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Concept Maps and Obliteration in Bilinguals

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Abstract

This study examines the effectiveness of concept maps in promoting long-term memory among Content and Language Integrated Learning (CLIL) students. It focuses on the accuracy of content transmission and the acquisition of meaningful learning in bilingual education by connecting new and carefully organized information to students' prior knowledge. Thus, the research assesses the use of concept maps as instructional tools in foreign language (L2) settings, addressing a lack of evidence regarding their effectiveness. It also considers how concept mapping affects long-term memory through factors such as perception, processing, cognition, and transfer. The study examines how bilingualism, bilingual education, and curricular content influence instructional design when using concept maps. The study involved 60 Spanish primary education students attending a semi-public bilingual school. The research results aim to contribute to the development of effective teaching strategies and instructional design in CLIL classrooms, ultimately enhancing students' long-term memory and learning outcomes.

Keywords

concept maps, long-term memory, CLIL, bilingual education, instructional design

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Concept Maps and Obliteration in Bilinguals

In bilingual education, it is crucial for students' scholarly success and cognitive development to effectively acquire, retain, and understand subject-matter facts (Kostiainen et al., 2018). Especially in foreign language (L2) settings, instructional strategies that connect new information to students' existing knowledge are vital for strengthening long-term memory (Nawrot-Lis, 2019). The concept of meaningful learning plays a crucial role in this process by aiding in the retrieval of information. This type of learning involves active engagement through constructive, intentional, and cooperative tasks, and it is more effective than rote learning – which focuses solely on memorization without context or comprehension (Jonassen et al., 2003). Meaningful learning is characterized by integrating new information into students' cognitive structures in a way that enhances their ability to apply knowledge in diverse and unfamiliar situations (Jonassen & Strobel, 2006). Therefore, understanding and promoting meaningful learning is essential for fostering deeper learning and improving knowledge transfer.

Research in this area highlights that meaningful learning involves a complex process of acquisition, retention, and eventual forgetting, as described by Ausubel (1968). According to Ausubel, meaningful learning occurs when learners actively connect new information to their existing cognitive structures, leading to more effective retention and application. This is in contrast to rote learning, where information is memorized without any meaningful connection to prior knowledge (Mayer, 1999). Brown (2007) further expands on this understanding by describing forgetting in the context of meaningful learning as a purposeful process, where less important details gradually fade away as learners consolidate broader concepts. In the context of bilingual education, particularly within Content and Language Integrated Learning (CLIL) frameworks, this distinction emphasizes the importance of using instructional materials and strategies that encourage meaningful engagement with the content (Hönig, 2010; Llinares et al., 2012). The challenge of effectively integrating content and language further underscores the need for precise and contextually relevant teaching approaches (Avello, 2020).

Therefore, this study aims to explore the potential of concept mapping as a powerful instructional strategy within CLIL settings, focusing on Anglo-Hispanic primary students in a semi-public school. It investigates how concept mapping enhances long-term memory retention and comprehension of information across languages. By delving into the cognitive processes involved and how students interpret these

visual tools, the research seeks to provide valuable insights into the practical application and efficacy of concept mapping in daily teaching practices. Ultimately, this study aims to fill a gap in existing literature by offering a framework for integrating concept mapping into CLIL settings to foster deeper engagement and understanding, thereby contributing to improved educational outcomes for L2 learners (Avello, 2020; Ausubel et al., 1978; Hönig, 2010; Kostiainen et al., 2018; Llinares et al., 2012; Nawrot-Lis, 2019; Novak & Cañas, 2009).

Meaningful and Rote Learning in School Settings

In bilingual education, it is important to ensure that students effectively acquire, retain, and understand subject-matter facts (Kostiainen et al., 2018). In the context of schools' foreign language (L2) settings, specific instructional approaches are particularly relevant for connecting new information to prior knowledge (Nawrot-Lis, 2019), which significantly contributes to students' long-term memory consolidation. When it comes to retaining previously learned knowledge, meaningful learning can be highly relevant for knowledge transfer among students. According to Jonassen et al. (2003), meaningful learning occurs when learners actively engage in constructive, intentional, and cooperative tasks.

