Learning and Instruction 44 (2016) 108–116

Contents lists available at ScienceDirect

Learning and Instruction

journal homepage: www.elsevier.com/locate/learninstruc

CLIL for all? A randomised controlled field experiment with sixth-grade students on the effects of content and language integrated science learning☆

Nicole Piesche [a, *], Kathrin Jonkmann [c], Christiane Fiege [b], Jörg-U. Keßler [a]

[a] University of Education, English Department, Reuteallee 46, 71634 Ludwigsburg, Germany
[b] University of Tübingen, Institute of Psychology, Schleichstraße 4, 72076 Tübingen, Germany
[c] FernUniversität in Hagen, Psychology Department, 58084 Hagen, Germany

ARTICLE INFO

Article history:
Received 15 December 2014
Received in revised form
23 March 2016
Accepted 1 April 2016
Available online 2 May 2016

Keywords:
Content and language integrated learning
Bilingual science teaching
Floating and sinking
Learning gains

ABSTRACT

Content and language integrated learning (CLIL) has been widely implemented in Europe. This article presents a randomised controlled field experiment on the effects of CLIL on students' science learning. Thirty sixth-grade intermediate-track German secondary-school classes (722 students) were randomly assigned to learn (5 lessons, 90 min each) a physics topic taught either in German or in English and German. We expected that the monolingually taught students would outperform the bilingually taught ones immediately after the intervention. For the follow-up test 6 weeks later, the same or smaller differences between the groups were expected due to the potential for a deeper processing of the subject matter in the bilingual condition. The results showed that the bilingually educated students' learning gains were smaller than the monolingually educated ones' immediately after the intervention ($d = -0.21$) and at follow-up ($d = -0.23$). The expectation of more sustainable processing was not supported.

1. Introduction

Due to the global interconnection of economies, people now need to be able to speak English as a lingua franca to ensure their individual success (Coyle, Hood, & Marsh, 2010). Moreover, "languages are (…) the key to knowing other people", and learning them "expands people's cultural horizon" (Commission of the European Communities, 1995, p. 47). Therefore, the Commission of the European Communities (1995) stated that each European citizen should be able to speak her/his mother tongue and at least two foreign languages. Content and language integrated learning (CLIL) is considered to be appropriate for reaching this aim (Commission of the European Communities, 2003). In this approach, a second language is used as the medium of instruction to teach a non-language subject such as geography or history. The implementation of CLIL has been fostered by the European Commission, and CLIL can now be found all over Europe (European Commission, 2006).

As a consequence of the increasing implementation of CLIL, studies with different foci (e.g., students' cognitive and motivational development, linguistic and content outcomes, stakeholder research) have been conducted in this field in recent years, most of them supporting the approach (for an overview, see Breidbach & Viebrock, 2012; Dalton-Puffer, 2011; Pérez-Cañado, 2012). A closer look at the research designs and results of such studies, however, reveals several limitations of their findings.

First, due to self-selection of applicants and the schools' selection of participants from a surplus of applicants, typically only high-achieving and highly motivated students take part in the bilingual programmes (Küppers & Trautmann, 2013). Hence, most of the field studies were conducted with positively preselected classes (Bruton, 2011). As a consequence, the internal validity of their findings remains unknown: Do the positive CLIL effects result from the programme or the positive characteristics of its participants (Küppers & Trautmann, 2013)?

☆ Nicole Piesche was a member of the "Cooperative Research Training Group" at the University of Education, Ludwigsburg and the University of Tübingen, which was supported by the Ministry of Science, Research, and the Arts in Baden-Wuerttemberg.

* Corresponding author.
E-mail addresses: nicole.piesche@gmx.de (N. Piesche), kathrin.jonkmann@fernuni-hagen.de (K. Jonkmann), christiane.fiege@uni-tuebingen.de (C. Fiege), kessler@ph-ludwigsburg.de (J.-U. Keßler).

http://dx.doi.org/10.1016/j.learninstruc.2016.04.001
0959-4752/

Second, longitudinal studies with pre-, post-, and follow-up assessments are still rare (Bruton, 2011; Pérez-Cañado, 2012). Such a design not only allows to control for certain preexisting differences due to selection effects, but it also allows to disentangle short- and long-term effects as well as to test the hypothesis that CLIL students elaborate the input stronger, thus leading to a better consolidation of their newly acquired knowledge (Wolff, 1997).

Third, the main focus of research so far has been on students' linguistic outcomes (e.g., Admiraal, Westhoff, & de Bot, 2006; Lasagabaster, 2008). Very little is known about the effects of CLIL on content knowledge (Dalton-Puffer, 2011). This situation still causes representatives of the content subjects to show an aversion to CLIL concepts (Breidbach & Viebrock, 2012; for science, see Haagen-Schützenhöfer, Mathelitsch, & Hopf, 2011).

