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Effects of Bilingual Biology Teaching at Middle Schools

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Abstract

This classroom-based study investigates the relative effectiveness of content and language integrated learning in Biology for students with limited knowledge of English. The sample comprised 252 German-speaking learners of English taking intermediate English courses (3rd year of English learning) at a special secondary school (German “Mittelschule”), who were randomly assigned to one of three groups: lesson being conducted in English, the lesson being conducted in German, and a control group. A teaching unit about the topic “breathing” served as intervention. To determine the effects of the two instructional methods, the participants’ prior knowledge about the topic and their motivation based on general interest in the subject, specific interest in the topic and the level of self-efficacy experienced was measured beforehand with pre-tests. An immediate post-test about content knowledge and motivation was taken right after the lesson, a post-test after one month should show long term consolidation or change in motivation. Even though most other studies show negative effects of bilingual teaching for students with a low level of language skills, the results here indicate that neither knowledge nor motivation in classes with relatively little knowledge of English was significantly different in both groups, students with multilingual background seemed to even benefit from the bilingual instruction provided that specially prepared lessons were used serving the learning needs of the students.

Keywords: *CLIL, Bilingual Biology Teaching, Second Language Acquisition, Multilingualism*

Introduction

Speaking English is required in the corporate world. More and more business meetings are conducted in English, and this language became the universal language of science (Drubin & Kellogg, 2012), for example. Furthermore, languages are the key to knowing other people and helping to expand people’s cultural horizon (Commission of the European Communities, 1995). Therefore, the Commission of the European Communities stated that each European citizen should be able to speak at least two foreign languages. All good reasons for children to start speaking English at an early stage. Furthermore, neuroscientists prove that early

multilingualism also shows positive effects on higher empathy, better impulse control, flexible thinking, and greater metalinguistic awareness (Mechelli. et al., 2004; Della Rosa et al., 2013; Crivello et al., 2016; Franceschini et al., 2003).

Considering the need for students to start using English as a second language (L2) as early as possible, the usual few hours a week of compulsory English lessons at school does not seem sufficient. To increase the amount of language input approaches like CLIL (Content and Language Integrated Learning), bilingual subject teaching as it is called in German-speaking countries or EMI (English as a Medium of Instruction) are spreading at a fast rate across the globe (Banegas et al., 2020; Bower et al., 2020; Hemmi & Banegas, 2021; Graham et al., 2018; Lin, 2015; Pérez-Cañado, 2016; Yang, 2017), offering a wide variety of subjects and school types, even starting at primary level (e.g., Bonnet, 2004). The objective is to promote content and language skills to pre-defined levels by using an additional language for learning and teaching content (Marsh & Frigols, 2010).

The term “bilingual” is misleading as the lessons are normally supposed to be taught monolingual, i.e. in the foreign language. The aim, though, is to bring children towards multilingualism. It is quite conceivable that a second language being used for learning might increase concentration and awareness leading to a better understanding and more sustainable processing. However, are the benefits on knowledge and motivation for the content and the language evidence-based and are there risks, especially for students with a low level of English competence?

Benefits and Risks of CLIL

Many recent studies have focused on the effects of CLIL for all three aspects of the Language Triptych (Coyle et al., 2010), meaning the language of learning, language for learning and language through learning, but also the effects on the content, many of them highlighting the benefits of integrating content and language in multilingual educational contexts (Várkuti, 2010; Corrales, Rey, & Escamilla, 2016). According to Lightbown and Spada (2020), integrating language teaching and academic subjects (e.g., geography) adds more time to L2 learning without subtracting time from meaningful content learning.

Most studies show improvement in general language proficiency through participation in CLIL (Köller, Leucht & Pant, 2012; Zydatiř, 2007) recently confirmed in a review of CLIL research carried out in Europe by Ohlberger & Wegner (2018), and Goris et al., (2019). The improvement is either related to several areas of language competence (as shown in the studies conducted by De Diezmas (2016), Mayo and Ibarrola (2014), Czura and Kołodyńska, (2015), or the large-scale study DESI by Nold et al. (2008). Some show improvement related to single areas such as linguistic correctness (Rumlich, 2012), reading (Bredenbröker, 2000, Admiraal et al., 2006) and listening comprehension (Dallinger et al., 2016). Other studies showed a broader productive and receptive vocabulary (Canga Alonso, 2015; Canga Alonso & Arribas Garcia, 2015) and the development of foreign language discourse skills (Breidbach et al., 2003).

Motivation is often viewed as one of the most determining factors in language learning (Lamb, Csizér, Henry, & Ryan, 2019; Ushioda, 2016). CLIL research suggests that CLIL models may enhance learning motivation for L2 provided that the second language is a mandatory subject at school (Lasagabaster, 2019).

Findings show that CLIL had a positive impact on student's motivation and attitudes towards the English language (Arribas, 2016), enhances learners' motivation to learn English (Banegas, 2013) and content (Lasagabaster, Doiz, & Sierra, 2014; Lasagabaster, 2011). The possible explanation for these findings is that CLIL contributes to motivation enhancement as the content, materials, tasks, and L2 communication (Fazzi & Lasagabaster, 2021) are authentic and connected to learners' academic interests and the L1 curriculum.

Rumlich (2014) or Abendroth-Timmer, (2007) found positive effects on motivation for the subject. An existing motivation for the subject could also have a positive effect on language learning, like a "double effect", according to Coyle et al. (2010).

Despite all those positive results, some researchers express their doubts about implementing bilingual subject teaching (e.g., Appel, 2011). Researchers like Pérez-Cañado (2018) point out that studies should always be interpreted with caution, as many often show weaknesses in the methodology and the so-called "creaming effect" (Rumlich, 2017) must be considered. Rumlich's research in the German context shows that the interest of CLIL students and non-CLIL students for English and English as a school subject is different before the start of CLIL. Their average interest was much higher at the beginning compared to non-CLIL students and schools without CLIL. Therefor the positive impact of CLIL on students in Germany might be explained. The assignment to CLIL classes does not happen randomly so that those learners might bring positive requirements like basic cognitive skills or foreign language-related motivation to learn. Other important factors influencing the results like the teacher's competence, the quality of teaching, the effects of specific teaching methods (Dalton-Puffer et al., 2010) would not be considered. Only some studies analyze the prior knowledge of the students (Bruton, 2013; Rumlich, 2014).

