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Bilingual (German–English) Molecular Biology Courses in an Out-of-School Lab on a University Campus: Cognitive and Affective Evaluation

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Taking into account (German) students' deficiencies in scientific literacy as well as reading competence and the 'mother tongue + 2' objective of the European commission, a bilingual course on molecular biology was developed. It combines CLIL fundamentals and practical experimentation in an out-of-school lab. Cognitive and affective evaluation of 490 students from upper secondary schools followed a quasi-experimental design, including two experimental (bilingual course and monolingual course) and one control group that did not take part in any of the courses. Cognitive achievement concerning molecular biology and self-concept were measured in a pre, post, follow-up test design. The study has shown that cognitive achievement concerning biological content knowledge of students having participated in a bilingual course (English and German) does not differ significantly from cognitive achievement of those that have participated in a monolingual course (German). Regarding biological self-concept, no significant differences between students having assessed themselves as being rather interested and talented in foreign languages and students having assessed themselves as being rather interested and talented in science could be observed. This indicates that bilingual courses in an out-of-school lab are equally beneficial for both of these groups.

Keywords: CLIL, experiments, out-of-school lab, biological self-concept, cognitive load, levels of processing, cognitive achievement.

INTRODUCTION

In today's knowledge based society that is getting increasingly globalized, scientific and foreign language competence is becoming ever more relevant for its members to actively participate in social life. In comparison to the demands society requires of its members, a serious shortcoming of these essential competences can be observed on different levels. International comparative studies, such as PISA, have revealed a high proportion of German students having large deficits in scientific as well as in reading literacy (Klieme et al., 2010). Therefore, several studies and initiatives have been designed to meet the challenges of a globalized world by promoting relevant competences. One concept we developed and conducted is the combination of practical biotechnological experimentation in a laboratory environment on a university campus with the concept of Content and Language Integrated Learning (CLIL). Research results concerning the learning of biological content under CLIL conditions are only scarcely available so far (Koch & Bünder, 2006). As yet no studies referring to the acquisition of biological content knowledge exist for the combination of CLIL with practical experimentation in a laboratory environment. Besides, the impact of this learning arrangement on students' self-concept, interest and motivation is unknown. Due to the combination of two cognitively demanding factors, aspects looked at in detail for biological monolingual out-of-school (Damerau, 2013; Glowinski & Bayrhuber, 2011; Scharfenberg, Bogner, & Klautke, 2006) and biological bilingual in-school settings (Bonnet, 2004; Bredenbröker, 2000; Koch & Bünder, 2006; Scheersoi, 2008) need to be taken into account furthermore. Open research questions concern cognitive performance and affective aspects under conditions where bilingual learning is combined with phases of practical experimentation.

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A closer look at the circumstances, corresponding theories and relevant literature leading to the ideas mentioned above reveals the following conditions.

LITERATURE REVIEW

***Practical Experimentation**:* In German schools, practical science is scarcely taught and science lessons often have little reference to everyday life (Euler, 2004). Thus, it is not surprising that PISA studies have indeed assessed great deficiencies in scientific literacy of German students (Klieme et al., 2010). The conditions in schools are also believed to be responsible for students' general lack of interest in science and consequently for an absence of graduates in these fields. Hofstein and Lunetta (2004) see teaching of science in the laboratory as a means to achieve students' understanding of scientific concepts and problem solving competences. Moreover, out-of-school labs focusing on practical experimentation are assumed to meet the challenge of promoting students' interest in science and positive attitudes towards engaging in scientific topics (Brandt, 2005; Glowinski & Bayrhuber, 2011; Markowitz, 2004). In Germany, out-of-school labs exist in various fields and institutions, but nevertheless it is possible to identify common cognitive and motivational goals that are to be met by practical experimentation in an authentic environment. They comprise the promotion of interest and understanding for modern natural sciences. Out-of-school labs want to teach an authentic, contemporary picture of the subject and through this illustrate its relevance for society. Moreover, they want to show potential career options and fields of activity. In the field of Biology Education, as in natural sciences in general, experimentation is seen as a means to gain knowledge. But experiments in the field of Biology Education are also used to reach other goals, such as an illustration of certain subject specific contexts and phenomena, gathering experiences or getting familiar with typical laboratory equipment (Euler, 2009; Haupt et al., 2013). Because of the focus on experimentation in an authentic laboratory environment, these goals are of special relevance when looking at practical experimentation in out-of-school labs.

