RESEARCH ON LEARNING

Using English as the Language of Science: An International Peer Video Exchange on Ecology

NINA MEYERHÖFFER, DANIEL C. DREESMANN

Abstract

*This article presents the development and testing of a content-based video exchange model as a motivating means to introduce lower secondary English learners to English as the language of science. The central goal was that students reach the required curricular content knowledge despite learning some of the content in a foreign language. The model was tested in German seventh-grade classes (*n = 133*), in which the students communicated with U.S. eighth-graders on the topic of ecology. Following field trips to a forest and a desert ecosystem, students presented and compared biotic and abiotic data in videos. The German students' content knowledge and their motivation were assessed in a pretest/posttest design. They met the curricular outcome requirements, and their motivation was remarkably high at both test times. We discuss implications for further application of the exchange model.*

Key Words: *content and language integrated learning (CLIL); bilingual education; science education; language of science; biology CLIL; out-of-school learning.*

○ Introduction

The singular role that English, as the language of science, plays in academic, professional, and private contexts is undisputed (Coleman, 2006). It is thus no surprise that English-language proficiency is linked to the academic success of non-native English speakers (Ghengesh, 2015). Yet most students in countries where English is not an official language only learn it in the traditional foreign-language classroom and thus may not experience its use in scientific contexts before entering higher education (Bolton & Kuteeva, 2012). They then often realize how the style, lexicon, and content of scientific discourse differ considerably from the everyday language they studied (Phillips & Norris, 2009). At the same time, English-bilingual instruction in non-language subjects is often restricted to bilingual programs (Dalton-Puffer, 2011). We argue that this is at odds with the prevalent curricular aim of enabling all students to participate in scientific discourse (e.g., KMK, 2004) and that all students must be given opportunities to develop and practice the necessary language skills. In language learning, the benefits of authentic reasons and situations have long been emphasized (Breen, 1985; Beatty, 2015), and this aspect is even more relevant when introducing young learners to English in the science classroom to help them recognize the language's value in scientific discourse.

We argue that the most authentic reason for using English is to communicate with actual English speakers, which is why we centered our instructional model around such an exchange. Expanding on our model of video exchanges with international scientists (Meyerhöffer & Dreesmann, 2019), we present an instructional approach to introduce non-native English-speaking students to scientific English in an authentic and motivating way. At the model's core is an international exchange of videos on different ecosystems with English-speaking peers. An authentic setting was created by communicating about two ecosystems that were not readily accessible to the respective partners. To further increase our model's value, we included approaches and activities that are known to yield high motivation, such as out-of-school learning sites (Behrendt & Franklin, 2014), cooperative work (Sharan, 2010), and modern technology (Molyneau et al., 2012). Drawing on principles of content and language integrated learning (CLIL), we developed materials to support students with the help of scaffolding and tasks incorporating both English and their native language (Meyer, 2010; Buxton & Lee, 2014).

CLIL is an umbrella term to describe "the use of at least two languages to teach various subjects in the curriculum" (Eurydice European Unit, 2006, p. 61). Because implementations vary, the outcomes of CLIL research are difficult to compare (Nikula, 2017), but certain trends are discernible in the extant literature. For example, most results indicate benefits for the participants' language abilities (Admiraal et al., 2006; Lasagabaster, 2011; Piesche et al., 2016), but existing research on content knowledge learning is less extensive and more inconsistent. However, most studies found no significant differences between students who were instructed through CLIL and their peers who were instructed in their native language (Admiraal et al., 2006; Rodenhauser & Preisfeld, 2015). From a practical perspective, ensuring that bilingually taught students achieve the required content knowledge goals is crucial, especially when working with young learners who have limited language proficiency. Assessing

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content knowledge gains was thus a central goal of the present study. Another area that lacks thorough empirical consideration is students' motivation in CLIL contexts. Most publications are either based on indirect estimations by teachers or feature very small samples (e.g., Scheersoi, 2008). Results of a study by Lasagabaster (2011) suggest that CLIL students are more motivated than their peers, but Bruton (2013) points out that most European CLIL programs select in favor of high-achieving and above-average motivated students, thus rendering comparisons with standard classes inappropriate. To account for this, four of our five participating classes were standard classes that had not undergone selection.

