How long can people with mitochondrial disease survive?* • *How do you know that you have mitochondrial disease?* • *How many people are there with mitochondrial disease?*
Immunology	Psychosocial specialist for HIV patients and relatives	• *Are there moments that make it hard to do your work?* • *Why are you motivated to do this work?* • *Does it take a long time until the kids/youths trust the people from the organization?* • *Are there adolescents who don't want help?* • *Are there more boys or girls who have HIV?* • *Are HIV-positive people being shut out from society?* • *Is it possible for you to say if there is a special social group in society that is hit hard by AIDS or HIV?*

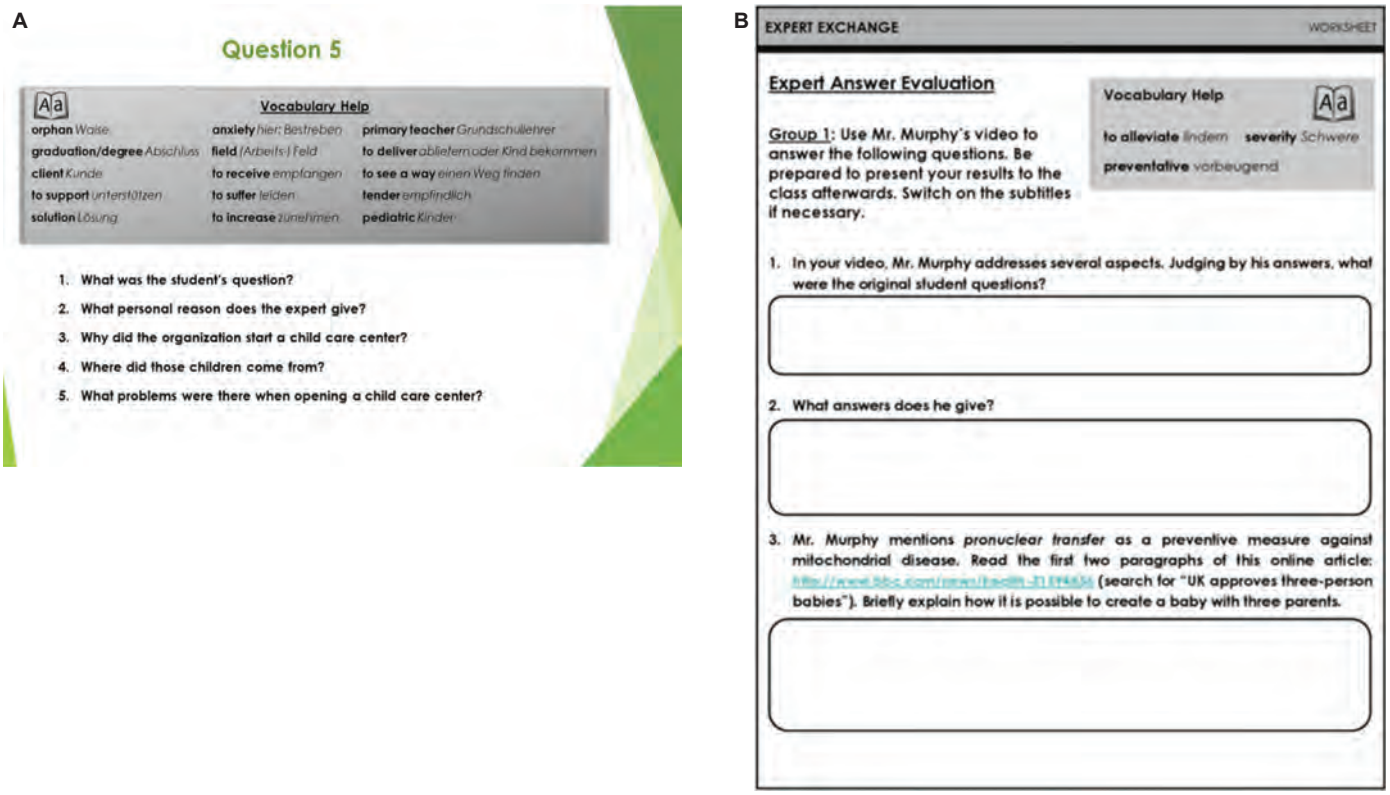

Figure 2. Sample of materials for the evaluation of experts' video answers. (**A**) Example slide for Method A in the immunology context. (**B**) Example group worksheet for Method B in the cell biology context.