Rather than placing the focus on how educators or curriculum designers interpret it, meaningful learning gains significance when learners demonstrate it themselves (Jonassen & Strobel, 2006). In this sense, when learners actively pursue cognitive goals, they engage in deeper thinking and learning as they strive to achieve their objectives. In education, there is also an emphasis on achieving meaningful learning through *authentic* tasks (Jonassen & Strobel, 2006) that are derived from real-life situations. Therefore, to avoid rote learning, it is important for students to acquire knowledge and skills from practical contexts in which they are presented with diverse scenarios to apply their ideas and facilitate the acquisition of meaningful learning (Jonassen, 1997).

Antagonistically to meaningful learning, rote learning aligns with the perspective that students integrate new information into their memory structures without necessarily understanding its true meaning (Mayer, 1999). As observed by Mayer (2002), when educators (consciously or unconsciously) promote rote learning, the emphasis is placed on recalling specific facts or information without considering their broader or transferable context and application. In contrast to meaningful learning, where knowledge is more likely to be transferred to new and unfamiliar

situations, rote approaches may force students to answer verbatim without understanding the true meaning of the learned content.

As stated by Ausubel (1968), meaningful learning is a conscious act that emerges when *potentially* meaningful signs, symbols, concepts, or propositions are related to the individual's cognitive structure in a non-arbitrary manner. This author divides such a learning process into three stages: *acquisition*, *retention*, and *obliteration* – where: the first relates to processing information from the external environment; the second to maintaining information in the knowledge structure; the third to forgetting residual information. Each of these processes occurs uniquely in each person and is influenced by learners' prior knowledge and their predisposition to learn meaningfully (Ausubel, 1968).

Forgetting, Accuracy, and Meaningful Learning Dynamics

Regarding oblivion, or what Ausubel (2000) refers to as *obliteration*, Brown (2007) argues that when meaningful learning occurs, forgetting is a purposeful process tied to the concept of subsumption. This process involves the gradual fading of specific items as they become less identifiable – and are eventually forgotten – because it is easier to remember a single broad concept than numerous specific details. As Brown (2007) notes, these specific items become "progressively less identifiable as entities in their own right until they are finally no longer available" (p. 94).

To address the challenge of forgetting, Ausubel's (2000, 1977, 1968, 1963, 1962) extensive research on meaningful learning emphasizes the importance of carefully applying teaching materials in the classroom. This involves a thorough examination of content accuracy and its impact on L2 skills. For instance, studies have investigated the accuracy of speaking and writing skills in an L2, focusing on syntax, lexical usage, and morphological correctness (Polio, 1997). In Content and Language Integrated Learning (CLIL), which integrates content with language learning, there is an ongoing debate among scholars and educators regarding the role of language in content assessment (Hönig, 2010; Llinares et al., 2012).

CLIL guidelines generally prioritize content over language while recognizing that language is also an essential part of the curriculum (Avello, 2020). Research indicates that CLIL assessment practices sometimes present challenges for teachers, who often struggle with assessment criteria and language corrections (Fuentes, 2013). Consequently, students' performance may be influenced by the cognitive cost of switching languages, with variations in response time and content accuracy

observed when students are both addressed and assessed in L2 (Avello, 2020). This highlights the need for effective teaching strategies, such as using relevant materials and other learning resources, to help students understand and process the information being learned. By activating prior knowledge and using effective teaching strategies, students can move away from rote learning and engage more deeply with curricular elements (Bruhn & Hasselbring, 2013).

Although concept mapping is central to cognitive psychology and constructivist epistemology (Novak & Cañas, 2009), and educators widely recognize the use of concept maps (Ausubel et al., 1978; Novak & Cañas, 2008), there is scarce evidence regarding its use in CLIL settings, where concepts are learned in a foreign language. Since "word meanings are psychologically represented by mapping words onto conceptual structures" (Murphy, 2002, p. 388), the cognitive processes involved in the procedure should be referred to in terms of how concepts are understood and *transferred* to real-life situations. Knowledge transfer refers to the conveying of meanings and structures from one language to another (Koch & Günther, 2021). The different languages used by bilingual speakers do not exist in complete isolation but rather interact with each other, leading to transfer phenomena "by which the speaker makes or attempts to make creative use of elements of the combined, full repertoire of linguistic structures" (Matras, 2012, p. 74).