○ Research Goal

We developed an instructional model unit to introduce lower secondary English learners to scientific English in a feasible and motivating manner. For this, we conducted an English-German bilingual teaching unit centered on a video exchange between German students and U.S. peers. Set in the curricular context of ecology, the exchange was complemented with CLIL-oriented materials and a field trip to support learning. The German students' content knowledge was assessed to examine whether English-language elements had a negative effect on content learning. Further, standardized motivational scales and comments provided insight into students' affective perception of the project. In summary, the following research questions guided our studies:

1. Will the English learners achieve the required content knowledge outcomes despite using English-language elements in class?
2. How do the English learners rate the motivational value of the peer video exchange project?

○ Content & Procedures

Figure 1 provides an overview of the instructional model's four phases, which are described in the following. Before the start of the project, we acquired an exchange group by contacting other teachers through school websites. We then discussed the desired curricular contents of the unit, the length and scheduling of the exchange, and the technical means we would rely on (e.g., e-mail, video, shared documents). This phase was aimed at clarifying the extent and goal of the project and ensuring that the needs of both parties were met. The curricular topic of ecology offered the opportunity to examine ecosystems hands-on in the students' immediate vicinity. Students' comprehension of foreign-language input could thus be supported by drawing connections to their everyday lives and through multimodal activities (Meyer, 2010; Buxton & Lee, 2014). Given their location, the German participants would introduce Central European forests to their exchange partners. Aiming at a vivid contrast, we worked with a middle school located in the Sonoran Desert of southern Arizona.

Regarding technology, we chose recorded videos rather than live video meetings as a more reliable method for our young participants. Students thus could produce their videos and watch the other groups' contributions at their own pace. Further, recorded videos made it possible to develop scaffolding materials in line with CLIL methodology (e.g., subtitles, comprehension tasks, and illustrations). Once the arrangements were clear, we prepared appropriate teaching materials, including CLIL-based language support for the German group. Overall, the exchange and the unit were conducted over the course of six to seven weeks. During this time, the teachers also carried out traditional formal assessment (in German) of some of the curricular content. Over the course of the project, English-language elements such as original texts, videos, and tasks were incorporated into the German biology lessons. Following CLIL methodology (e.g., Meyer, 2010; Buxton & Lee, 2014), scaffolding in the form of vocabulary help, phrasing suggestions, and guiding tasks facilitated access for the bilingually inexperienced students.

In the introductory phase, the students shared some personal information through introductory videos and had lessons on basic ecological concepts. On one hand, this was to establish a friendly relationship between the peer groups and give the students a concrete target audience for the following tasks. On the other hand, it provided students with the necessary background knowledge and tools to work efficiently during their respective field trips. In this third phase, the students collected abiotic and biotic data at