(vocabulary lists, guiding questions, transcripts, and subtitles) for evaluating the expert's answers in class. The two options for evaluation are illustrated in Figures 1 and 2. Method A is to watch the answer videos with the full class, who are then given cooperative tasks. In our pilot study, for example, we had students focus on one or two basic comprehension tasks at first before distributing more detailed questions. Depending on the school's equipment, we also suggested a method in which students worked in small groups with

their own computer to evaluate different expert answers (Method B in Figures 1 and 2). Afterwards they presented their results to their peers.

○ Implementing the Instructional Approach in the Classroom

Participants & Method

We tested a first draft of the model in a preliminary case study in the curricular context of genetics. The participants were two 12th-grade courses (n = 37, 22 female) at a gymnasium (comparable to "honors" programs in the U.S. system) with an average age of 17.9 years. The students had attended English language courses for at least six years. Following the federal curriculum for English as a foreign language, their proficiency was about B2 on the Common European Framework of Reference for Languages (CEFR; KMK, 2004). In our second study, we adapted the exchange model for two classes in grade 10 in the context of cell biology (n = 50, 23 female; average age = 15.8 years). Both classes were part of a bilingual track at a German gymnasium and were thus enrolled in English-German history and geography CLIL lessons. Their proficiency level was around higher B1 and lower B2 on the CEFR (KMK, 2004). Our sample for the third study in the topic of immunology comprised three other bilingual classes (n = 82, 49 female) and three classes (n = 85, 40 female) that were inexperienced in CLIL. All students had been learning English for at least four years (total n = 168; average age = 14.3 years). Their proficiency level was about B1 on the CEFR (KMK, 2004), whereas the bilingual classes were likely to range slightly higher between B1 and lower B2 level.

The participating teachers instructed their classes themselves using materials provided by us and following the methods we had discussed in detail beforehand. Either the teachers were trained in both biology and English education or they were biology instructors who had acquired English proficiency during long-term stays in English-speaking countries. The first author attended the lessons of the video exchange in all three studies.

Instruments & Data Analysis

For the qualitative evaluation of the exchange, students were asked to provide a freely written answer to the item "What comments or suggestions do you have for improving the expert exchange project?" Their contribution was voluntary and students' feedback was assessed at the end of the lesson in which the expert's answers had been evaluated. Following Schreier (2012), students' statements were analyzed by two independent raters to develop a content-based coding scheme. Similar aspects were organized into qualitative categories. The interrater reliability was above 90 percent, and diverging cases could be resolved through discussion.

Preliminary Case Study

The main focus of the preliminary study was to identify potential pitfalls and ways to improve the probability of successfully implementing the new approach. Complementing the classes' standard unit on genetics, we designed six lessons on cancer as preparation for the exchange project (Figure 3).

The exchange itself was conducted with two hours of class time allocated to introducing the expert and filming questions and two hours in the following week to evaluate the expert's answers. For the video introductions, we asked the experts to provide information on their personal background and to describe their research field and workplace. Students were instructed to film short videos in which they said their names and asked questions in simple and clear language. They submitted these clips electronically within three days. Most students produced concise videos in which they introduced themselves and thanked the expert for her efforts. Some of their phrasing was very direct and may have seemed a little impolite ("I want to hear an answer"; all student comments translated from German). To counteract this issue, we included information on polite speech into our materials in the following studies. Students' questions ranged from content they had worked on in their lessons to more general aspects about the prevention of cancer and the chances for a final cure (examples in Table 1). Some students asked personal questions regarding their experiences with the cancer treatment of relatives. The expert sent her answers after about a week, which proved to be a rather short timeframe. We thus extended this phase to two weeks to make the schedule more feasible for the following studies. We used video editing to remove parts of the expert's answers that would have required very extensive support and discussions