For most students, the working language in CLIL classes is a foreign language and not their first language. Therefore, they are language learners and do not acquire the language. Due to the limitation in teaching time, they do not fully immerse themselves in the foreign culture and do not have enough time for language production (Zydatið, 2000). Language learning depends on individual factors such as age, previous knowledge, motivation (Bach & Timm, 2013), and general cognitive factors, the so-called learning universals (Roche, 2005) such as language and information processing processes in the brain and neural networks.

According to content knowledge in CLIL classes, critical voices claim that students who learn a subject in a foreign language cannot reach the same level of knowledge about the content as if they were to acquire it in their first language (Appel, 2011; Mehisto et al., 2008). There are only a few evidence-based findings for this (Lamsfuß-Schenk, 2008), which mostly relate to a very small population, having the character of a case study. Only some studies focusing on content are quantitative studies (Piesche et al., 2016; Dallinger & Jonkmann, 2015). There are more quantitative-based studies covering the linguistic area (Fehling, 2008; Rumlich, 2013). The teachers' assessment of the content knowledge of bilingual vs. monolingual taught students was quite balanced, according to the study by Milla Lara & Casas Pedrosa (2018). Another study showing no differences in content performance was carried out in Finland, where the students had a very high level of foreign language skills (Seikkula-Leino, 2007).

Positive results on subject competence with development of higher-order thinking skills or reflexive competencies shown by Bonnet (2004, 2015) or Dallinger & Jonkmann (2015) were achieved with high school students. Surmont et al. (2016) found a significantly higher level of

subject learning in mathematics, a subject that can also be understood in its logic independently of linguistic input. In a study with a relatively large number of participants (N=722), Piesche et al. (2016) found out that the bilingually educated students' learning gain was smaller than the monolingually educated ones' immediately after the intervention and at follow-up. Their expectation of more sustainable processing was not supported. The students were randomly assigned to both groups.

Studies in Great Britain show that high-performing students benefitted most in bilingual taught classes, whereas low-performing students did not (Mearns, 2012). Other studies underline this finding, showing negative effects on learning success for the subject among students with a low level of foreign language skills (Marsh, 2002; Bonnet, 2015; Mearns, 2012). Therefore Ball et al. (2015) have hinted that CLIL is not for all since one criterion for CLIL success is learner academic L2 ability so that teachers and learners can maintain acceptable levels of subject knowledge. Furthermore, in CLIL classes, poor foreign language skills can also cause negative effects on motivation for the subject (Yassin et al., 2009). These effects were especially strong for children whose parents have no higher educational qualifications (Anghel et al., 2016).

It has been shown that students' English competence at secondary schools and integrated, comprehensive schools in Germany shows many deficits (DESI study, Klieme, 2008). On the other hand, especially in those schools, students have a migration background and thus speak different first languages (Gogolin, 2010). The hypothetical benefit of the multilingual background on bilingual subject learning was not proven yet (Gogolin & Brandt, 2015) but seen as having great potential (Hu & de Saint-Georges, 2020).

Regarding the empirical evidence, Bonnet describes research on bilingual science teaching as very "patchy", meaning incomplete (Bonnet, 2015, p. 173). Even though this statement is already a couple of years old, studies among underperforming students are still missing. Two recent studies with state secondary school learners (Banegas & Lauze, 2020; Garzón-Díaz, in press) have provided evidence that CLIL when it includes systematic language support, allows learners with an A2 (CEFR) level of English to acquire subject knowledge and develop their academic L2 proficiency. Banegas (2021) claims that further research is needed to examine what pedagogical strategies can succeed in extending CLIL to contexts such as state schools, where English provision may be limited compared to private bilingual schools (Yilorm Barrientos & Acosta Morales, 2016; Pimentel Siqueira et al., 2018).

To summarize, it can be stated that bilingual subject learning might have many positive effects on language acquisition and content learning but only for those high-performing students with good foreign language skills. Among underperforming students with the educationally disadvantaged background, studies indicate that there is hardly any increase in learning. However, students with multilingual background might have advantages with bilingually taught subjects if their special learning needs are met.

These considerations and lack of studies lead to the following research questions:

RQ₁: Is there a difference in the motivation of middle school students with low English competence between a monolingually vs bilingually taught biology module specially arranged to meet their needs?

RQ2: Is there a difference in content knowledge of middle school students with low English competence between a monolingually vs bilingually taught biology module specially arranged to meet their needs?

The Study

A quasi-experimental study aimed to uncover the causal relationship between different treatments and effects on motivation and learners' scores by giving a treatment (in L1, L1 and L2 and no treatment) and administering a pre-, post- and follow-up test on randomly assigned classes.

Table 1. *Summary of Study Design*

Pre-Test	Intervention	Post-Test	Follow-Up Test
Collecting control variables: age, gender, multilingualism, school grade in English and Biology, prior knowledge interest/motivation	G 1 English (plus German if necessary) G 2 German Teaching material and instruction time was kept constant between group 1 and 2 G 3 Control group	Right after the treatment Testing learners' gain Interest/motivation	After four weeks Testing persistent knowledge/ Interest/motivation

Sample

For this study, 254 students (42% female) from 13 seventh-grade classes from 5 so called "Mittelschulen" located throughout Bavaria/Germany were randomly assigned to receive either German or German/English instruction on a module about breathing or no instruction in the control group. None of the participating schools offered bilingual programs for their students in grade 5 and 6. The students had been learning English since third grade. 28% of all participants spoke two or more L2s. Altogether, 134 bilingually educated students (42% female) vs 90 monolingually educated ones (45% female) and 18 students in the control group (50% female). Even though both groups were divided equally, two German classes could not conduct one of the tests and were not included in the evaluation.

Procedure

The lessons were methodologically structured in the same way, but language scaffolds were given during the intervention in English. Even though the intervention was dominantly held in English and the materials are written in English, the students were allowed to switch the code. To create comparable conditions, the instruction material and the given time were standardized. The instruction and especially the verbal parts of the teaching, was written down and discussed with the teachers.

The prior knowledge and motivation were tested in a pre-test, the increase in knowledge and changes in motivation were queried in a post-test immediately after the treatment and a follow-up test after about a month.