Bilingualism, Bilingual Education, and the Experimental Subject Matter

Though different definitions have been formulated across the entire spectrum of bilingual abilities (Bloomfield, 1933), bilingualism is the ability to communicate fluently in two languages. According to Bloomfield (1933), it is "the native control of two languages" (p. 56). In more recent research, it is stated that individuals who know or recognize a few sentences or have some skills in another language could be considered bilinguals (Diebold, 1964; MacNamara, 1969). According to Haugen (1953), bilingualism is the stage where a speaker can express complete meaningful statements in another language. According to Mackey (1962) and Weinreich (1968), bilingualism is the alternate use of two or more spoken languages.

At the turn of the 21st century, researchers focused on the application of languages rather than the speaker's skill levels. For example, Hamers and Blanc (2000) suggested that a person's language use may not be stable but prone to switching and adequately chosen based on conditions like time, location, purpose, and social

context. According to Grosjean (2008, p. 14), "the bilingual uses the two languages – separately or together – for different purposes, in different domains of life, with different people". Li (2008) and Myers-Scotton (2009) referred to bilinguals as those able to use two languages for casual communication or anyone who can engage in multilingual communication actively through speaking and writing, or passively through listening and reading.

Nowadays, bilingualism can be acquired through different means, including formal education (Alatis & Tan, 2001) or exposure to linguistic diversity (Yip & Matthews, 2022), and it is considered a valuable skill in today's globalized world (Marian & Shook, 2012). Yet, bilingualism explores cognitive (Peal & Lambert, 1962), linguistic (Stein et al., 2012), and socio-cultural implications (Lambert, 1978). It also shows advantages in areas like cognitive flexibility (Adi-Japha et al., 2010), cultural competence (Antoniou, 2019), and metalinguistic awareness (Cummins, 1978).

Researchers approach bilingualism and psycholinguistic analysis differently. Brain imaging (Kovelman et al., 2008) and socio-linguistic investigations (Fishman, 1968) are some mechanisms used to study bilingualism. Through these approaches, researchers seek to gain an insight into language processing (Kroll & Bialystok, 2013), language acquisition (Bialystok, 2007), language attrition (Schmid, 2010), and socio-linguistic dynamics (Opitz, 2013). The goal is to enhance understanding of the cognitive and socio-cultural implications of language diversity and propose effective educational strategies for promoting bilingualism in diverse learning environments.

Evidence from empirical studies shows that bilingual education improves cognitive skills (Cummins, 1977), language proficiency (Freeman & Schroeder, 2022), and cross-cultural understanding (Tomyuk et al., 2019), contributing to academic success and equipping students for life in a multicultural society. It also promotes language proficiency in both the native (L1) and the foreign (L2) languages, providing valuable skills and professional results (Charoenphon, 2023). In this regard, bilingual education programs have become a priority worldwide.

In Spain, bilingual education is subject to specific regulations, with CLIL as the main point of reference. CLIL, which involves teaching in either L1, L2, or both, has been implemented in various educational settings (Coyle, 2007). In this country, bilingual programs are offered at all levels of education, with English being the L2 typically chosen. In order to achieve this, teachers receive specialized training and implement a range of teaching methods to support language development.

Although the outcomes of bilingual education programs in Spain have been varied, they continue to be a significant component of the educational system, promoting linguistic diversity and preparing students for a multilingual society.

In the primary education curriculum, science plays a significant role in developing students' understanding of the natural world. In this context, students are exposed to these concepts in L2, which promotes bilingualism and enhances their scientific knowledge. Within this background, studies have looked into the impact of concept maps on long-term memory in science education (Nesbit & Adesope, 2006; Ruiz-Primo & Shavelson, 1996). These visual tools, which connect related ideas and concepts, have been shown to improve students' understanding and retention of information by structuring and linking key concepts. Therefore, concept maps not only promote meaningful learning, but also aid in organizing knowledge and improving critical thinking skills (Friedman, 2010). The integration of concept maps into science education has shown promising results in improving students' long-term memory.

Perception, Memory, Intelligence, and Learning Styles in Bilinguals

Learning "involves acquiring and modifying knowledge, skills, strategies, beliefs, attitudes, and behaviors" (Schunk, 2014, p. 2) – where factors like age can influence task achievement (Kail, 1988). In bilingual education, research has shown that bilinguals tend to outperform their monolingual counterparts in situations with distractions, showing better focus on visual items for identification and faster discrimination of simple shapes (Chabal et al., 2015; Friesen et al., 2015), which indicates higher levels of natural control over selective visual attention. Since autobiographical memory can vary from lucid to dull (Schrauf & Rubin, 2000), it raises questions about whether perceptive skills could be connected to conscious or unconscious aspects of autobiographical memory that contribute to delayed explicit memory recall. This line of inquiry suggests that students may resort to rote memorization when they lack clarity about a given task.