***Learning Science in a Foreign Language**:* The aim of the European Union's language policies (European Commission, 2012) is that every European citizen is able to speak at least two languages in addition to their mother tongue. Multilingualism is considered necessary for a common future of a European union, in which different nations, cultures and language groups are living together. As a means for reaching this goal, the commission recommends CLIL as an exposure to a foreign language that does not require extra time in the curriculum (European Commission, 2004). In practice, it has been shown several times that this concept has got the potential to positively influence students' foreign language competence (Bonnet, 2004; Bredenbröker, 2000; Seikkula-Leino, 2007). This is often ascribed to the fact that the focus is not on language learning, but on working on the content matter, which constitutes a more authentic use of language as a medium of communication (Müller-Hartmann & Schocker-von Ditfurth, 2004).

Cognition and Working Memory: According to Cognitive Load Theory (CLT) (Chandler & Sweller, 1991) irrelevant activities can interfere with learning or even inhibit the acquisition of skills. The theory distinguishes between intrinsic, extraneous and germane load, whereat extraneous load is the effect caused by overloaded information presentation leading to an obstruction of the capacity of the working memory (Paas, Renkl, & Sweller, 2004). Thus, to reduce the total cognitive load in learning situations, extraneous load should be avoided and germane load – the one that leads to schema acquisition and transfer to long-term memory – should be promoted. Nevertheless, CLT indicates that the reduction of cognitive load is not necessarily beneficial. Load can also have positive effects on learning as long as it is imposed by relevant mental activities that do not interfere with the actual process of acquisition (Paas et al., 2004).

Another theory concerning working memory and the transfer of information to long-term memory is the levels of processing framework suggested by Craik and Lockhart (1972). It indicates that the degree of semantic analysis determines if and how information is stored in long-term memory. More precisely, deep (respectively semantic) processing leads to more durable memory traces than shallow (respectively merely phonetic or orthographic) processing. For CLIL settings, Heine (2010) found that processing of subject matter in a linguistic form causes reflections about the semantic content and thus a deeper semantic processing of the subject matter. As CLIL is combined with practical experimentation in an out-of-school lab in the current study, these findings cannot be transferred to the actual educational concept and need to be examined again.

***Self-Concept**:* Self-concept is a person's perception of himself. These perceptions are generated through experiences with the environment and influenced by environmental reinforcements (Shavelson, Hubner, & Stanton, 1976). Concerning learning situations, it is assumed that past performances partly influence a person's self-concept and that following experiences and behavior are in turn influenced by self-concept (Dickhäuser, 2006). Thus, self-concept can serve as a variable helping to explain following performances and even career decisions. The self-concept of a person is supposed to be hierarchically structured. According to Shavelson et al. (1976), the general self-concept consists of the academic and non-academic self-concept. The academic one is again subdivided in self-concepts concerning different subject areas. As a revision of this model, the internal/external frame of reference model (Marsh, 1986) proposes three second-order factors, which represent nonacademic, verbal/academic and math/academic self-concepts. According to the theory of temporal comparisons (Albert, 1977), persons compare their actual performance to former performances and thus get information about changes. An increase in performance leads to a rise of self-concept and a drop in performance to a reduced self-concept. Referring to the situation in an out-of-school lab, students are able to compare their performances during the course to former school performances. In other studies concerning practical experimentation in out-of-school labs it could be shown that hands-on activities in this kind of learning environment in general do have the potential to strengthen students' scientific self-concepts (e.g. Euler, 2009).

RESEARCH QUESTIONS & HYPOTHESES

The research questions arising from these theoretical considerations and existing research results with respect to practical experimentation in out-of-school labs as well as CLIL in Biology concern cognitive as well as affective aspects.