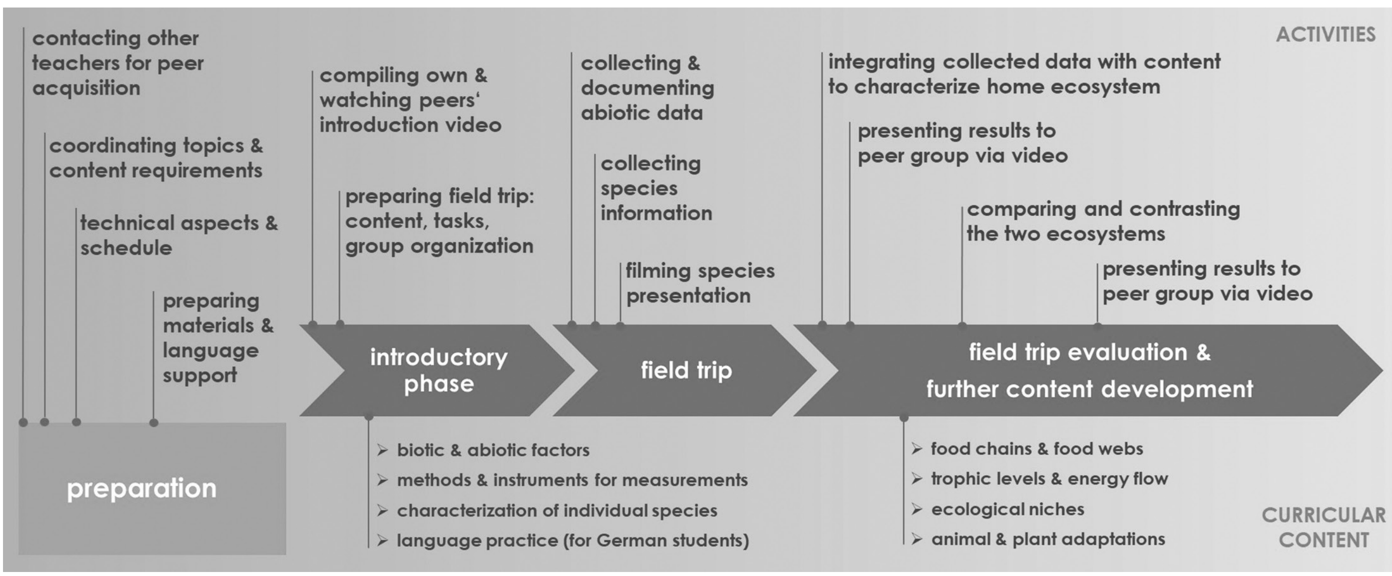

Figure 1. Overview of the instructional model for a peer video exchange in the curricular context of ecology.

an out-of-school learning site to characterize their respective ecosystems. Collecting their own data and receiving information from their peers was intended to help students develop an interest in and a closer relation to the object of learning.

For the field trip to a forest ecosystem, a nearby forest park, Fasanerie Wiesbaden, offered an ideal combination of near-natural conditions on one hand and a high probability of observing forest animals on the other. On the day of the trip, the German students worked on three tasks: (1) Each group had been assigned an abiotic factor (temperature, relative humidity, or light intensity) that was measured and documented at different locations. (2) They had been assigned two or three forest plant or animal species. They went to their species' compounds in the park and used the park's signs to complete a profile of the plant or animal. (3) Each group was given a tablet computer so that they could record short videos in which they presented each species to their U.S. peers. We collected students' videos afterward and sent them to the U.S. teacher. For the U.S. students' field trip, the Arizona-Sonora Desert Museum, a desert zoological and botanical park similar to the German forest park, was located in the school's vicinity. The U.S. eighth-graders fulfilled the same tasks as their peer group, but to prevent comprehension issues, we added subtitles and vocabulary support to their videos.

In the final phase, the data acquired on the field trips were exchanged and served as a basis to further develop curricular content during lessons. For example, students arranged the different species into food webs and trophic levels. They then used their peers' videos to transfer these concepts to desert equivalents. Evaluating and comparing their own data set with that of their peers provided the students with concrete examples they could personally relate to, in order to help them absorb the contents thoroughly. At the end of each of these units, a short video of the results was recorded for the exchange group. For example, the U.S. students gave a definition of trophic levels and the German students explained their food web of the forest. Abiotic data were compared between the two ecosystems and ecological niches were defined for species from both regions. Based on this work, students then proceeded to examine adaptations of desert plants and animals. This last phase also featured a comparison of two species in a web quest – for example, Eurasian lynx (*Lynx lynx*) and bobcat (*Lynx rufus*). The continued exchange of short videos on the results of some lessons served as a means to maintain contact between the peer groups and to sustain students' motivation.

○ Study Design

Participants

Five seventh-grade classes were recruited from two German academic-track schools (n = 138 [58 girls]). The students' average age was 12.6 years, and they had all been learning English for at least two years. One class was part of a bilingual track that did not, however, include bilingual science classes. Therefore, all five classes experienced English as the language of science for the first time in their school careers. After extensive discussions and preparations with the research team, the four teachers taught their classes themselves to avoid potential novelty effects due to instructors. The English-speaking partners for the video exchange were eighth-grade students in a large city in southern Arizona, USA (n = 38 [22 girls]). Their teacher selected the participants out of her classes based on an essay of motivation. Since we set our focus on the group of English learners, no empirical data were collected from the exchange partners at this stage.

Instruments

All assessment was carried out in the students' native language, German, to avoid comprehension issues. The content knowledge test was based on the curricular standards of the participants' state of Rhineland-Palatinate and had been thoroughly reviewed by the participating teachers to make sure that it was in accordance with their standards. The test consisted of four close-ended items (three true-false, one matching item) and six short-answer items. The items asked for the definitions of ecosystems, measurements of abiotic data, the naming of concepts like *ecological niche* and *symbiosis*, assigning trophic levels to organisms, and naming animal and plant adaptations to desert ecosystems. Open items were graded by two independent raters (with inter-rater reliability >90%) and all remaining cases were solved through discussions. The pretest score was deducted from the posttest score to calculate students' content knowledge gains.