Perception and memory can be influenced by the rate at which materials are presented to learners (Matthews & Henderson, 1970; Norman, 1966) and how the subject matter is designed and taught. Thus, when using concept maps for instructional purposes, "science teachers should give careful thought to the *exact* [emphasis added] nature of the concept mapping tasks selected for use in their classrooms" (McClure et al., 1999, p. 490). From our standpoint, the cognitive abilities of students and

their depth of understanding are not exclusively determined by their intelligence. Students are also influenced by the teaching methods used by their instructors and their knowledge of instructional design.

Sternberg (2002) argues that many educational institutions still heavily rely on narrow measures of intelligence for academic purposes, which can significantly influence learners' outcomes. Even though the notion of intelligence can be analyzed from different perspectives, this research defines it as an individual's cognitive abilities and processes to adapt behaviorally to their surroundings. According to Jensen (1998, p. 46), these encompass "stimulus apprehension, perception, attention, discrimination, stimulus generalization, learning, learning-set acquisition, remembering, thinking (e.g., seeing relationships), and problem solving". This definition aligns with the measurement of the general factor (*g*). Thus, non-verbal IQ assessments could serve as reliable predictors for individuals who are less proficient in the English language (Kuschner, 2013).

Consequently, perception plays an important role in how bilinguals process and interpret information. In fact, bilinguals utilize their linguistic and cultural background during the learning process (Ozfidan & Toprak, 2019), which can influence how they perceive new information and ideas. The interplay between languages and the ability to switch between them can shape how bilinguals interpret and understand educational materials (Li & Dong, 2020). Building upon this premise, bilingual memory – which encompasses learning and perceptual-cognitive attributes – affects how information is encoded, stored, and retrieved. More specifically, working memory – a component of memory responsible for holding and manipulating information – has a significant impact on language processing and learning for bilinguals (Gathercole & Thomas, 2009).

Intelligence quotient and learning styles also contribute to the development of bilinguals (Gueye, 2015), but intelligence alone does not determine learners' understanding and learning outcomes. When bilinguals struggle to understand the task at hand, it becomes difficult for them to learn (Sternberg, 2018). This highlights the importance of tailoring instructional approaches to learners' cognitive abilities, preferences, and learning styles. Likewise, teachers' instructional approaches and awareness of diverse learning styles also influence the learning process. For example, teachers who are aware of different learning styles can adapt their teaching to accommodate learners, thus improving engagement and understanding (Dunn & Griggs, 2000). By considering both intelligence and learning styles, educators can

create inclusive and effective learning environments for students, therefore having a significant impact on students' learning outcomes (Altarriba & Soltano, 1996; Bialystok, 2001) and helping them improve their understanding, engagement, and overall school experience (Cummins, 2000; Gardner, 2006).

Instructional Design: Integration of CLIL, Concept Maps, and Assessment

Understanding Content and Language Integrated Learning

Pioneered by a diverse group of experts such as educational administrators, researchers, and practitioners (Marsh, 2002), the concept of CLIL emerged in Europe during the 1990s. Marsh (2002) described it as "a pragmatic European solution to a European need" (p. 11). According to Coyle et al. (2010), CLIL is an instructional approach that combines content learning with language acquisition. CLIL aims to help students learn both content and language simultaneously, resulting in improved engagement and language skills, as well as improved understanding across subjects like science, social studies, and mathematics (Coyle et al., 2010).

CLIL is an interdisciplinary approach that involves using varied teaching strategies (Coyle et al., 2010) to develop a deep understanding of subject-matter ideas and higher-order thinking skills (Coyle et al., 2010; Biggs & Tang, 2011). CLIL also helps students develop a broader range of vocabulary and language skills (Coyle et al., 2010). Through CLIL, cultural awareness and understanding in addition to exposing students to different cultures and ways of thinking is promoted, which also fosters a more global perspective and tolerance (Coyle et al., 2010). As for the relationship between CLIL and bilingual education, Coyle (2018) states that integrated learning is also known as "bilingual education", as it includes a diverse range of second or additional language contexts in education.