Cognitive Achievement: On the cognitive side the question arises whether the combination of practical experimentation and the use of a foreign working language generates conditions in which each factor causes the impediment of the other. More specifically, it is unclear whether both the instruction and the teaching materials presented in a foreign language generate extraneous load. And whether this subsequently leads to less capacities of the working memory for the acquisition of experimental skills and knowledge on molecular biology and the other way round. Hence, one could also expect that the bilingual learning environment causes germane load instead of extraneous load and, therefore, results in positive effects on learning. Through the heavier load of the working memory, one could also conclude that the present educational concept results in worse cognitive achievement.

Research Question on Cognitive Achievement: Does the processing of biological content in a foreign language accompanied by hands-on activities cause cognitive overload and worse cognitive achievement in the end?

Self-concept: Concerning self-concept, one could expect that the experience of experimenting independently in the learning environment of an out-of-school lab results in a rise in self-concept per se. But because of the combination of these conditions with the concept of CLIL, the prerequisites are different and might lead to different results. Besides, results might differ, depending on students' general orientation. Thus, students seeing themselves as being rather foreign-language oriented might react differently to the educational concept than those that see themselves as being rather scientifically orientated persons.

Research Question on Self-Concept: In how far does the combination of CLIL and practical experimentation influence the biological self-concepts of students assessing themselves as being rather foreign-language oriented and students assessing themselves as being rather scientifically oriented?

MATERIALS & METHODS

Sample and Setting

The quasi-experimental study was conducted between 2010 and 2013 with two experimental groups and one control group. One of the experimental groups took part in a bilingual (English – German) course on molecular biology in an out-of-school lab and the other group attended a monolingual (German) course with exactly the same content and procedure. Both groups were provided with preparatory materials containing background information on molecular biology and genetics and methodological instructions. Besides the use of an additional working language, the only difference for the bilingual courses is that the preparatory material contained additional 'support-sheets' with support measures helping students understand the content linguistically. The control group, that did not take part in a course and for which the topic of genetics was not covered in the classroom during the period of data collection, was included to be able to exclude any potential pre test effect. Therefore, this group did not receive any treatment, but only filled in the questionnaires.

Data was collected in a pre, post, follow-up test design, with cognitive performance and students' biological self-concept assessed at all reference times. The first measurement was taken in school, one week before the students took part in the course on molecular biology in the out-of-school lab. In the meantime, teachers had to prepare their students with the help of the preparatory experiment-related materials provided by the investigator of the study. The second measurement took place immediately after the course in the lab. The control group took the test in school, just one week after the pre test. The follow-up test was conducted in the classroom about 8 to 10 weeks after the