Students' motivation for the exchange project and the accompanying teaching unit was assessed on the basis of expectancy-value theory, which proposes that an individual's behavior is determined by how likely they consider their success at a task and how much value they attach to it (Wigfield & Eccles, 2000). We used two standardized tests, one designed to be implemented before treatment and the other afterward. At the pretest, Freund et al.'s (2011) short form of the Questionnaire on Current Motivation (QCM) measured students' current achievement motivation with the four subscales *anxiety*, *probability of success*, *interest*, and *challenge*. At the posttest, students' intrinsic motivation for the unit and video exchange was tested with the short form of Deci and Ryan's (2003) Intrinsic Motivation Inventory (IMI) by Wilde et al. (2009). It featured the four subcategories *pressure/tension*, *perceived competence*, *interest/enjoyment*, and *effort/importance*. The phrasings of both QCM and IMI short form were adapted to fit the study context. In addition, students were asked to rate the project's difficulty level from 0 (not difficult at all) to 4 (very difficult), and they rated their willingness to participate in similar projects in the future. Lastly, they were asked to freely write suggestions for improvement of the project.

Data Analysis

Students rated all psychometric items on a five-point Likert scale from 0 (strongly disagree) to 4 (strongly agree). Reverse scored items were recoded and a total score for each standardized scale was calculated. The data were analyzed using IBM SPSS 23.0. Although Charter (1999) explains that Cronbach's alpha is an imprecise measure with sample sizes <400, we calculated it to assess scale reliability and interpret it with care. Cronbach's alpha was acceptable for *effort/importance*, *perceived competence*, and *interest/enjoyment* (Table 1). It was below acceptable for the QCM categories *probability of success* and *anxiety* and rather low in the categories *interest*, *challenge*, and *pressure/tension* (Table 1). In the case of *interest*, reliability could be increased to α = 0.777 by deleting one item. The data were not normally distributed, so nonparametric procedures were used for statistical testing. The significance threshold was set at 0.05. Students' comments on the item asking for suggestions for improvement were collected and organized into categories of similar aspects by two independent raters. Differences could be solved through discussions. Representative student comments are given below.

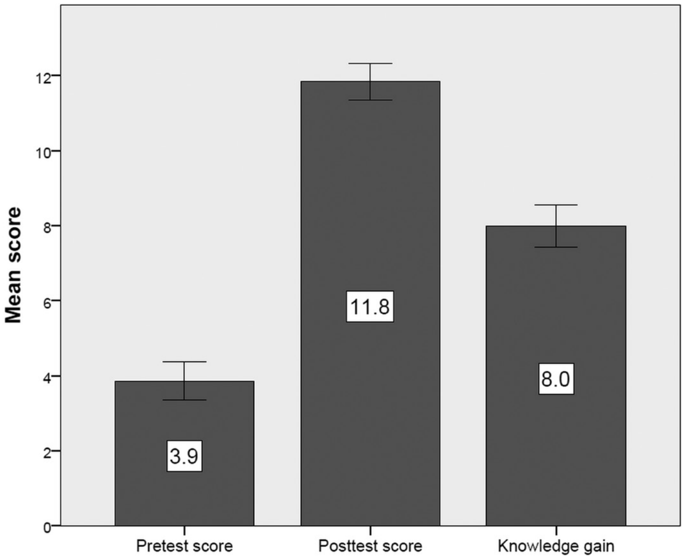

Figure 2. Mean of students' scores (out of 20) on the ecology content knowledge test before and after the unit and mean knowledge gains.

○ Results

Content Knowledge

While the students achieved a low average score (median = 3.0 out of 18) on the pretest, all five classes achieved significantly higher scores on the posttest (median = 12.0) ($Z = 9.47$, $P < 0.001$, $r = 0.86$, Wilcoxon signed-ranks test; Figure 2).

A Q-Q plot indicated that the results of the knowledge posttest followed a normal distribution with a mean of 11.84 (out of 20 possible points) and a standard deviation of 2.70. Regarding the content of test items, students scored particularly high when asked about methods for abiotic measurements (>80% answered correctly) and the components of an ecosystem (>90% answered correctly). The majority were also able to assign different forest species to their trophic level (mean = 6.41 out of 7) and to name at least some animal adaptations to the desert (mean = 1.14 out of 2). Students had more difficulties naming plant adaptations to the desert (mean = 0.97 out of 2), but their increase in correct answers was still statistically significant (median = 0.00 and median = 1.0) ($Z = 4.674$, $P < 0.001$, $r = 0.48$, Wilcoxon signed-ranks test). However, many were still unable to provide the terms *ecological niche* (mean = 0.04 out of 1) and *symbiosis* (mean = 0.01 out of 1) in the short-answer questions.