Thus, CLIL – as a dual focus – involves the use of an additional language for learning content and language skills (Coyle et al., 2010; Marsh, 2002). According to Marsh (2008), the uses of CLIL are diverse and depend on the educational level, environment, and approach adopted. According to Coyle et al. (2010), there is no fixed formula or method to implement CLIL. As such, CLIL is a broad concept frequently regarded as slippery (Cenoz et al., 2014). For this reason, Coyle (2008) underlines the lack of consensus on CLIL pedagogies, stating that there is no single approach or theory governing CLIL. Due to its suitability for bilingual education, CLIL has become pivotal in driving bilingualism forward (Coyle, 2018).

To better understand the role of CLIL in Spain, it is necessary to make a distinction between bilingual education and foreign language education. Even though both are closely tied to the learning and use of language, the term *foreign* holds a nuanced connotation in distinguishing non-native languages from native ones (Yuan, 2005). Bilingual education involves instruction in two languages and their use as mediums for teaching across the school curriculum (Cohen, 1975).

In the context of Spain, there was a shift in foreign language education following the release of the European Commission's (1995) White Paper on Education, which established that secondary school students should begin learning subjects in an L2 (i.e., another language). Consequently, educational institutions in Spain have made concerted efforts to implement these guidelines by promoting multilingualism, cultural awareness, and bilingual programs based on CLIL (Palacios-Hidalgo et al., 2021).

Benefits of using Concept Maps in Instructional Design

Concept maps are tools designed to help learners visualize and organize information (Novak & Cañas, 2008). They are effective in helping learners understand the relationships between different concepts and ideas, allowing them to grasp how these concepts fit together as part of a larger system (Novak & Cañas, 2008) to help learners understand the broader context. By presenting the interconnectedness of information rather than isolated facts, concept maps allow learners to observe how parts fit together as a whole, which, in turn, facilitates deeper understanding and enhances long-term retention (Novak & Cañas, 2008). They can be used in a variety of instructional contexts and aid learners in understanding complex concepts across different subject matters (Novak & Cañas, 2008). By encouraging learners to create concept maps, instructors also foster active participation to create further and more dynamic learning environments (Cliburn, 1990).

Assessment and Instructional Design

Assessment is a crucial part of instructional design. It serves as a valuable tool for guiding instructional decisions, monitoring progress, and promoting meaningful learning. A key aspect of assessment in instruction relies on its ability to provide ongoing feedback to both learners and instructors. This feedback helps them identify strengths and weaknesses and guides them towards achieving the intended learning outcomes (Hattie & Timperley, 2007). Assessment also plays a pivotal role in promoting student engagement and motivation. When assessable tasks are created to reflect real-life situations, they increase pupils' engagement and relevance in the

learning process (Wiliam, 2011). By incorporating formative assessment tasks, such as self or peer assessments, learners take ownership of their learning and develop metacognitive skills (Black & Wiliam, 2009).

Through continuous assessment, instructors can identify students' individual needs and adjust their teaching methods accordingly, providing targeted support or extension activities (Hattie, 2012). By analyzing assessment results, instructional designers can identify gaps in learning and make necessary adjustments to teaching methods and materials (Shepard, 2000). Assessment serves as a catalyst for integrating different teaching approaches. For example, when using concept mapping based on Universal Design for Learning (UDL) principles, it is important to have ongoing feedback that aligns with the instruction (Ausubel, 1968).

Regarding assessment, concept maps can be used as resources for providing students with feedback, helping them organize their knowledge, and clarifying misunderstandings or distortions in their comprehension of the content (Novak & Cañas, 2008). As highlighted by Croasdell et al. (2003), many educational institutions now conduct end-of-course evaluations and end-of-program assessments to gauge students' learning. In the evaluation process, concept maps can be an alternative to traditional examinations (Croasdell et al., 2003) and serve as assessment tools to collect evidence on knowledge structure in a particular domain, the format of students' answers, and the scoring for evaluating the concept maps made by pupils (Ruiz-Primo & Shavelson, 1996). According to Beaudry and Wilson (2009), concept maps should be used as formative assessment tools for most learning goals and not be graded or scored.