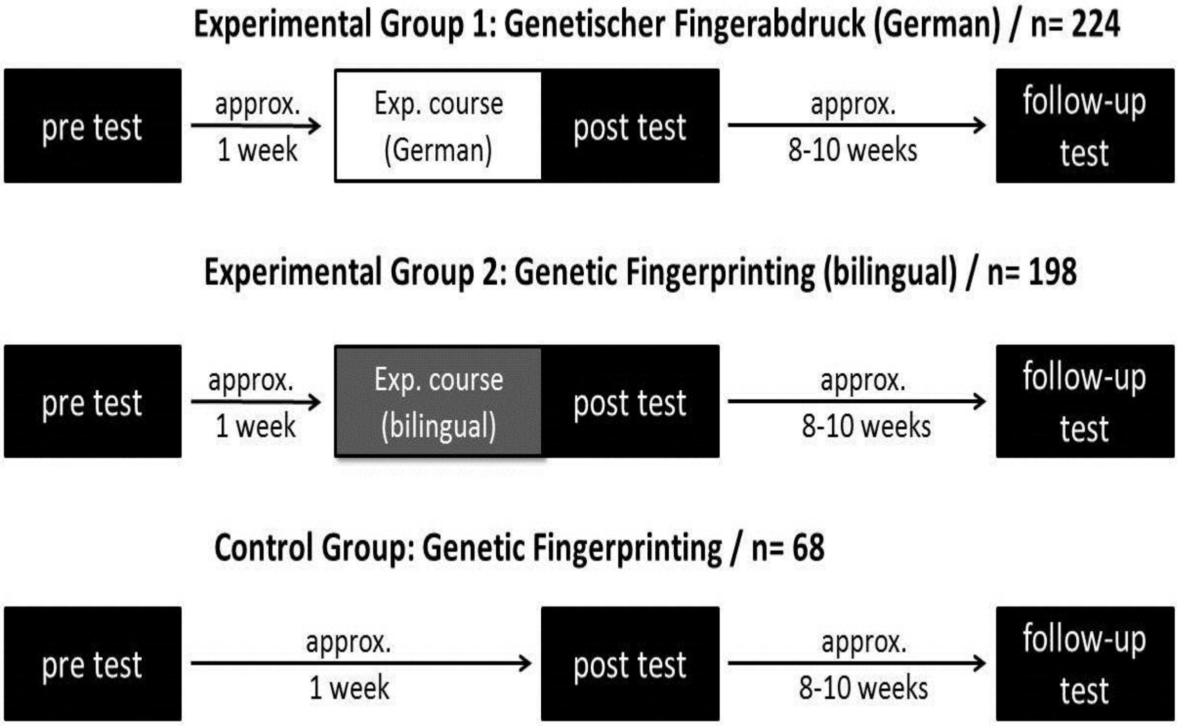

Figure 1. Overview of the experimental setting showing both experimental and the control group, including sample sizes

post test for all groups. An overview of the experimental setting showing all groups including sample sizes is presented in Figure 1.

A total of 490 upper secondary students from biology classes of different German schools participated in the study. 198 of them took part in a bilingual (English – German) course, 224 in a monolingual (German) course in the out-of-school lab and 68 students belonged to the control group. The monolingual sample is composed of 171 students from a previous study (Damerau, 2013) and 53 students that were instructed in German by the investigator of the study, to be able to exclude a possible teacher effect. The students' age was between 16 and 18 (M_{age} = 17.3, SD = 1.31). About 60 % of the students were female.

Educational Concept: The educational concept combining practical experimentation and CLIL fundamentals has been implemented in a course on molecular biology in an out-of-school lab on a university campus, for which the general procedure (for German and bilingual courses) will be outlined first (Damerau, 2013). In general, students have to find a (virtual) criminal by using the technique of genetic fingerprinting. Practically, their task is to extract DNA from oral mucosa cells, perform PCR and gel electrophoresis afterwards and compare the bands of the amplified genes to identify the offender in the end.

As successful lab-work is not possible without having basic experimental skills (Bryce & Robertson, 1985), elementary laboratory methods as well as background knowledge on genetics and molecular biology need to be prepared in advance (Scharfenberg, 2005; Sunal, Sunal, Sundberg, & Wright, 2008). Therefore, teachers are provided with the preparatory handout already mentioned. They are obliged to work through these materials with their students before coming to the lab. The general course procedure is contextualized in that students are confronted with a (virtual) criminal case presented in the form of a newspaper article. They are provided with information on victim, suspects and saliva samples from the crime scene. Following the concept of knowledge-based constructivism (Linn, 1990; Resnick & Hall, 1998), the criminal case, background information and methodological instructions are presented in a short pre-lab phase, in which students are encouraged to reflect on and discuss laboratory methods needed to be able to convict the offender. Moreover, they get a safety and a pipette handling instruction before starting the experimental phase in the laboratory (cf. Hodson, 1998; Lunetta, 1998). In this way, students are provided with knowledge they are able to construct their findings made during the experimental phase with. During the experimental phase, students work independently in groups of two to three persons. They are supported by an experimental manual and are able to enlist on experts' (usually research associates) help whenever needed. Each group can choose one of three different DNA samples (two from the suspects and one from the crime scene) to perform a genetic fingerprint with. First, the sample is prepared for the replication of the locus D1S80 (Budowle, Chakraborty, Giusti, Eisenberg, & Allen, 1991; Kasai, Nakamura, & White, 1990) by PCR. During the PCR process, students extract their own DNA from oral mucosa cells to be able to reconstruct the extraction process having been applied to the DNA samples they received. As soon as the amplified DNA sequences (D1S80) are available, a gel electrophoresis involving all the preparatory steps, as casting the gel and applying the samples to it is carried out by the students. Afterwards, DNA bands in the gel can be observed under UV light. By comparing the bands of the three samples, students are able to identify the murderer. As it cannot be assumed that students develop an understanding about course contents and methods simply by doing the experiments (Abd-El-Khalick et al., 2004), students' results and problems or questions that they may have encountered are talked about in a reflection phase at the end of the course.