Intervention

Table 2. *Expected Content Knowledge*

Terms, structures and function (in German)	Terms in L2 and phrases being used during the intervention
Parts of the body used for breathing	nose, mouth, windpipe, bronchi, bronchiole, ribcage, diaphragm, lungs, air sacs
Breathing mechanism (diaphragmatic breathing)	inflate -deflate inhale - exhale diffuse
Oxygen uptake, carbon dioxide release	oxygen carbon dioxide

Design of the Teaching Unit

Students first discovered the parts of the body needed for breathing using a torso and a bilingual glossary. After that, the breathing mechanism (diaphragm as a muscle is pulling down → lungs expand → breathing in) was made understandable with a self-made functional model and a short film clip. The transition of oxygen from the alveoli to the blood vessels and of carbon dioxide from the blood vessels to the alveoli and the dangers of smoking was all made clear using models. No phase should involve long class discussions but rather be varied to acquire material-based knowledge and express it at their own learning pace, supported by the teacher when needed. Each step should be accompanied by phrases using key terms given as a fixed and restricted vocabulary written down on the blackboard and the worksheets. Semantic support was provided through visualization, hands-on activities using the own body (feeling the chest and abdominal wall being lifted, running in place for a minute and then checking the pulse...), using models (torso as a structural model, model of pulmonary alveoli and trachea, functional models for diaphragmatic breathing created by the students themselves), original objects such as tar (Figure 1), many illustrations with the technical terms in English and German (Figure 2), and a short film clip on gas exchange.



Figure 1. Examples for Visualization (from left, model for diaphragmatic breathing, tar, model of alveoli, model of the trachea, all self-made)

Where is the air going through our body?

Part 1:

windpipe	Luftröhre	
bronchus, pl. bronchi	Bronchie	
bronchiole	Bronchiole	
air sacs	Lungenbläschen	
Capillary, capillaries	Kapillar (kleine Blutäderchen)	
ribcage	Brustkorb	

Figure 2. Part of the worksheet with bilingual glossary

Varied and frequent consolidation phases took place both orally and in writing, supported by sentence structures (Figures 3 and 4).

Check it out:

Explain how the oxygen is traveling through your body. You can use following sentences:

- We inhale air with oxygen through*
- Air with Oxygen flows down*
- The carry the air into both*
- The bronchi divide into smaller*
- At the end of the there are the little*
- Oxygen diffuses through into*

Figure 3. Scaffolds to describe the way oxygen takes through our body

If you pull the plastic bag, the balloons _____ because air is coming in through the glass tube. If you push the plastic bag inside, the balloons _____ because air is going out of the glass tube.
Inflate aufblasen deflate schrumpfen

Figure 4. Part of the worksheet to consolidate the function of breathing using a model

Consolidation phases were often performed collaboratively using the flowchart (Figure 5) by putting the cards correctly and verbalizing it.

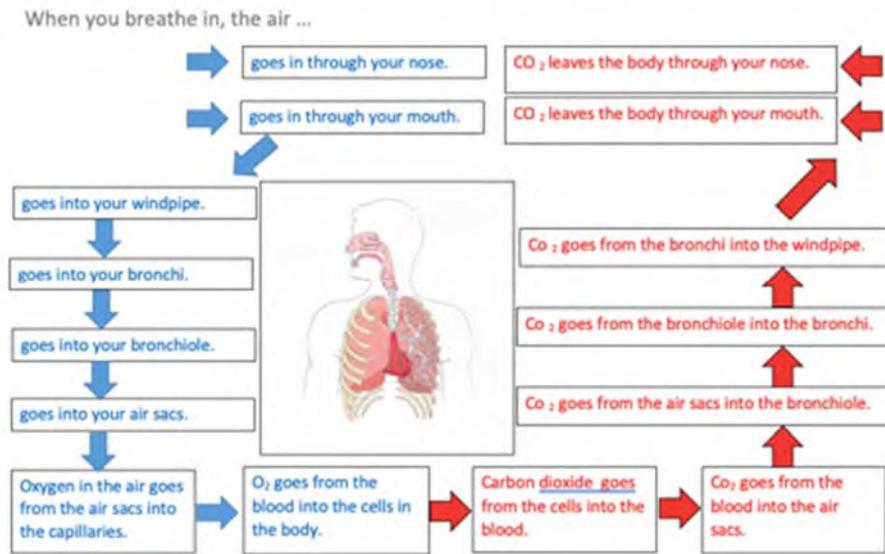


Figure 5. Flowchart to consolidate the way the air takes through our body

Another way of practicing was labelling in English and German (Figure 6).

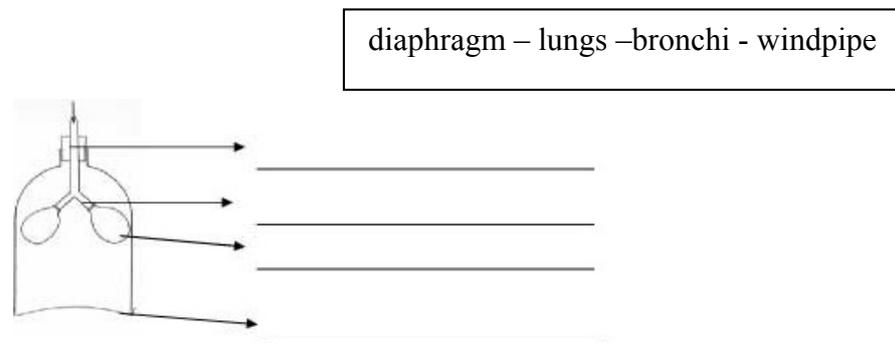


Figure 6. Labelling task on the worksheet with support

Instruments

All tests collected general variables as well.

Gender and multilingualism (0= monolingual, 1= bilingual, 2 & 3 multilingual) should be ticked and the school grade in English and Biology written down.

Testing Motivation

Based on a standardized test on achievement motivation, the so-called FLM 7-13 - a self-assessment questionnaire with a total of 30 items - supplemented by items to determine subject-related and topic-related motivation, 22 items were formulated (Figure 7), which were assessed using a 5-point response scale (“fully applies” to “does not apply at all”). With this procedure, central constructs for the three areas “general interest”, “specific interest”, and “self-efficacy” were generated. Based on Bandura (1992), self-efficacy is understood as the person’s optimism

to act with their abilities. This is considered a basic requirement for motivating yourself to complete a task.