Motivation

Students' average ratings of the motivational tests are presented in Table 1. The pretest subscales *probability of success*, *interest*, and *challenge* and the posttest subscales *interest/enjoyment* and *effort/importance* featured high average ratings of around 3 (on a scale from 0 to 4). The same applied to the additional item asking whether students would like to participate in similar projects in the future. *Anxiety* and *pressure/tension* were rated low at around 1. Their mean *perceived competence* after the project was in the upper medium range of the scale, and they rated the unit's level of difficulty as low to medium.

Students' Comments & Suggestions

Sixty students provided comments or suggestions for improvement of the bilingual project. The categories (numbers of mentions in parentheses) that could be identified by the two raters were *demands for extensions* (30), *appreciation* (17), and aspects of *language* (10),

Table 1. Case number (No.), mean, standard deviation (SD), median, and range of seventh-grade student ratings in the four motivational categories of pretest and posttest. Ratings on a five-point Likert scale from 0 (strongly disagree/not difficult) to 4 (strongly agree/very difficult), with scale reliability as measured by Cronbach's alpha.

		No.	Mean	SD	Median	Range	α
Pretest	*Anxiety*	133	1.04	0.729	1.00	3.0	0.453
	Interest	133	3.23	0.880	3.50	4.0	0.777
	Challenge	133	2.94	0.798	3.00	4.0	0.678
	Probability of success	133	3.00	0.668	3.00	3.0	0.443
Posttest	*Pressure/tension*	122	0.96	0.739	1.00	3.0	0.604
	Interest/enjoyment	123	3.16	0.775	3.33	4.0	0.832
	Effort/importance	123	3.04	0.743	3.00	4.0	0.743
	Perceived competence	122	2.67	0.768	2.67	3.7	0.806
	How difficult did you find the unit and the exchange project?	120	1.12	0.758	1.00	3.0	NA
	I would like to participate in a similar project again in the future.	122	3.29	1.024	4.00	4.0	NA

content (6), and *technology* (4). A last category of *external aspects* (7) pooled comments that were unrelated to the design of the project itself (e.g., bad weather, composition of groups). Some longer comments covered several categories. In the following, representative student comments for each category are listed (all statements translated from German). The majority of statements are related to *demands for extensions* of different parts of the project. For example, students wished for "more contact with the American students" to "get to know the exchange students better" (10). Similarly, some wanted to "continue the project and film and watch more videos" (14). Others said they "would like to go to the forest several times" (4), or generally wished for "more time" during the project and to "make it longer" (3). One student suggested transferring the concept to other ecosystems, stating, "I would like it if we could maybe interact with several countries, including other places (e.g., somewhere cold)." A number of students expressed their *appreciation* of the unit and exchange by statements like "It was super" and "It was a lot of fun and interesting, thank you" (12). Some comments were more specific, for example, "I really liked the field trip" or "The videos were interesting" (5). Some comments in the category of *language* demanded "doing the exchange in German" (4), and others wished for "worksheets in German" or "lessons in German" (5). One student wrote that "the English on the worksheets was above my level most of the time." Regarding *content*, students asked for "covering some topics more thoroughly" (3) or wanted "more consolidation" (2). Comments regarding *technology* were mainly demands for "better video quality" (3), and one student suggested "using video chat."

○ Discussion

Students' Content Knowledge Gains

The students had limited prior knowledge in the pretest, but after participating in the exchange and its complementary teaching unit, they showed a significant gain in content knowledge. The participating teachers confirmed that the mean and distribution of the content knowledge test results corresponded with those of their formal assessment in school. Based on the data and their evaluation, it can thus be said that the students were able to acquire the desired content knowledge about ecology during the bilingual project. When looking at items with a particularly high percentage of correct answers, students seemed to remember content that was related to their field trip to the forest park well. This included the measuring of abiotic factors and the trophic levels of the plant and animal species they had researched. Such an outcome is in line with numerous studies showing that hands-on activities and field trips benefit learning (e.g., Hamilton-Ekeke, 2007). Students had more difficulties with more abstract content in the lessons following the field trip (e.g., the niche concept or species interactions), and previous research has shown that such ecological concepts may be hard to grasp (Jordan et al., 2009). Although the same tasks were used to work on both animal and plant adaptations, students seemed to remember desert animals better than plants. This result confirms previous findings of students being more likely to recall content about animals rather than plants (Wandersee & Schussler, 2001). It thus seems that students' learning during the project was similar to the results of previous studies in which foreign-language elements did not play a role.