***Distinctive Features of the Bilingual Courses**:* The general course program is the same for both experimental groups. The only distinctive features of the bilingual courses are the working language and the preparatory material containing additional linguistic support measures. For the major part of the course the working language is English, even though in some cases, attention is drawn to the mother tongue to indicate similarities or differences between both languages. In general, students should be able to explain all the issues discussed in the course in both languages. Therefore, the corresponding German technical terms are not excluded, but mentioned deliberately in some cases. As there usually is a discrepancy between cognitive and linguistic competences in CLIL settings (Thürmann, 2005), the preparatory material contains so-called support sheets. These sheets comprise linguistic advice for specific formulations, matching tasks for laboratory equipment, recommendations to reading foreign-language scientific texts and vocabulary including phonetic transcriptions. During the course, students are encouraged to speak English, but in cases where the foreign language would hinder communication, they are allowed to express few sentences in German.

INSTRUMENTS

***Cognitive Test**:* The questionnaire we developed included a cognitive test (Damerau, 2013) consisting of 106 items in the form of 26 multiple-choice questions regarding modern genetics and laboratory methods applied during the course (DNA extraction, PCR, gel electrophoresis). Each question includes four to eight items of which one to four are correct. The questions are the same at all three reference times, but the order varies. Items were scored with one point for a correct and no point for wrong answers. A sample question can be found in the Appendix.

As the cognitive test consists of topics being part of the biology curriculum, its criterion validity was checked by correlating Test Scores with the external criterion Students' Biology Grades. It is approved by a highly significant correlation ($r(489) = -.263$, $p \leq .001$), which is negative, because in the German grading system 1 is the best and 6 the worst grade. The objectivity of the test analysis is guaranteed because it only consists of multiple-choice items, for which a sample solution was created beforehand.

Cognitive load was measured in an indirect, objective way (Brünken, Plass, & Leutner, 2003) by using performance outcome data in form of knowledge acquisition scores. According to Brünken et al. (2003) it can be assumed that the more knowledge the learners acquire, the less extraneous load is induced by the instruction.

***Affective Questionnaire**:* Self-concept was measured using a five-point Likert-type scale (*0 = strongly disagree*, 1 = *disagree*, 2 = *neither agree nor disagree*, 3 = *agree*, 4 = *strongly agree*). Moreover, the following personal data was collected: gender, mother tongue, possible stay abroad (longer than six months), last grade in Biology and English, self-assessment concerning students' general orientation (rather scientifically oriented, rather foreign-language oriented,

Table 1. Affective Variables with Scale Name, Reliability, Description and Sample Items

Scale	Reference time	Cronbach's *a*	Description	Sample item (original item)	Sample item (translation)
Self-concept (2)					
	pre-test	α = .85	science-related self-concept	Für Biologie habe ich einfach keine Begabung.	I am just not talented in Biology.
	post-test	α = .77			
	follow-up-test	α = .86			

equally interested in both).

Students' biology-related self-concept was measured using two items at all reference times. The measurement and evaluation was carried out in accordance with similar studies (e.g. Glowinski, 2007). An item example and Cronbach's alpha values for pre, post and follow-up test are given in Table 1. Showing values between .77 and .86, the internal consistency of the scale is satisfactory.

DATA COLLECTION

The whole test was conducted as a power test (Rost, 2004), because it was only intended to measure if students are able to answer the questions correctly in an adequate processing time. It was not intended to produce pressure of time. Questionnaires were used in German for all groups and reference times to exclude insufficient understanding of questions because of translation problems. All data was collected under supervision of the investigators of the study either in the classroom or in the rooms of the out-of-school lab.

DATA ANALYSIS

All analyses were conducted using SPSS (Vers. 21). As the cognitive test is intended to measure the cognitive capacity concerning course topics, items must not be too easy or too difficult. Thus, according to similar studies (Damerau, 2013; Großschedl & Harms, 2008; Leibold, 1997), only post test items showing an index of difficulty between 10 % and 90 % in the post test are included in further steps of evaluation. After having excluded 28 items by the use of the item-difficulty-index, the discrimination coefficient was determined for the remaining 78 items. Items not showing an adequate discriminatory power were eliminated from the scale (Häußler, Bünder, Duit, Gräber, & Mayer, 1998). Thus, items showing a discrimination coefficient of $r < .09$ were excluded from further evaluation. 51 items remain, showing a Cronbach's alpha value of internal consistency of .89.