The value for the general interest was formed from items 1, 2, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22 (like “I enjoy science lessons”). The specific interest in the topic of breathing related to items 7 and 9 (I have a lot of questions about breathing, I am interested in the topic breathing) and items 3, 4, 5 and 20 were combined for self-efficacy (like “I can improve my achievement if I work harder”). The control questions had to be re-coded for the evaluation. The mean value was calculated from the corresponding items.

	trifft völlig zu	trifft etwas zu	trifft teils/teils zu	trifft wenig zu	trifft gar nicht zu
1. Ich bin in PCB gut drauf.	O	O	O	O	O
2. In PCB bin ich oft unkonzentriert.	O	O	O	O	O
3. Wenn ich mich anstrengte, verbessern sich meine Leistungen in PCB.	O	O	O	O	O
4. Mit meiner Leistung in PCB bin ich unzufrieden.	O	O	O	O	O
5. Meine Hausaufgaben in PCB erledige ich, ohne ermahnt zu werden.	O	O	O	O	O
6. Meine Mitarbeit in PCB könnte besser sein.	O	O	O	O	O
7. Das Thema Atmung interessiert mich.	O	O	O	O	O
8. Ich bin nicht gerne in der Natur.	O	O	O	O	O
9. Ich habe viele Fragen zum Thema Atmung.	O	O	O	O	O
10. Ich weiß wenig über biologische Themen.	O	O	O	O	O
11. Fernsehsendungen wie Galileo interessieren mich.	O	O	O	O	O
12. Ich führe daheim Versuche durch.	O	O	O	O	O
13. Ich lese gerne Sachbücher.	O	O	O	O	O
14. PCB gehört nicht zu meinen Lieblingsfächern.	O	O	O	O	O
15. Ich fühle mich im PCB Unterricht wohl.	O	O	O	O	O
16. Den PCB-Unterricht finde ich interessant.	O	O	O	O	O
17. Im PCB-Unterricht bin ich oft angespannt.	O	O	O	O	O
18. PCB ist mir zu schwierig.	O	O	O	O	O
19. Ich werde im PCB Unterricht oft gelobt.	O	O	O	O	O
20. Bei der Themenwahl im PCB Unterricht kann ich wenig mitentscheiden.	O	O	O	O	O
21. Im PCB Unterricht ist mir oft langweilig.	O	O	O	O	O
22. Ich freue mich auf die PCB Stunden.	O	O	O	O	O

Figure 7. Test for motivation

Testing Content Knowledge

With a total of 16 items, content knowledge about breathing concerning the basic concept of structure and function was tested - using multiple-choice, connection tasks, labelling tasks, using “w” for true (German “wahr”) and f for false (German “falsch”). In addition to pure reproductive tasks (1, 7, 11, 13), there were also tasks related to reorganization (2, 3, 4, 5, 6, 8, 9, 10) and transfer tasks (14, 15, 16). The answers were supposed to be given in German.

Results

Changes in Motivation

The change in motivation in comparison to pre-test and post-test is very similar for all three areas in group 1 (English) and group 2 (German) (Figure 12). Thus, M1 is the interest in biology, M2 is interested in the topic, and M3 is the self-efficacy experienced.

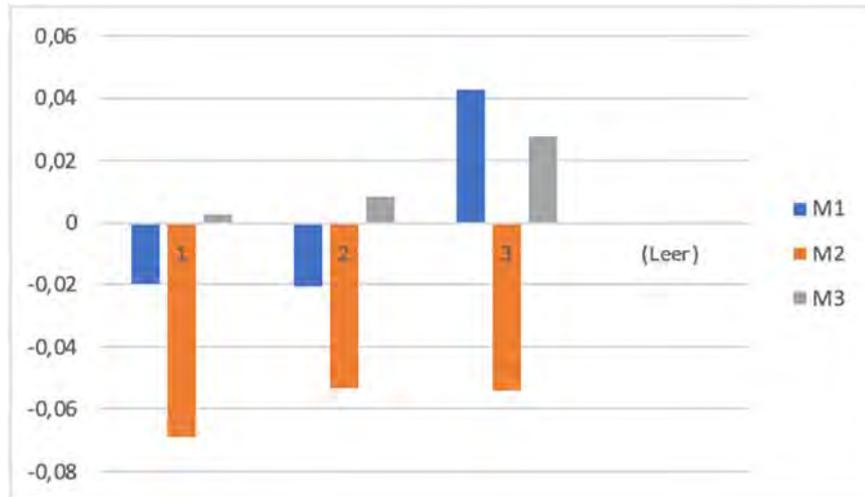


Figure 8. Changes of mean values between pre-test and post-test for 3 areas of motivation in 3 groups

The difference in motivation between the follow-up test and the pre-test (see Figure 9) shows that in the English group, the general motivation (M1) for the subject biology decreased shortly after the intervention but increased higher than in the German group after some time. On the other hand, the value for the specific interest in the topic (M2) decreased continuously in both groups.