Practical Strategies for Integration

Practical strategies for incorporating CLIL, concept maps, and assessment in teaching can greatly enhance the learning experience for students. One effective approach is to combine CLIL and concept maps, where students create concept maps in the L2 to demonstrate their understanding of the content (Dalton-Puffer, 2013). Other strategies may involve using concept maps as assessment tools by having students create them and assess them based on expected learning outcomes (Novak & Cañas, 2008). As mentioned, integrating formative assessment techniques like peer and self-assessment can prompt student reflection and improve metacognitive skills (Wiliam, 2011) to enhance content learning and language skills.

Methods, Participants

Participants in the study were not randomly chosen but were naturally given, resulting in an experimental design with naturally occurring groups. The experimental and control groups were matched on key conditions except for the intervention, ensuring control over nuisance variables to minimize the potential effects or variations among subjects receiving treatment. While the findings may be limited by factors such as randomness, sample size, and the specific characteristics of the schools involved, the chosen sample of (pseudo) bilingual schoolchildren still effectively represents the larger population of interest. In other words, testing only one school may limit the generalizability of the results, but the sample still provides valuable insights into the performance of bilinguals with similar traits.

The sample size and characteristics showed no significant differences. The study involved 60 primary education students in Spain, aged 9-11 (M_{age} = 9.78; SD = 0.49), from a semi-public Spanish bilingual school with an English program based on CLIL. In terms of age, the groups were homogeneous (t_{56} = 1.32; p = 0.191). Out of the total (N = 60), the control group comprised 21 males and 9 females, while the experimental group included 19 males and 11 females. A special needs student was included in the study to reflect real-life classroom environments, in accordance with Ausubel's (2000) belief that classrooms should maintain their inherent nature. Although there were more male students in the sample, there were no significant differences between the groups (p = 0.081).

Despite differences in levels of involvement, no participants dropped out of the program, so each of them remained in their assigned treatment group. As Keppel and Wickens (2004) point out, maintaining equal sample sizes guarantees "that each treatment condition contributes equally to the analysis of a study, [and] reduces any problems associated with violations of the assumptions underlying the analysis of variance" (p. 54). According to these authors, quasi-experimental research involving participants with different past treatments and uncontrollable factors like age or gender may lead to unequal sample sizes. However, in our study, no student was excluded from it or the analysis to alter the results.

Ethical praxes

When considering the ethical aspects of research involving human subjects (World Medical Association [WMA], 2013), various steps were taken prior to commencing the instructional procedures. Initially, a meeting was held with the school's Man-

agement Team, who acted as the Research Ethics Committee/Institutional Review Board, to obtain approval (American Psychological Association [APA], 2020) for implementing the *innovative* Instructional Program for the Retention of Knowledge Acquired in a Foreign Language (PIRSC-L2), as well as ensuring data protection (General Data Protection Regulation [GDPR], 2016). After receiving approval for PIRSC-L2, individual consent was obtained from the legal guardians/parents of the students through documented agreements. All parties were informed that the research aimed to generate new observational knowledge while ensuring respect for participants' rights and interests. During the intervention, data collection took place in school settings, and only the researcher gathered information on students' academic achievements.

Given that children are considered as vulnerable, the intervention was carefully designed to meet their specific needs. This took into account factors such as their developmental stages, learning rhythms, and styles. Furthermore, to ensure positive experiences, participation in the activities was voluntary, with no pressure or coercion. Additionally, the activities were seamlessly integrated into regular instruction. To protect the participants' identities, their names were replaced with random codes. This information was not publicly available or sent to repositories. Feedback on their child's progress was only provided to parents who requested it after the experiment. Similarly, student grade reports were sent to schools, but neither schools nor families had access to the research data files.

Materials and Procedure

The instruments for instruction and data collection are categorized as *conventional* (i.e., traditional educational resources that adhere to established norms), *unconventional* (i.e., alternative approaches to teaching and learning that deviate from mainstream practices), and *standardized* (i.e., referring to the use of uniform assessment criteria to evaluate student performance). In this specific study: [x] *conventional* materials refer to the exams with which students are familiar with; [y] *unconventional* materials encompass both intangible and tangible elements related to PIRSC-L2 that were introduced to trained participants for the first time; [z] *standardized* materials involve nuisance variables assessed through standard instruments before and after treatment in both groups to evaluate participants' cognitive abilities. The references ([x], [y], and [z]) given to these categories should not be linked with x or y axes/variables in scatter plots. It is important to note that: it took one month to select the

school/sample; 15-20 days for intervention approval; three months for intervention design; and one school year was dedicated to implementing PIRSC-L2.