To answer the posed research questions concerning changes in cognitive achievement and self-concept over the three reference times, repeated measures ANOVAs were used. As some participants' characteristics will be used as factors in further analyses, descriptive statistics of relevant participants' personal data will be presented first.

RESULTS

Descriptive Statistics: About 60 % of all students were female. This was also the case for the two experimental groups. For the control group, the distribution was contrary. In the overall sample, for about 87 % German was the mother-tongue. Similar values could be observed for the bilingual and the control group. In the monolingual group, even 96 % were native speakers of German (n= 53; data was only available for the current study). In all groups, less than 10 % had already been abroad for longer than six months. For self-assessment concerning students' general orientation, in the overall sample 39.5 % stated to be rather scientifically oriented, 33.8 % to be rather foreign-language oriented, and 26.8 % stated to be equally interested in both. In the bilingual group, 44.4 % were rather scientifically oriented and 29.1 % rather foreign-language oriented (for all descriptive values see Appendix).

Table 2. Cognitive Test: Means and Standard Deviations for Pre, Post and Follow-up Test for Both Experimental Groups and the Control Group

Group		Pre Test		Post Test		Follow-up Test	
	n	M	SD	M	SD	M	SD
Experimental Group 1 (German)	224	28.50	5.95	39.31	6.56	34.74	6.79
Experimental Group 2 (bilingual)	198	28.42	4.90	36.57	6.65	33.70	6.29
Control Group	68	22.13	3.20	22.01	3.10	24.26	3.99

Results of the Cognitive Test: The average scores of the cognitive test were compared for the three groups and the three reference times. Means and standard deviations for all three groups and reference times are shown in Table 2.

The control group did not show any significant changes in knowledge from pre test to post test. A dependent samples *t* test revealed no significant difference in test scores between the two reference times (t (67) = .260, $p >$ .05). Thus, repeated testing alone exerted no influence and a pre-test effect can be excluded. Moreover, a repeated measures ANOVA was used to see if average test scores of monolingual courses depend on the course leader. It revealed no significant interactions between monolingual courses from a previous study (Damerau, 2013) and monolingual courses conducted during the present study. As Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of Reference Time, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity, $F(1.88, 418.24) = 2.19, p = .116, \eta_p^2 = .01$. Thus, a teacher effect can be excluded and data for all monolingual courses will be analyzed together.

Through the use of three repeated measures ANOVAs, statistically significant interactions between the three reference times and groups were revealed. Degrees of freedom were corrected using the Greenhouse-Geisser estimates of sphericity. There was a significant main effect of Reference Time between pre test and post test, $F(1, 487) = 404.07, p < .001, \eta_p^2 = .45$, between post test and follow-up test, $F(1, 487) = 41.21, p < .001, \eta_p^2 = .08$, and between pre test and follow-up test, $F(1, 487) = 222.15, p < .001, \eta_p^2 = .31$. These results indicate that in general, students gained knowledge between pre test and post test and that they forgot some of the knowledge up to the follow-up test. The comparison between pre test and follow-up test reveals a sustainable retention of knowledge. Moreover, a statistically significant interaction Group x Reference Time could be observed between pre test and post test, $F(2, 487) = 85.98, p < .001, \eta_p^2 = .26$, between post test and follow-up test, $F(2, 487) = 45.07, p < .001, \eta_p^2 = .16$, and between pre test and follow-up test, $F(2, 487) = 12.69, p < .001, \eta_p^2 = .05$, for all three groups. To further test the differences between the groups, post hoc tests were conducted. The comparisons using the Scheffé post hoc criterion of significance indicate that knowledge gain from pre test to post test is significantly different between the following pairs of groups: control group and bilingual group ($p < .001$), control group and monolingual group ($p < .001$) and bilingual and monolingual group ($p > .01$). The same applies to knowledge loss from post test to follow-up test ($p < .001$ between all pairs of groups). The difference in test scores from pre test to follow-up test is statistically significant for the comparison between the control group and the two treatment groups ($p < .001$), but not significant for the comparison between the bilingual and the monolingual group ($p = .52$). These results indicate that there is no significant difference in retention of course contents, whether they were presented in a bilingual or a monolingual course in the out-of-school lab.