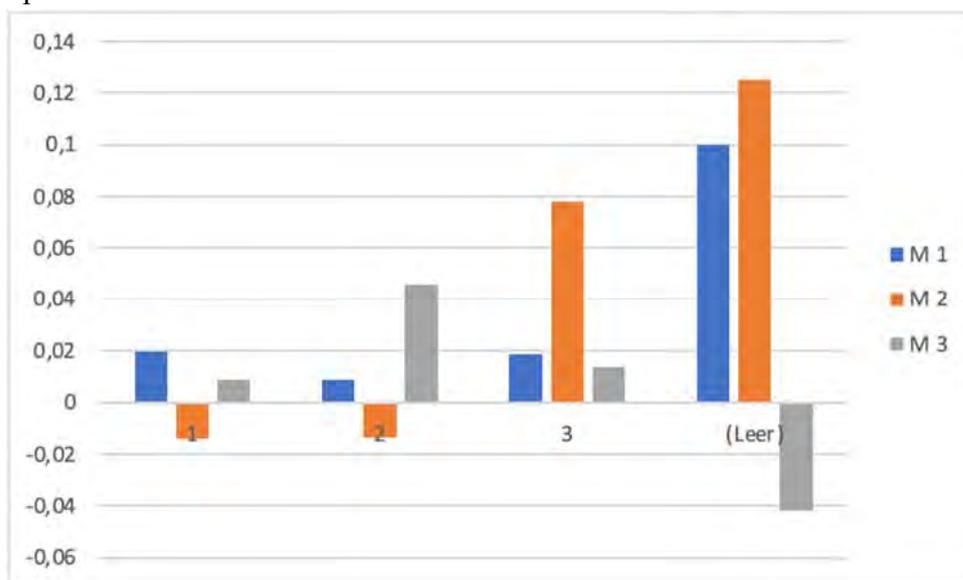
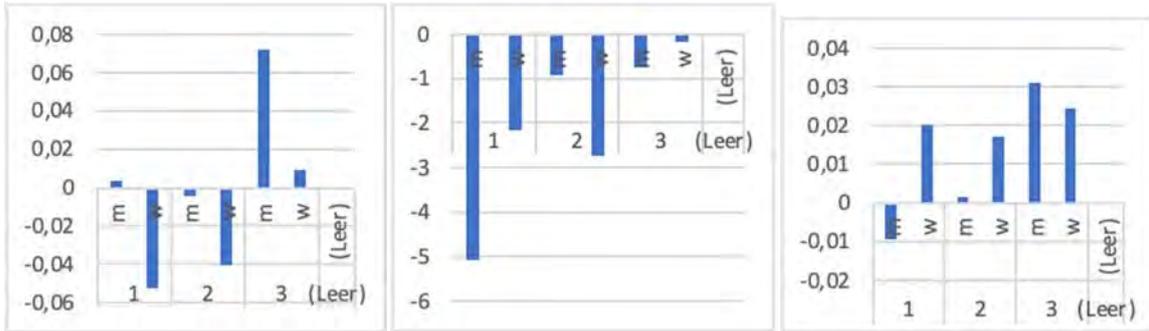
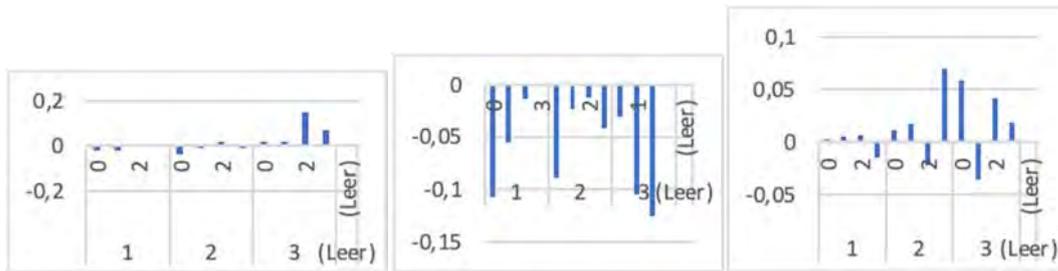


Figure 9. Changes of mean values between post-test and follow-up test for three areas of motivation in 3 groups

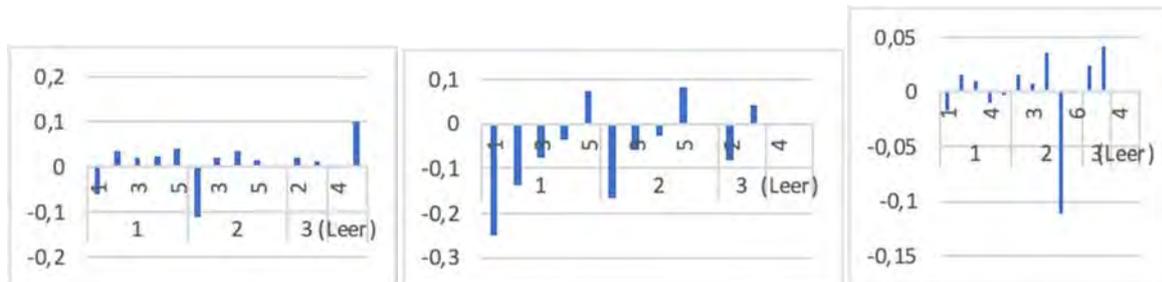
A change in the general interest (M1), special interest (M2) and self-efficacy (M3) in relation to gender, multilingualism, grades in English and Biology in the groups English (1), German (2) and the control group (3) showed the following (see Figure 10-13). The value of interest is given as the mean value of the change from pre-test to the main test:



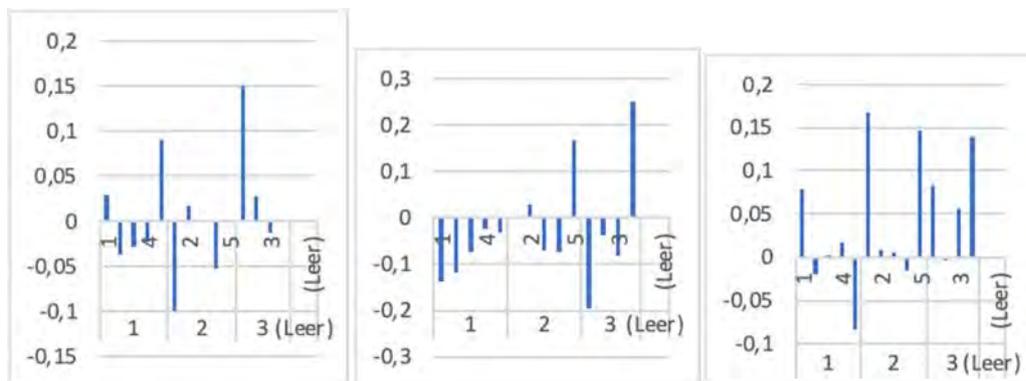
General interest in subject specific interest self-efficacy
 Figure 10. Change of interest in relation to gender (male/m-female/w) in groups 1, 2 & 3



General interest in subject specific interest self-efficacy
 Figure 11. Change of interest in relation to multilingualism (0=monolingual, 1=bilingual, 2/3=multilingual) in groups 1, 2 & 3



General interest in subject specific interest self-efficacy
 Figure 12. Change of interest in relation to school grades in English (1 = the highest grade) in group 1, 2 & 3



General interest in subject specific interest self-efficacy
 Figure 13. Change of interest in relation to school grades in Biology (1 = the highest grade) in groups 1, 2 & 3

Change in the Content Knowledge

Learners' gain was higher in group 2 than group 1 after the intervention but has changed in the follow-up test (Figure 14).