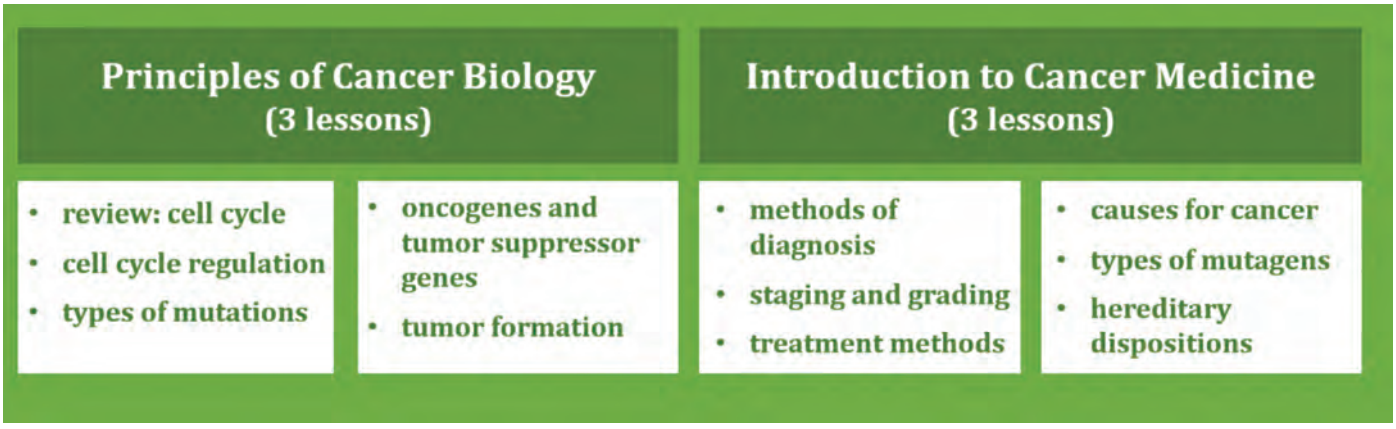

Figure 3. Overview of the six content lessons on cancer that served as preparation for the expert exchange in the preliminary case study.

due to difficult language and very detailed content. In following studies, we asked the experts to consider students' language and subject proficiency when formulating answers. For evaluation in class, Method A was applied (Figures 1 and 2) using the most relevant answers about cancer prevention, treatment, and misconceptions. The students whose answers could not be discussed received them as a video file. As an adjustment to the model for the future, we asked students to hand in their questions in small groups to reduce the overall number of inquiries.

When prompted to provide comments on the project, four students asked for "more time" to film questions and for the evaluation of expert answers. We thus moved the task of collecting potential questions to the very start of the teaching unit. One student suggested subtitles for the answer videos, and we followed this recommendation. Two students would have preferred live video chat, but, due to technological concerns, we adhered to the method of recorded videos. Regarding content, one student found the experts' field "too specific" and asked for "more general information on cancer." However, we believe this to be a realistic reflection of professions in the sciences and therefore did not alter our expert recruitment criteria.

Main Studies

After amending the instructional model as described, we tested it in the context of two other curricular topics: cell biology and immunology. The exchange on mitochondrial disease was incorporated after lessons on the structure and function of mitochondria. Following the research assistant's introductory video, we included a publicly available video of a patient with mitochondrial disease to give the students a concrete idea of its implications. In both classes, the evaluation of expert answers was conducted using Method B (Figures 1 and 2). The expert partner in the immunology context was a psychosocial specialist concerned with children and youths that are affected by the virus. The background of how HIV is transmitted and how AIDS may later occur had been covered in the previous two lessons. Two classes evaluated the expert's answers following Method B and four used Method A (Figures 1 and 2).

○ Results

We analyzed students' statements in the two main studies and identified three general categories into which they could be assigned: *appreciation, language comprehension*, and *method and content* (see Figure 4). Representative comments for each category are given in the following text and in Table 2.

In the context of cell biology, the category of *appreciation* featured two students commending the exchange as "super" and "a good idea," and another said that she "liked interacting with the experts" and "think[s] these kinds of things should be done more often." Regarding *language comprehension*, two students asked for