The *conventional* materials used in the yearly experiment were the same as those traditionally used by the school's teaching staff for end-of-year exams. These tests, which were provided by the subject's book publisher, included a variety of activities to assess students' knowledge of each work unit (WU) on the curricular contents (usually 8 to 12 [in this research eight units total]). After covering each unit (~ means approximately one month per WU), students took an official test, whose average scores appeared as their final marks in their reports. As the exams were official and it was agreed with the Institutional Review Board that regular classroom procedures would not be altered, both groups of participants were *informed* with sufficient time (a week) before taking each test following completion of a unit of work. Hence, students took the last exam (8th WU, *Energy* and *Technology*), which consisted of an *uninformed* and unofficial test covering all work units. This test was administered at the beginning of the last week of the school year and was designed to be similar to the official tests to assess the long-term memory [x] of participants. Since the goal of the research was to measure what the participants remembered instead of their language skills, they were allowed to give definitions in both languages – and they did.

The *unconventional* materials used during the yearly experiment are known as PIRSC-L2 (designed *ad hoc* for concept mapping) and include charts, Venn diagrams, learning portfolios, concept maps, propositions, and definition-translation templates, among others. As these materials were new to students and were used for the first time, they posed some challenges at the beginning. For example, in identifying and classifying noun categories, the researcher had to modify the instructions and introduce Venn diagrams to help students understand the task better. These *ad hoc* materials encompassed both physical and non-physical elements fulfilling different roles in teaching, learning, and formative assessment. Moreover, such instruments were not only designed for concept mapping but also served as instructional aids to assist participants in understanding the basic principles of concept mapping and effectively participating in the activities. In addition, digital blackboards, traditional blackboards, and other tools were used for teaching purposes. In contrast, learning portfolios and CmapTools were used to enhance the learning experience. Similarly, peer assessment techniques were employed for formative assessment purposes. The data gathered from this evaluation was used to assess the effectiveness of the PIRSC-L2 program [y] during any stage of the process.

The *standardized* materials were used at the beginning (pre-tests) and end (post-tests) of the annual experiment to measure different facets of the participants, such as their attributes in the L2 language, learning styles, and IQ. In this respect, the Flyers Cambridge exam was conducted to assess both receptive and productive language skills, since it is widely recognized for evaluating language proficiency in young students. In addition, data on learning styles was collected using the Group Embedded Figures Test (GEFT), which is an evaluation that identifies people's cognitive styles and their preferences toward either global or analytical processing. Furthermore, IQ scores were calculated using the g factor, a widely used approach for measuring overall intelligence. The data gathered from both the pre- and post-tests yielded significant insights into these extraneous variables [z], allowing for their consideration and control in the research analysis.

Research Design

The research was quasi-experimental, with participants being chosen in a non-random way. They all received the same instructions, except for the treatment they received (see Figure 1). The study also involved an inferential hypothesis about how using concept mapping in everyday teaching may affect the long-term memory of bilingual individuals. To do this, the researchers compared two groups (the *treatment* and *control* group), using statistical analysis to look for differences between them. The focus was on the group that received the treatment (T_1). To evaluate the impact of concept mapping on long-term memory, a unifactorial analysis was conducted using null hypothesis testing. Also, it is worth noting that this study does not involve analyzing any secondary data.

Figure 1. Structure and Research Design

$$\begin{array}{lll} (T_1)\ M_{NR}\ O_1 & X & O_2 \\ \hdashrule{\textwidth}{0.4pt}{2pt} & & \\ (T_0)\ M_{NR}\ O_3 & & O_4 \end{array}$$

Note: From Cohen et al. (2018)

A one-way analysis of covariance was performed to assess the impact of using concept mapping on the long-term memory of acquired knowledge. The between-subject factor considered participants who received training on concept mapping versus those in the control group who did not. The study checked if the groups were similar at the beginning and if certain factors affected how well they

remembered the information. Thus, students' previous grades, IQ, learning styles, and L2 skills were included as factors. Before the intervention, a comparison of the two groups was conducted using t-tests on various variables. The results indicate that both groups were similar in terms of reading and writing abilities, as well as IQ. Additionally, the Group Embedded Figures Test (GEFT) showed similarities in both groups, which could be attributed to non-random assignment leading to quasi-experimental conditions.