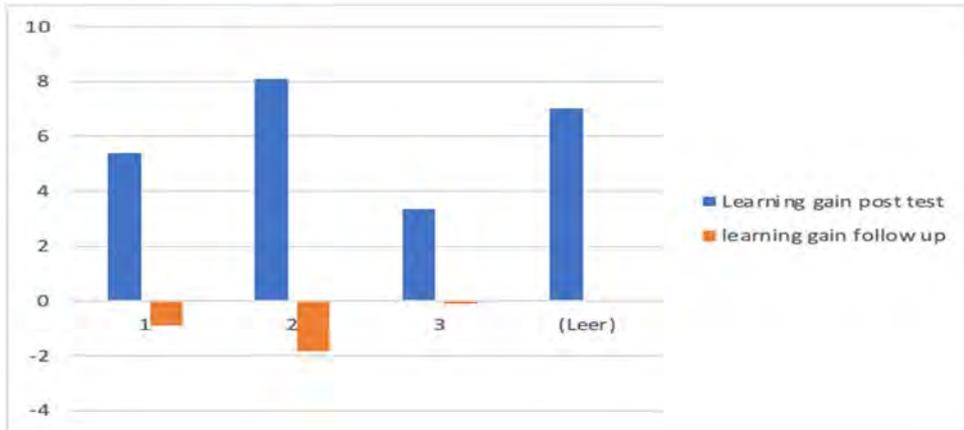


Figure 14. Comparison of the mean value of gain of knowledge in groups 1, 2 & 3 in post- and follow-up test

Comparison of the mean value of gain of knowledge based on gender (Figure 15) showed that girls performed better in both groups.

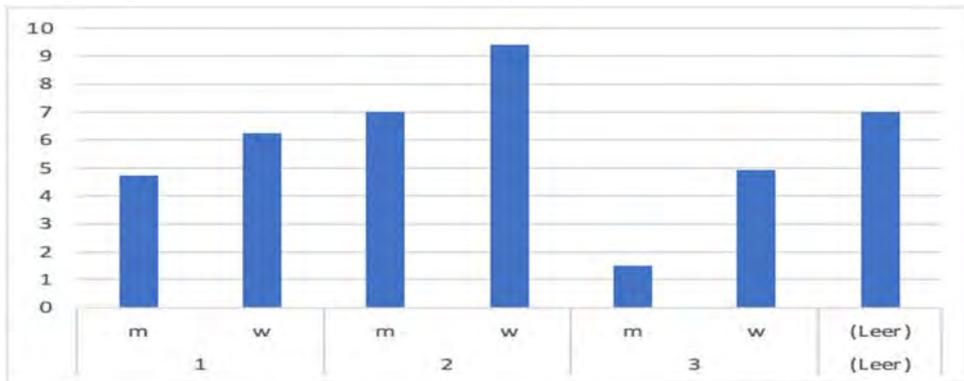


Figure 15. Comparison of mean value of gain of knowledge for male (m) and female (w) in groups 1, 2 & 3 in post- and follow-up test

Regarding multilingualism, students speaking several languages had much better knowledge gains in the English group than in the German group (Figure 16). Otherwise, the values were relatively similar.

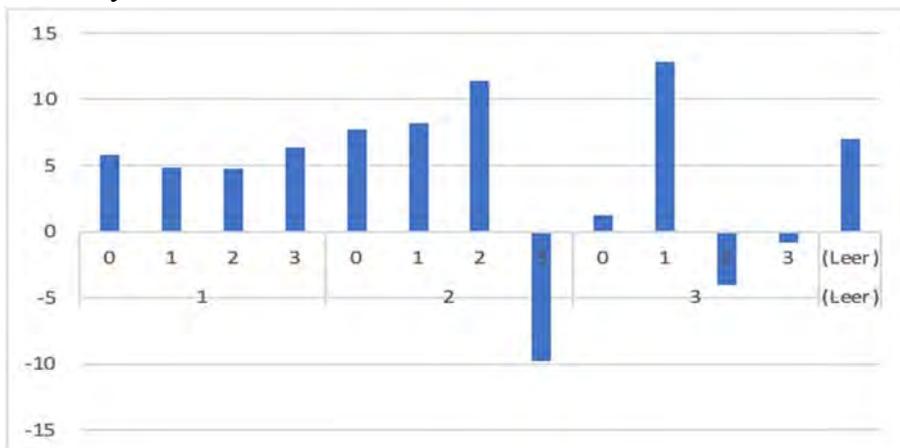


Figure 16. Comparison of the mean value of gain of knowledge correlating with multilingualism in groups 1, 2 & 3 in post- and follow-up test

It is not surprising that students with very good English grades did very well in the English group, while those with very poor grades did accordingly poorly (Figure 17).

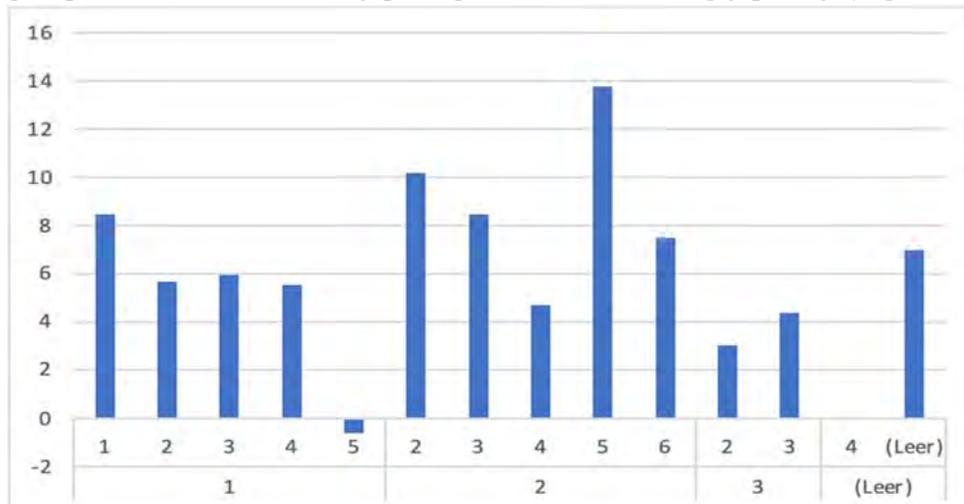


Figure 17. Comparison of the mean value of gain of knowledge correlating with grades in English in groups 1, 2 & 3 in post- and follow-up test

Regarding the grade in Biology, the increase in knowledge was relatively similar for most grades (Figure 18).