Results of the Affective Evaluation: Potential differences in biological self-concept of participants of bilingual courses were examined over the three reference times to see if students that assessed themselves as rather scientifically oriented ($n = 87$) or rather foreign- language oriented ($n = 57$) differ concerning self-concept changes. Means and standard deviations for the two groups at all reference times are given in Table 3.

A comparison from pre test to post test between these groups using a univariate ANOVA, in which the difference in self-concept at the time of the pre test (t (142) = 9.50, $p < .001$) was considered as a covariate, revealed that the groups do not differ significantly in change of their biological self-concept, $F(2, 141) = .41, p = .52$. When looking at the changes in biological self-concept for the different groups (see Table 3 for means and standard deviations), there seems to be a tendency for the ones being rather foreign-language oriented to increase their biological self-concept, whereas there is not for those being rather scientifically oriented. To see if these differences are statistically significant, repeated measures ANOVAs were conducted over the three reference times for both

Table 3. Biological Self-concept: Means and Standard Deviations for Students Having Assessed Themselves as Being Rather Foreign-Language/Scientifically Oriented

Group	Pre Test		Post Test		Follow-up Test	
	M	SD	M	SD	M	SD
Rather scientifically oriented	3.43	.72	3.37	.85	3.34	.72
Rather foreign-language oriented	2.06	1.00	2.21	1.08	2.08	1.12

groups. A statistically significant effect of Reference Time could be observed for neither of the two groups (science: $F(2, 170) = .60, p > .05$; foreign languages: $F(2, 112) = 1.46, p > .05, \eta_p^2 = .03$). These results indicate that even if no significant changes in biological self-concept could be observed, bilingual courses in an out-of-school lab seem to be at least equally beneficial for both of these groups. Moreover, there seems to be a tendency for students that assessed themselves as being rather foreign-language oriented to strengthen their biological self-concept more than the other group.

DISCUSSION

Cognitive Evaluation

The cognitive achievement research question, whether the processing of biological content in a foreign language accompanied by hands-on activities causes cognitive overload and worse cognitive achievement in the end, can be answered in two ways. On the one hand, the processing of biological content in a foreign language accompanied by practical experimentation does not seem to have a negative impact on cognitive achievement. Eight to ten weeks after having participated in a lab course no significant difference in memory performance between students of both experimental groups could be identified. This is contrary to our expectations to some extent, because participants of the bilingual courses had to process contents on different levels at the same time. In our bilingual courses, the acquisition of biological content is accompanied by thinking about word meanings, looking for the right wording or looking up vocabulary, which is a component completely missing in the monolingual courses. Thus, equal cognitive achievement can be explained in accordance with the levels of processing theory (Craik & Lockhart, 1972). Besides, this has already been suggested for in-school settings by Heine (2010). She states that the incorporation of the foreign language causes a deeper semantic processing of the content leading to better memory performance in the end. But in comparison to the present study, her data was collected in a non-experimental situation, what makes the fact that there is no difference between both experimental groups in our experimental setting even more interesting. Even though the processing of content knowledge and the usage of a foreign language is furthermore accompanied by practical experimentation, the effect of the depth of processing seems to be strong enough that we cannot observe differences between the experimental groups in the end.

On the other hand, the combination of two cognitively demanding factors seems to generate extraneous load (Chandler & Sweller, 1991). Participants of bilingual and monolingual courses differ in knowledge gain from pre test to post test, which leads to the assumption that the working memory of participants of a bilingual course is loaded stronger than that of participants of a monolingual course. Another possible explanation for this difference may be the fact that questionnaires were used in German for all groups. This may also have had a negative influence on bilingual course participants' average test scores. As they processed the majority of the biological content in English during the course, filling in the German questionnaire directly after the course may have been more demanding for this treatment group as for the other one. Overall, the difference in knowledge gain is relatively modest between both experimental groups. Thus, our interpretation of the data is that the current educational concept does not seem to generate as much extraneous load that it leads to cognitive overload.