Students' Motivation

Whether a low Cronbach's alpha of some motivational scales was due to our small sample size cannot be answered in this context. However, looking at the pretest and posttest scales overall, students' motivation for the project was high. Current achievement motivation before the unit was on the same level or even above that of other projects in school settings (e.g., Freund et al., 2015), and the same applied to the results of the motivation posttest when comparing it to student ratings reported by Wilde et al. (2009). This notion of high motivation is further supported by the students' willingness to participate in similar projects again and by several written comments in the category of *appreciation*. It should be emphasized that students' learning of the unit's content was not only assessed empirically in the context of this study, but was also subject to formal school assessment that would factor into their final grade. Therefore, it was possible that students felt anxious about learning through bilingual instruction. Indeed, 10 of the 138 students wrote comments stating that they would have preferred to do the exchange in German, or that they wished for fewer English elements in class. For them, more individual scaffolding (e.g., guidance through specific questions, vocabulary chunks, visuals) could prevent comprehension issues. However, despite their low reliability, low average ratings of *anxiety* and *pressure/tension* are complemented by a low level of mean perceived difficulty of the project. This indicates that overall, students did not feel overwhelmed by learning and communicating in English, even though they had been studying the language for only about two years.

On one hand, students' frequent wishes for a longer exchange and more contact with the U.S. students emphasize their positive emotional involvement in the project. However, along with demands for more thorough content and consolidation, this also illustrates how crucial the aspect of time is for the exchange project. A possible approach to address this issue might be to collaborate with the classes' English teachers and transfer the introductory phase into the foreign-language classroom. The groups could exchange some more information on their personal and cultural background via videos, e-mail, or messenger services. This would extend the cultural component of the project as a higher level of familiarity could be achieved, which should then make the exchange easier and more enjoyable for the students. Regarding methods and activities, some comments demonstrate that students enjoyed the field trip and filming their own videos, thus confirming the motivating effect of out-of-school learning sites and the use of modern technology (Behrendt & Franklin, 2014). It can thus be said that these best-practice approaches are useful in fostering students' positive attitude toward working with English outside of the foreign-language classroom. Schiefele (2009) explains that a repeated occurrence of high task-related interest might lead to the development of a more stable subject-specific interest. Since the mean motivational ratings of all five seventh-grade classes were high, implementing similar exchanges at several points in their school careers could potentially increase their general interest in biology or English over time. Further research is indicated to examine whether such effects exist.

Limitations & Further Research Implications

The present study design was focused on the English learners, and feedback from the U.S. group, albeit highly positive, was limited to informal reports by their teacher. However, empirical insight into the U.S. students' perception of the video exchange would certainly be conducive to the recruitment of international peer groups in the future. Another question that should be addressed is whether students' high motivation during a peer video exchange might also have positive long-term effects on their attitude toward biology and English. If this could be demonstrated, it would increase the model's value for practical application in school remarkably. Further, exploring the model's feasibility in other curricular contexts is indicated. For example, a trip to a genetics laboratory as presented by Rodenhauser and Preisfeld (2015) could be combined with a peer video exchange.

Educational Implications

The study showed that the peer-video-exchange model is feasible in lower secondary school and can be used as a motivating introduction to English as the language of science in the biology classroom. The results confirm that students can indeed acquire the desired content learning outcomes when foreign-language elements are incorporated using CLIL methodology. Outside of empirical contexts, there are high demands on teachers when preparing appropriate materials to ensure access to foreign-language sources and to facilitate students' English-language output. Further, scheduling the exchange carefully and including ample buffer time is paramount. However, these efforts were rewarded with high student engagement as reflected in the ratings and comments. We also presume that once the general framework and contact with a peer group are established, preparation requirements for future exchanges will decrease considerably. To improve the quality of communication and the relationship between German and U.S. students, future implementations should include a more extended introductory phase in which students get to know each other better. For this, an interdisciplinary approach with the schools' English teachers could offer additional time and learning resources.

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NINA MEYERHÖFFER (nmeyerhoeffer@uni-mainz.de) has recently earned a PhD from the Department of Biology Education (Institute of Organismic and Molecular Evolution), Johannes Gutenberg-University, Mainz, Germany, where DANIEL C. DREESMANN (daniel.dreesmann@uni-mainz.de) is a University Professor.