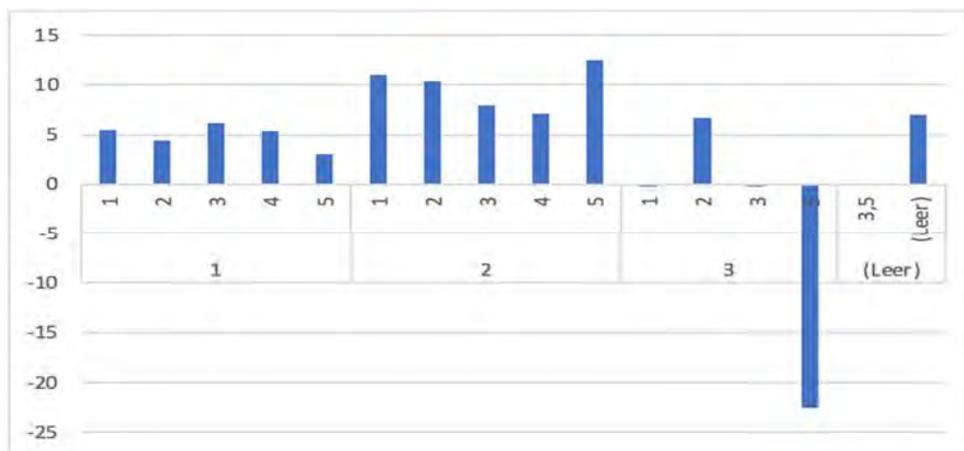


Figure 18. Comparison of the mean value of gain of knowledge correlating with grades in Biology in groups 1, 2 & 3 in post- and follow-up test

Discussion

So can motivation, the most determining factor in language learning, be influenced by a CLIL module if randomly assigned German “Mittelschule” students with low English competence are either taught a didactically prepared module in English or German (research question 1)? The only motivation for the subject and not the language was focused on by this study, even though correlations to grades in English can give hints to the underlying motivation for the language and language learning. Regarding those grades in English, there was not the so-called “creaming-effect” (Rumlich, 2017), as the grades of all participants were equally distributed in all groups, and the stated motivation for Biology was similar in the pre-test. Surprisingly, the value for **specific interest** (i.e., in breathing) was lower in both the German and the English

group after the lesson than before. However, the situation was different in the control group. Here, interest in the topic increased at the post-test. Perhaps the novelty effect and thus the students' interest was reduced by the intervention. However, it was different in the control group. The questions in the test may have generated interest. This would also explain why in the follow-up test, after one month, the interest in the subject was higher in the other two groups.

Interest in the subject of biology has not changed much due to the intervention in both the English and German groups. It is hard to imagine that one single intervention can immediately impact the subjective assessment of the entire subject. However, if the values of the follow-up test are included, a higher increase of general interest in the English group compared to the German group can be detected. The existing motivation for English language learning could have caused this positive effect on interest in the subject of Biology, like Coyle's "double effect" (Coyle et al., 2010) in reverse order.

For the experienced **self-efficacy**, understood as the optimism of a person to be able to perform an action with his or her abilities (Bandura, 1992), a short-term effect was shown in the English group. In the long run, it has risen in both groups. However, the students in the English group did not assign themselves lower self-efficacy after the treatment in English despite their poor knowledge of English. It appears that they have judged themselves to be competent enough to cope with the tasks on their own. The assessment of the teachers also underlines this. They were all very astonished to see how their students dealt with the topic in a very motivating way, despite little knowledge of English.

Regarding gender, it was found that especially girls in the English group showed a drop in their general interest in biology after treatment. There are many ways to explain that. Maybe they enjoyed a biology lesson in English so much that their interest in "normal" Biology classes dropped. This explanation is underpinned by the result of the general interest correlating with English grade. Those with very good grades indicated a drop in general interest at the post-test. They might also have transferred their frustration due to excessive demands on the subject. However, the good results in the knowledge test speak another language. Especially boys of the English group showed a drop in their specific interest after the treatment. They might get bored more quickly and therefore the drop in special interest.

Regarding self-efficacy, the girls in the English group rated themselves stronger after the treatment, the boys weaker. Girls in general are often better linguistically. This, in turn, could also be the reason for the girls' better results in the knowledge test (Figure 14).

Multilingualism correlates positively with the specific interest. Children who speak several languages showed higher values than the others after the English intervention. Perhaps due to their language skills, they found themselves better able to cope with the challenge. The proven advantages of multilingualism, like flexible thinking (e.g., Crivello et al., 2016), might be a reason for this. This can also be seen as evidence for the hypothetical benefit of the multilingual background on the bilingual subject learning formulated by Gogolin & Brandt (2015) and supporting the postulated advantages of multilingualism as a resource for learning (Hu & de Saint-Georges, 2020). Those shown effects are different from what Anghel et al. (2016) postulated as those children at German "Mittelschule" are most likely to have no higher educational qualifications.

Regarding school grades, all previous studies agree that lack of English competence is associated with a decrease in motivation for the subject (e.g., Yassin et al., 2009). However, in

this study, there was a drop in general interest in the post-test among students with very good English grades.

However, the drop correlating with grades in English applied for the German group as well, even though the drop was much lower in the English group. Thus, according to grades in Biology, students with very good and very low grades in Biology indicated a more general interest in the English group, whereas, in the German group, both showed a drop in interest. Thus, interestingly enough, a module in English boosted interest in two diametrically opposed groups. This finding reminds a little bit of Coyle's double effect (Coyle et al., 2010).

The specific interest related to school grades in English dropped more in the English group than the German group after the intervention and mainly for students with good grades in English except for those students with low grades in English. Perhaps students with good grades in English had their curiosity satisfied after the intervention, but the others still had the need to learn more about the topic.

What about acquiring **knowledge** if randomly assigned students are taught either in English or in German in a didactically prepared module of biology lessons (research question 2)? In contrast to most other studies about CLIL, which do not consider the prior knowledge of the students, which has been criticized by Bruton (2013) or Rumlich (2014), this study analyzed the prior knowledge about the topic of the participants. Activating learners' prior knowledge can also help them understand new knowledge (Alonso-Belmonte & Fernández-Agüero, 2018).

In terms of knowledge, the learning gain of the students in the German group was a little bit higher at the post-test than the one in the English group, but the students in the English group were able to catch up before the follow-up test. This finding is different from the one Piesche et al. (2016) found out. Although in their study, the learning gain of the monolingually educated ones was higher at the post-test and the follow-up test, the gain of the bilingual educated ones' was less compared to the monolingually educated ones at every test.