To address these issues and in particular to raise internal validity, we present a randomised controlled field experiment on the effects of CLIL on subject-matter learning in science (physics). 30 classes from schools that do not offer a CLIL-programme were randomly assigned to the monolingual or bilingual treatment condition. The study employed a repeated-measures design (pretest, posttest, follow-up) and was conducted in the *Realschule*, which is the intermediate track in the German three-tiered secondary school system. Science (physics) was chosen because bilingual science instruction has not received ample research attention yet and its feasibility for CLIL is highly debated. Some argue that science is inappropriate for bilingual instruction because of the difficulty and abstractness of the topics as well as the dominance of the technical terminology (Kircher, 2004). Others argue that science is particularly suitable for bilingual instruction, because it has specific characteristics that facilitate understanding in the bilingual setting: the language of the scientific discourse is highly standardised (e.g. easy syntax, no metaphors or irony; Crystal, 1993), many different display formats (real objects, pictures, language, symbols and formula) can be used (Leisen, 2013), and science lessons provide many opportunities for students to work with real and concrete objects as well as to do hands-on experiments (Bohn & Doff, 2010).

2. Theoretical background

2.1. Forms of content and language integrated learning (CLIL)

According to the European Commission, CLIL is an educational approach in which a "non-language subject is […] taught […] *with* and *through* a foreign language […]" and "[…] seeks to develop proficiency in both the non-language subject and the language in which it is taught, attaching the same importance to each" (2006, p. 7; emphasis in original). The CLIL approach, in which up to 50% of the subjects are taught in the target language in addition to traditional foreign-language lessons, has to be distinguished from immersion settings, in which more than 50% of the subjects are taught in the foreign language (Elsner & Keßler, 2013a). In Germany, two main CLIL-forms can be observed: bilingual tracks and bilingual modules. In schools with a bilingual track, mostly one to three subjects are taught in the foreign language for the whole school year. Access to these tracks is often restricted to high-achieving and highly motivated students (Dallinger, Jonkmann, Hollm, & Fiege, 2016). In schools that pursue a modularised approach, only certain topics in different subjects are taught in a foreign language for a limited timespan (Breidbach & Viebrock, 2012). Bilingual modules can be found in schools with bilingual tracks to raise the number of subjects taught in the foreign language but also in schools without bilingual tracks to allow all students to experience CLIL (Bechler, 2014; Krechel, 2003). CLIL programmes were mainly offered to learners at the highest (i.e., the academic) track (*Gymnasium*) of Germany's tracked secondary school system. In recent years, however, the implementation of CLIL programmes in primary schools (Elsner & Keßler, 2013b) and the intermediate track (Breidbach & Viebrock, 2012) can be observed. However, research results of larger empirical studies conducted in these tracks are hardly available yet and it is unknown whether findings from the academic track can be transferred to *Realschule* with less cognitively strong students.

2.2. Theoretical and empirical background of CLIL-effects on content learning in science

While several research studies around Europe have shown positive influences of bilingual teaching on students' language-learning outcomes (Admiraal et al., 2006; Lasagabaster, 2008), little is known about the learning effects of CLIL with regard to content areas (Dalton-Puffer, 2011). Work from different research disciplines, however, suggests positive effects.

Research on bilingual children for instance shows that they are superior on, for example, cognitive control and selective attention (Bialystok, 1999; Bialystok & Martin, 2004) which prevents the working memory from being overloaded and therefore leads to more effective cognitive processes (Hasher, Zacks, & May, 1999). CLIL contexts seem to be able to bring about some of these positive outcomes, too (Poarch, 2013). Based on information processing theories such as Craik and Lockhart's (1972) idea of different levels of processing, it is assumed that in bilingual teaching students process information more deeply because they have to invest more mental effort "to come to an understanding of the issue" (Vollmer, 2010, p. 32). As a consequence, they are expected to show better long-term retention of the content (Wolff, 1997). This argument was supported by Heine (2010). Using think-aloud data, she showed that language-related problems cause a comparison of the concepts in both languages and a continuing engagement with the content which leads to deeper semantic processing, which in turn fosters long-term retention of the subject matter.

Another mechanism that might promote learning in bilingual science instruction is based on the constructivist view of learning. Students enter science lessons with 'everyday' concepts in their minds that often differ from the scientific concepts. As the 'everyday' concepts are highly persistent, they can hinder the development of the scientific ones (Haagen-Schützenhöfer et al., 2011). If instruction is done in a foreign language, technical terms are maybe less strongly connected with the 'everyday' concepts and so the scientific concepts can be developed with less interferences from the 'everyday' concepts which might result in better learning (Haagen-Schützenhöfer et al., 2011; Hegerfeldt, 2006).

While these theoretical arguments propose that CLIL supports content learning, other theories suggest negative effects. From the perspective of cognitive load theory (Sweller, Ayres, & Kalyuga, 2011), one might argue that students' working memory is overloaded by simultaneously processing new content and the foreign language. This might particularly be the case when students' ability level in the foreign language is still relatively low and therefore demands a high amount of working memory capacity. This argument is related to Cummins' (1979) Threshold Hypothesis, which states that sufficient competences in both the native and foreign language are necessary to avoid negative effects of bilingual teaching.

The few existing empirical results on CLIL-effects on science learning are contradictory and partly based on small exploratory studies. Supporting the concern that in bilingual science teaching language learning is achieved at the expense of content learning (Bohn & Doff, 2010), Marsh, Hau, and Kong (2000; $N = 12{,}784$; Hong Kong) found negative effects of middle and late immersion