Results

When examining the results of the hypothesis testing, several conclusions can be drawn from informed and uninformed test outcomes. The study showed differences in test results between trained and untrained participants ($F_{1.54} = 6.834$; $p = 0.012$; $\eta^2 = 0.112$).Differences favored participants in the control group when they were informed about exam dates. When students were unaware of exam dates, significant differences between groups disappeared, putting participants in the control group at a disadvantage. In this case, there is a significant decrease in scores between being aware or unaware of upcoming tests (a variation of 1.13 marks between values); whereas, under similar circumstances, the scores between the tests remain almost unchanged in the experimental group (with a difference of 0.48 marks). This changes the statistical differences between the groups from *significant* to *not significant*.

Discussion

Regarding the significance of reading and writing skills in CLIL, it has been proven that they are crucial for both understanding and creating content (Loranc, 2009). Other researchers argue that language proficiency alone is not sufficient for students to succeed academically (Elder & von Randow, 2008; Kerstjens & Nery, 2000). Our study demonstrates the importance of considering multiple factors when interpreting performance differences resulting from different teaching strategies. It also reveals that students' bilingual memory, both short-term and long-term, may influence their performance. In this regard, it has been demonstrated that providing exam dates did not significantly benefit trained participants and may have even resulted in decreased attention during day-to-day assessments.

To address this issue, it is recommended that assessments during the learning process and at the end of it be closely linked to the teaching methods employed. This will help to keep students consistently engaged and discourage them from re-

lying solely on memorization-based learning methods. Furthermore, the study emphasized the importance of aligning exam design with the instructional approach. Therefore, it is advisable to create exams that engage short-term memory and foster meaningful learning, rather than relying solely on rote memorization. Additionally, throughout the study, the control group consistently outperformed the experimental group, indicating that individuals have varying memorization abilities. These findings underscore the need to thoroughly understand instructional design and take into account students' diverse learning styles and abilities.

This research addresses a gap in the application of concept mapping in CLIL, showing how it can enhance long-term memory. This has several implications for educational practice, research, and policy. Specifically, the integration of concept mapping can transform teaching strategies, promoting deeper understanding and meaningful learning rather than rote learning. In terms of research, this study suggests that future investigations into cognitive processes and instructional strategies in bilingual education are necessary. It also encourages further exploration of how concept mapping can be optimized for different students and age groups, contributing to a broader understanding of its benefits and limitations. Researchers can build on these findings to develop more refined methodologies and interventions that enhance learning in diverse educational settings.

Conclusions

The study presents *three* main findings regarding CLIL, instructional design, and long-term memory. The *first* finding suggests that having higher English skills can aid in understanding L2 content effectively, but it may not necessarily enhance long-term memory. Based on this premise, research indicates that concept mapping, along with its structured and comprehensive pedagogy, is strongly linked to long-term memory – even when students' English skills are not advanced. Therefore, concept maps are considered the most effective tools for shaping cognitive structures, aiding students in conceptualizing and comprehending L2 content in greater depth. In this context, the accurate transmission of subject matter plays a crucial role in *conceptualization* and *recall*, or *obliteration* patterns in bilingual memory.

The *second* finding is related to the importance of instructional design and its clarity in bilingual classrooms. Traditional L1 approaches should be cautiously integrated into L2 classrooms as L2 learning poses a challenge for many students at the beginning of their learning journey. Hence, well-designed teaching tailored

to students' characteristics and learning styles leads to increased engagement and participation without negative effects. While the instructional design was generally accurate, some elements needed adjusting to enhance students' comprehension – especially regarding word category recognition patterns, which are crucial for creating concept maps.

The *third* finding suggests that when students are notified of an upcoming exam, their tendency is to concentrate on memorizing the learning material rather than comprehending it. Consequently, in order to assist students in preparing more effectively, it is advisable to utilize more targeted assessments that allow them to focus on reviewing the content specifically for the exam. Keeping this in mind, one limitation of this study is the mismatch between the instructional design and the exam design. Therefore, in order to draw more comprehensive conclusions, further research should be conducted on instruction and test design for CLIL settings in order to understand how formative and summative assessments align with instructional approaches.

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