For this study, reproductive knowledge was tested and higher-order thinking skills (Coyle et al., 2010; Uribe-Enisco, Uribe-Enisco, & Vargas-Daza, 2017). Those thinking skills and strategies, together with the language needed to perform those skills, should enable students to deal with the demands of L2-content instruction, according to Coyle (2010). Therefore, it was important to provide enough verbal scaffolds for each instructional phase. Like Fazzi & Lasagabaster (2021) stated, more sustainable processing with a CLIL-module could be due to authentic content, materials, tasks, and communication in L2.

In this study, the topic of breathing is very authentic content connected to the students' environment and own body and thus very motivating. The used material was stimulating with many hands-on activities like creating the lung diaphragm model. The tasks had to be mastered collaboratively and supported using scaffolds for subject-specific terms and also for general-academic phrases. The semantic clarification was achieved by visualization, like corresponding pictures, short descriptive film sequences and simple experiments with the own body. Providing the necessary verbal scaffolds, the students had plenty of opportunities to communicate in L2 even though the use of L1 was allowed to encourage the students to talk. The positive results could also be related to the fact that by dealing with the topic in English, the learners continued to be involved with the topic on their own even after the instruction to clarify possible questions. Because of that, some students showed an increase of knowledge not right after the instruction but in the follow-up test a couple of weeks later.

Regarding gender, the girls, as mentioned above, performed a little better in the knowledge test in the English group than the boys. However, they were also better in the German group and the control group. They may have carried out the assignment more obediently and paying more attention to filling out the test. The significantly greater increase in knowledge of the girls in the English group than the boys could possibly be explained by the better linguistic performance of the girls in general. In this study, the girls had slightly better grades in English than boys. The boys had a little better grade in biology than the girls.

The multilingualism of the students was noticeable in the English group in the knowledge test compared to the German group. That might be an indication of the advantages found in previous studies that multilingual people have when solving problems with other languages.

It is not surprising that those students with good grades in English also did well on the knowledge test. They did better than those with good grades in Biology, even though the tests asked for specialist knowledge in German. Apparently, the topic was relatively new to everyone, and therefore the children with good Biology grades did not have an advantage. It was more important that they were able to understand the content in English, and it helped them to have good grades in the English language.

If you take a closer look at evaluating the individual questions, it sometimes showed a problem with learning, meaning the language related to the topic like technical terms. The knowledge tests asked for the German equivalent, and some mistakes made with the German technical terms might have been caused by confusion with the English term. For example, the English term “air sacks” has the correct German equivalent “Luftbläschen”. “Luft” meaning “air” and “Bläschen” meaning “little bubble”. Quite often, students stated the wrong name “Luftsäcke”, with “Säcke” meaning “sacks”. This happened even though the teachers were asked to point out those tricky words with the risk of confusing the terms. The fundamental problem with this study design is indeed the comparability. Despite precise instructions for the teachers and equal materials for each lesson, an identical implementation of the lessons could not be guaranteed. The participating teachers all had a different level of English competencies even though they were all qualified to teach English and Biology. The lesson plan with all the main verbal impulses in English was also provided. However, there is always a chance that some teachers were not strictly following the plan.

The shown positive effects on motivation and knowledge could be further proof of how important the right CLIL-material with scaffolding tools and the right teaching methods are for successful CLIL instruction (Mahan, 2020; Ball, 2018). Materials, helping to visualize the complex matter supported by the necessary language of learning and language for learning, like the flowcharts with bilingual glossaries. However, furthermore, it was important that the students acquired the knowledge not through long class discussions, but rather very varied and material-based collaboratively with frequent consolidation phases and plenty of opportunities to switch the code and translanguaging being allowed (García & Wei, 2014) to open a new perspective on multilingualism. Simplified speech, graphic organizers, hands-on activities, cooperative learning, visual aids, demonstrations, many consolidation phases all remind of the “sheltered instruction” (Friedenberg & Schneider, 2008). Therefore, it can be an approach to integrate L2 learning with content instruction for secondary schools (Avila-López et al., 2021).

Suggestions for Further Studies

Since the study field for bilingual subject teaching is very “patchy”, especially as far as it concerns studies on students with low foreign language competence and from uneducated parents, further studies must be carried out focusing on this population before the introduction to secondary schools to create the mandatory conditions for successful bilingual content learning beforehand. The positive tendencies shown in terms of motivation and knowledge, especially on multilingual students using diverse support systems, need to be confirmed in studies over a longer period with several subjects. In addition to that, the same teacher should conduct the teaching units, or the intervention should be filmed to keep the procedure constant. Because students of “Mittelschule” often have problems with written tests, one should also use qualitative methods such as interviews to determine better the motivation and self-efficacy experienced. As only motivation for the content was measured in this study, further studies should concentrate on motivation for the language in L2 among multilingual students in CLIL classes.

It is important to develop a didactic for bilingual teaching for the various subjects. In particular, one should determine the content and goals for each subject and analyze the added value of support systems in studies for the area of methodology, like studies on the use of the olfactory sense for language learning (Rolletschek, 2019).

Conclusion

A study with almost 260 participants from the German “Mittelschule” with pre-, post- and follow-up test and a standardized intervention provided new evidence-based facts contributing to the “patchy” field of research on bilingual Biology teaching. It has shown that students with low English competence can have similar learning gain than the German-speaking comparison intervention. Especially those students with multilingual background seemed to profit from the bilingual teaching. Those positive results might have been due to the special arrangement of the module. However, the children with good English grades did better than the others. Therefore, multiple linguistic support systems are required to enable all students to gain more knowledge about the subject and not lose interest. Before expanding bilingual subject learning to other types of school further studies on effects of supporting systems for bilingual content teaching are mandatory. Based on that, didactically designed teaching material that meets the learners` needs is necessary.

Regarding the methods, the results indicate that the planful use of code-switching, postulated by Butzkamm (2010), should become an important factor of CLIL lessons, so the students can master the important frequent change between languages. This way, it would actually turn the lessons into real “bilingual” lessons taught in two languages. Furthermore, comparing the teaching time with Canadian immersion teaching, at least 50% of the curriculum is taught in the second language while promoting the first language (Skog-Södersved, 2008), teaching time provided needs to be increased. In addition, it requires teachers who are native speakers, bilingual or at least linguistically very competent but still be able to support the students at different levels and are trained for the subject (Brohy, 2005).

Finally, the development of a specific didactic of the subjects in a bilingual context with considerations on goals, content and methods in a heterogeneous context and curriculum development is overdue.

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