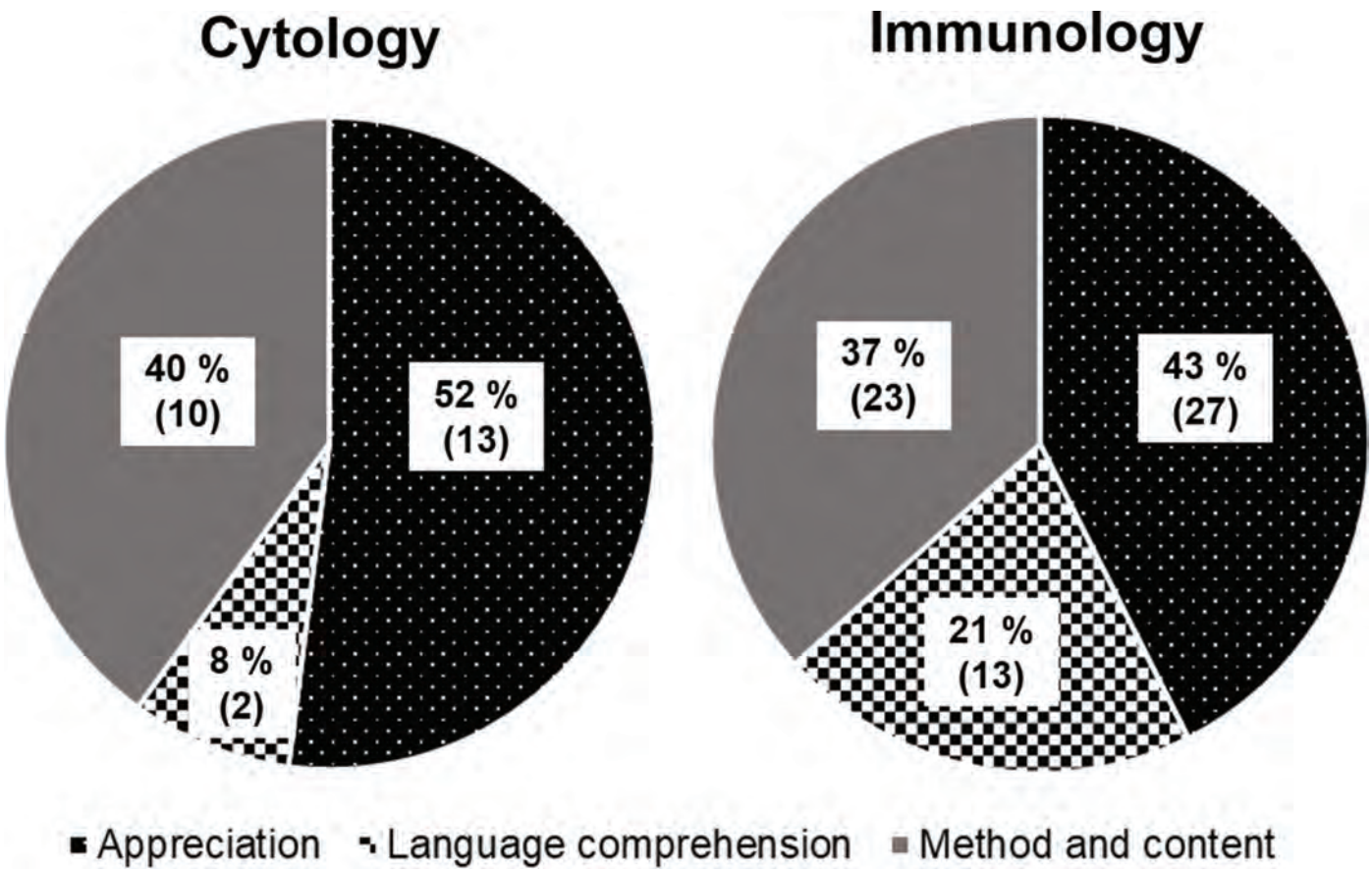

Figure 4. Proportion of cytology and immunology students' comments and suggestions for improvement for each of the three different categories (total mentions in parentheses).

Table 2. Sample of students' comments and suggestions (translated from German) for improvement, ordered by category, with curricular context in parentheses.

Qualitative Category	Sample Student Comments
Appreciation	• *It was super*. (cell biology) • *I liked interacting with the experts and I think these kinds of things should be done more often.* (cell biology) • *I liked that it was someone who lived far away and whom we would never have had contact with otherwise*. (immunology)
Language comprehension	• *It would be good to ask the expert to speak more slowly*. (cell biology, immunology) • *Subtitles for all videos/at all times*. (immunology)
Method and content	• *I actually liked all of it, but it might be interesting to do a live chat*. (cell biology, immunology) • *Exchange videos more often to answer further questions*. (cell biology) • *Longer evaluation of the experts' answers*. (immunology) • *More insight into [the experts'] work*. (immunology)

the expert to "speak more slowly" and wanted "better audio or subtitles." The category of *method and content* featured the wish for live video chats and three students wanted to have "multiple rounds" of exchange with the experts to "answer further questions." Two students wanted to watch the videos by themselves instead of working in groups, and one student wished for "less specific topics." In the last lesson of the exchange, some school computers malfunctioned, which elicited complaints by seven students.

In the exchange on HIV, 10 comments attested to students' *appreciation* of the video exchange, declaring it to be "good the way it was" and "very interesting." Others said the expert was "authentic" and "very likable," and that communicating with her "made for a nice change" and was "touching" and "thought-provoking." Regarding *language comprehension*, seven students wished for more support in the form of "subtitles" or "illustrations." Four of them explained that those aids would help them understand the experts' unfamiliar accent. Another three students asked for the expert to talk more slowly. In terms of *method and content*, there were five comments asking for "more time to film the videos" and to analyze the experts' answers. Another six students wanted to "gain further insight into [the expert's] work" by "having more questions answered." A popular idea (12 mentions) was the use of "live video chat."

○ Discussion

We will discuss insights from all three studies to answer our research questions.

