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Supporting science learning in linguistically diverse classrooms: Factors related to the use of bilingual content in a computer-based learning environment

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ABSTRACT

Computer-based learning environments (CBLEs) are a promising means to support language minority (LMi) students in acquiring knowledge and skills through the integration of authentic support in their home language. This study aimed to determine the use of scientific bilingual content offered to fourth-grade students (n = 250) in the CBLE E-Validiv and to identify both student and classroom characteristics related to this use. All the content in E-Validiv is accessible in the language of instruction and one of six other languages. For LMi students, the other language is set to their home language. Multilevel hierarchical regression analyses show that especially LMi students who assess themselves as highly proficient in their home language use the content more in the other language than language majority students. However, even LMi students focus mainly on content in the language of instruction, which indicates that they particularly apply their home language to support their learning process in the language of instruction. Additionally, students who perform higher on science subjects access content more in the language of instruction. The presence of linguistic diversity in the classroom and the positive use of linguistic diversity by the teacher do not seem to matter. The theoretical and practical implications are discussed.

1. Introduction

In general, and particularly for the domain of science education, language minority (LMi) students often face a great challenge to attain the same performance level than language majority (LMa) students. While LMi students are defined as students who use a language at home that is different from the language of instruction (LOI) applied at school, LMa students have the same home language as the LOI. This achievement gap between LMi and LMa students has been identified in large-scale studies, indicating that students with another home language than the LOI run a higher risk to perform weakly on science subjects (e.g. Bellens, Arkens, Van Damme, & Gielen, 2013; Maerten-Rivera, Myers, Lee, & Penfield, 2010; Martin, Mullis, Foy, & Stanco, 2012; OECD, 2009, 2010; Van Laere, Aesaert, & van Braak, 2014). However, while LMi students' home language is often excluded from classroom practice, it could also be considered as a resource to support their learning process and thus help to bridge the achievement gap (Cummins, 2001). Yet, more research is needed on how this can be realized, for example by means of educational technology.

One of the main reasons put forward for the observed achievement gap is that LMi students are confronted with a double challenge (Goldenberg, 2008). All students, including LMa students, must become proficient in the literacy skills needed to develop scientific knowledge and skills (Cummins, 1979; Fang, 2006; Shanahan & Shanahan, 2008). These skills comprise the mastery of a specific scientific language, typified by a complex vocabulary and grammar, an underlying assumption of causal relationships, abstract thinking, and restricted support from the surrounding context (Curenton & Justice, 2004; Fang, 2006; Hiebert & Lubliner, 2008; Van den Branden, 2010). While LMa students need to acquire these new literacy skills in the LOI, LMi students face an additional problem. LMi students must not only learn these skills, just like LMa students. They also have to master these skills in the LOI, while they are often still struggling to become proficient in the LOI.

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Moreover, LMi students' home language is often considered as an obstacle for their learning process, especially when it is regarded as a less prestigious language (Agirdag, 2010; Goriot, Denessen, Bakker, & Droop, 2015; Shannon, 1995). As a consequence, the focus in most schools exclusively lies on learning in and through the LOI (Auerbach, 1993; Kenner, Gregory, Ruby, & Al-Azami, 2008; Riches & Genesee, 2006). However, Baker (2011) suggests that the present achievement gap can be linked to the neglect of the expertise students have already built up in their home language. As an alternative, their home language can also be called upon to support their learning process (Cook, 2001; Jiménez, García, & Pearson, 1996; Kempert, Saalbach, & Hardy, 2011; Msimanga & Lelliott, 2014; Sierens & Van Avermaet, 2014).

Nevertheless, it is a great challenge to include every student's home language as many classrooms are characterized by a moderate to large linguistic diversity, particularly in urban areas. This puts a high demand on both daily classroom practices and students' achievement throughout their school career (Sierens & Van Avermaet, 2014). Moreover, teachers do not have the resources to attend to and support every student in his/her home language (Clark, Touchman, Martinez-Garza, Ramirez-Marin, & Drews, 2012). Educational technology, and more specifically the development of computer-based learning environments (CBLEs), can offer new pathways to respond to this challenge. First, CBLEs can offer content in different languages through different pathways (Pederson, 1986). Next, they can be a powerful means to foster students' acquisition of complex knowledge and skills (Lajoie & Azevedo, 2006; Zhang et al., 2015). Finally, recent research offers promising results of CBLEs as an educational means to realize multilingual education, for example by offering authentic language support in the home language (Clark et al., 2012).