Summarizing these two answers, average cognitive achievement is the same for all participants, no matter if they have participated in a bilingual or monolingual course. Through the present educational concept students do not only acquire biological content knowledge, but also practice their foreign language competence and their ability to experiment at the same time. Thus, three competences can be promoted at the same time without sacrificing cognitive achievement concerning biological contents.

Affective Evaluation

The research question on self-concept was, in how far the combination of CLIL and practical experimentation influences the biological self-concepts of students assessing themselves as rather foreign-language oriented and students assessing themselves as rather scientifically oriented. The results of the evaluation indicate that the combination of practical experimentation with foreign language elements does not seem to be more or less advantageous for students assessing themselves as being rather foreign-language oriented than for those assessing themselves as being rather scientifically oriented. Against the background of the internal/external frame of reference model (Marsh, 1986), one could expect that it is less likely for the former group to strengthen their biological self-concept, because they assess their capabilities in science as rather low from the outset. But in fact, this does not seem to be the case and there seems to be a tendency especially for this group to a positive change of biological self-concept. These results may stem from positive experiences made during practical laboratory work, because this may have been so different from usual biology lessons in school that students experience their abilities in a completely different way. Another explanation may be that the effect stems from external comparisons with other course participants. Possibly, students having a high verbal and a low biological self-concept, experience that they are better at understanding the experimental manual and background information and therefore better in conducting the experiments than their schoolmates. Hence, our study shows that it seems to be advantageous especially for these students to combine practical science with a foreign language, namely something they feel secure with.

Future Prospects

In the further course of the study, several other affective aspects, such as interest in biology and foreign languages, motivation, perceived authenticity and career plans are to be measured. Besides, foreign language reading competence and learning strategies concerning reading foreign language texts are going to be assessed. On the one hand, the evaluation of this data will give even more insight into the suitability of the educational concept to especially promote foreign language oriented students' attitudes towards science. On the other hand, it will be possible to see if the integration of a foreign language has an impact on scientifically oriented students' biological and foreign language self-concept, motivation and interests. Concerning students' cognitive performance, the aspect of depth of processing would be interesting to investigate further. A suitable method to be applied in a following study would be the thinking aloud method, that has already been used for CLIL in-school settings (Heine, 2010).

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Appendix.

Cognitive Test: Sample Question (Original)

Welches der folgenden DNA-Fragmente wandert bei einer Elektrophorese in einem 1,1 %igen Agarosegel am schnellsten? (kb = Kilobasen, 1 kb = 1000 Basenpaare)

- ☐ 1kb - Fragment
- ☐ 0,2kb - Fragment
- ☐ 0,3kb - Fragment
- ☐ 2,3 kb - Fragment

Translation (not used in the original test):
Which of the following DNA fragments is migrating through a 1.1 % agarose gel fastest during electrophoresis? (kb = kilobases, 1 kb = 1000 base pairs)

Descriptive Statistics of Participants' Personal Data

Variable	Category	Overall Sample		Bilingual Course		German Course		Control Group	
		n	%	*n*	%	*n*	%	*n*	%
gender	female	287	58.6	128	64.4	129	57.6	30	44.1
	male	203	41.4	70	35.4	95	42.4	38	55.9
mother tongue[1]	German	276	86.8	170	85.9	50	96.2	56	82.4
	English	5	1.6	4	2.0	-	-	1	1.5
	Turkish	10	3.1	10	5.1	-	-	-	-
	Russian	2	0.6	2	1.0	-	-	-	-
	Others	25	7.9	12	6.1	2	0.9	11	16.2
stay abroad[2]	yes	24	7.5	17	8.6	2	1.9	6	8.8
	no	294	92.5	180	91.4	50	98.1	62	91.2
general orientation: self-assess-ment	science	124	39.5	87	44.4	8	15.4	29	43.9
	foreign languages	106	33.8	57	29.1	26	50.0	23	34.8
	both	84	26.8	52	26.5	18	34.6	14	21.2

[1&2] Data was only available for the sample of the current study (n= 318); it was not available for the sample from Damerau (2013) (n= 172)