Research Question 1: Is our instructional approach for an expert video exchange feasible in realistic school contexts? If so, what are the relevant factors for a successful implementation?

Compared to similar approaches (Basiliko & Gupta, 2015; Woods-Townsend et al., 2015), our concept posed an additional challenge due to the use of a foreign language. Answering our first research question, the results confirm that the model is feasible in school settings with different curricular topics and age groups. There are, however, several aspects to consider for ensuring a smooth and successful implementation. Compared to Basiliko and Gupta's (2015) model, our practical testing showed that school settings require more detailed planning and preparation than university courses. One factor is the critical role of an intermediary who checks video contributions for clarity, politeness, and redundancies. In addition to developing support materials for the evaluation of answers, this imposes considerable time requirements on the teacher. However, it transpired that these demands decreased with experience and already developed materials. Further, our observations and some students' comments indicate that the project should be scheduled generously.

Because all the students in our studies were ELLs, language comprehension was of central interest. Some participants perceived the experts to speak too fast, which might be due to their being used to learner-oriented, often slower-paced speech rates. Natural speech rates are, however, a valuable element of authentic conversation and might even improve comprehension skills over time (Hayati, 2010). Also, since there are options to rewatch videos and to use subtitles, a potential loss of information is kept at a minimum. Although the unusual variety of Ugandan English was perceived as an additional challenge, students were confident that this could be resolved by further language support. Also, given appropriate time, the six classes were able to answer guiding questions and extract relevant information from the videos by collaborating. It can thus be said that experts with unusual varieties of English are a viable option.

Our experience with malfunctioning computers in the cell biology context emphasizes the need to consider potential alternatives beforehand. In our case, one teacher remained with the students whose computers worked, while the other evaluated the answers using Method A (Figures 1 and 2) in a different classroom.

Using live video chats was a popular suggestion in all three contexts. However, all three studies confirmed that recorded videos feature possibilities for mediation, preparation, and methodology, which live video chats cannot match. Short live video chats about less complex matters might be feasible (e.g., having students introduce themselves or present their questions after practicing them). Given the technological basis, this could boost their motivation without risking substantial comprehension difficulties.

Research Question 2: What insight into their affective perception of the video exchange will students' comments provide?

In the two main studies, students' comments in the category of *appreciation* indicate that they enjoyed the method and valued the experts' efforts. Especially noteworthy is some students' wish to continue the exchange further; such willingness to repeat can be interpreted as a strong indicator for motivation (cf. Sansone & Morgan, 1992). Meeting this wish, a project-based approach could be tested in which student groups work on their questions and answers over the course of several weeks while keeping a learning journal, for example. The feasibility of this idea of course depends on the individual experts.

In contrast to the oncology and cell biology projects, the HIV expert was rooted in the social sciences. Although a direct comparison between curricular topics is inappropriate due to different participants, it can be said that a remarkable number of comments attested to high emotional involvement (e.g., calling the exchange "touching" and "thought-provoking"). Thus, such an interdisciplinary approach seemed especially effective in illustrating the real-life relevance of science content.

Limitations & Directions for Further Research

In this first attempt at an expert video exchange model, we focused on its methodology, organizational feasibility, and students' immediate perceptions. Now that the general model could be established, further research is indicated to elucidate its effects on students. It might be worth investigating if the exchange can influence students' perception of the variety of professions and personalities in the natural sciences. Stereotypical depictions of scientists as middle-aged, bespectacled men in lab coats still dominate the media and most students' minds (Christidou et al., 2010). Salonen et al. (2017) suggest that direct interactions with actual scientists might be the most effective method to deconstruct such stereotypes, and the exchange model seems well suited for contributing to this matter. Further, a longitudinal analysis could show whether the exchange influences students' subject-specific motivation for biology and (in the case of ELLs) English. Also, the concept might be expanded by having students conduct independent research for which the expert provides professional advice. Numerous citizen science projects that can be found online offer ideas on different curricular topics. Moreover, we suggest that the exchange model might be adapted to other subjects (e.g., social sciences or arts).

Educational Implications & Conclusion

We present a method to give secondary students personal insight into science-related careers. Students' comments attested to an emotionally positive perception of the project. The exchange thus enables ELLs to practice English as the language of science in an engaging context. Conducting expert exchanges on different curricular topics can therefore provide a new perspective on the content of science courses, which is relevant to both ELLs and native English-speaking students. The method's efficiency depends on a number of arrangements and preparations that impose considerable time requirements on the teacher. However, we observed that these demands lessened with repeated implementation of the model, so we believe that in the long term they are eventually outweighed by the authentic and purposeful interaction that students experience.

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