However, more research is needed into how students interact with complex CBLEs and which characteristics are related to this (Clarebout & Elen, 2006; Proctor, Dalton, & Grisham, 2007; Snow, Jackson, & McNamara, 2014; Zhang, Ordóñez de Pablos, & Xu, 2014). This can offer new insights for the theoretical development, the design as well as the practical use of these CBLEs. Research on how bilingual content, and more specifically the support in the home language, is approached in CBLEs is still very limited. Moreover, the use of code-switching has not yet been studied in the context of CBLEs. Code-switching, which refers to the shifting between languages by appealing to someone's whole linguistic repertoire, is a skill that is common in people who are highly proficient bilinguals (Canagarajah, 2011; Liebscher & Dailey-O'Cain, 2005). It can be used in a conversation (e.g., Bono & Melo-Pfeifer, 2010), but also in other contexts, such as writing (e.g., Losey, 2009) or reading (e.g., Ng, Gonzalez, & Wicha, 2014).

Therefore, the purpose of this study is to gain insight into how students approach bilingual content (i.e. in the LOI and another language) offered in a CBLE focusing on science education. Furthermore, we will examine student and classroom characteristics related to students' time spent on content offered in the two languages and the associated activity of code-switching. Special focus will be put on LMi students' use of the bilingual content as they have access to their home language in the CLBE. In what follows, we will first argue why LMi students' home language can be a valuable tool to support knowledge acquisition. Next, we will take a closer look at code-switching. Finally, we will review factors that are likely to be connected to the use of bilingual content in CBLEs.

2. Background

2.1. The home language: a valuable tool for learning

Language is one of the main symbolic tools children learn to master (Vygotsky, 1978). As LMi students' home language is mostly the first language they have learned, they regulate their cognitive processes through it and apply it as a cognitive tool to mediate their learning process in the LOI (Lantolf, 2000; Lantolf & Thorne, 2007; Swain & Lapkin, 2000; Vygotsky, 1978). This is in line with Cummins' (1979) linguistic interdependence hypothesis, which states that the level of competence in the LOI is strongly related to and influenced by the type of competence the student has already developed in his/her home language. Through a common underlying proficiency, knowledge and skills can transfer across languages, thereby strengthening literacy in both the home language and the LOI (Bialystok & Hakuta, 1999; Duibhir & Cummins, 2012; Genesee, Geva, Dressler, & Kamil, 2006; Riches & Genesee, 2006). Thus, LMi students can appeal to their own expertise in their home language as a support tool to acquire knowledge and skills in the LOI (Upton & Lee-Thompson, 2001). This empowers them to take the next level, just beyond what is possible to accomplish independently (Freeman & Crawford, 2008; Vygotsky, 1978; Wood, Bruner, & Ross, 1976).

As a cognitive tool, the home language may serve different functions. First, it can act as an important information source to construct meaning (e.g. Goodrich, Lonigan, & Farver, 2013; Jiménez, García, & Pearson, 1995, 1996; Langer, Bartolome, Vasquez, & Lucas, 1990; Proctor, August, Carlo, & Snow, 2006). In line with this, it can appeal to prior knowledge already developed in the home language (Butzkamm, 1998; Fung, Wilkinson, & Moore, 2003; Jiménez et al., 1995, 1996; Kenner et al., 2008). Third, it can stimulate metalinguistic awareness as a way of thinking about how things are expressed in different languages (Kenner et al., 2008; Martin-Beltrán, 2010). Finally, it can make the curriculum content more accessible through solving missing links when students have not yet acquired the appropriate knowledge in the LOI (Clark et al., 2012; Kenner et al., 2008; Riches & Genesee, 2006). As a consequence, the use of the home language has the potential to facilitate classroom activities and foster high-level educational achievement, particularly in the context of complex tasks (Alegría de la Colina & del Pilar García Mayo, 2009; Swain & Lapkin, 2000). Students with an immigrant background and a low academic proficiency may profit from integrating their home language in the learning process, thereby allowing them to work at a higher cognitive level than what would be possible if they could only use the LOI (Kempert et al., 2011; Storch & Wigglesworth, 2003).

Valuable efforts have already been undertaken to integrate support in the home language into CBLEs. Examples of such CBLEs in compulsory education are HELP Math (Freeman, 2012; Freeman & Crawford, 2008), the Universal Literacy Environment (Dalton & Proctor, 2007; Proctor et al., 2011), and the Wolves Project (Clark et al., 2012). However, the research on these CBLEs mostly takes into consideration a whole range of different support tools, without focusing on the home language support in itself. As a consequence, no conclusions can be drawn about the added value of offering bilingual content to students from different linguistic backgrounds. An exception to this is the study by Clark et al. (2012). They have compared the influence of providing supports only in the LOI versus providing supports in both the home language and the LOI in an online science inquiry environment. The results show that LMi students gain greater understanding about science topics in the LOI when they have access to the content and supports in both their home language and the LOI, in comparison with the LOI-only format (Clark et al., 2012). However, it is necessary to take a step backwards and first determine the factors related to students' use of the bilingual content before its potential for raising achievement can be identified. Additionally, most CBLEs are focused exclusively on Spanish-English bilinguals, as this is one of the most represented groups of bilingual learners in the U.S. (e.g. Proctor et al., 2011). In