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Fundamentals of the neuroscience of learning to support Content-and-Language Integrated-Learning-(CLIL)-based lesson planning in primary education: potentialising learning through a basic understanding of the brain in childhood.

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Yr Athrofa: Education and Humanities

DECLARATION FORM

Name of the Programme of Study: Master of Arts: Bilingualism and Multilingualism

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DECLARATION

I certify that the whole of this work is the result of my individual effort, and that all sources have been acknowledged.

Signed:

Rafael Henrique Bianchi
Date: 16-01-24

DECLARATION

I am satisfied that this work is the result of the student's effort.

Signed:

Dr Hywel Glyn Lewis
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Date: 27-01-24

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ABSTRACT

This dissertation is the result of a cross-sectional study conducted to investigate the potential synergies between the principles of Content and Language Integrated Learning (CLIL) and the neuroscience of learning. The study aimed to determine if the application of basic neuroscience principles in CLIL lesson plans within a bilingual primary education program could enhance the effectiveness of educational tools and strategies for improved learning outcomes.

Through the proposed exploration, the present researcher attempted to address the question: ***Can the neuroscience of learning corroborate or refute CLIL (Content and Language Integrated Learning) principles applied in primary school lesson plans?***

The research objectives were sought through a literature review encompassing historical perspectives of CLIL and the field of neuroscience of learning, lesson observations, and self-evaluation questionnaires with the experimental group. The study also examined the alignment of CLIL with fundamental neuroscience principles, with an emphasis on the work of Stanislas Dehaene (2022).

Field research was conducted within a CLIL-based bilingual program implemented in a Brazilian mainstream school, Colégio Santa Úrsula. Teachers from grades 1 to 5 participated in the study, which focused on the planning and delivery of CLIL lessons in this primary education setting.

Preliminary findings indicate a convergence between CLIL principles and the neuroscience of learning, as observed during the literature review phase. The theoretical frameworks underlying both fields appear complementary and aligned in many aspects.

Elements of the CLIL approach are likely to support the learning process from a neuroscience perspective, and there are significant correlations between reported findings in neuroscience and CLIL pedagogical practices. It has also been observed that the intentional changes proposed for lesson planning and delivery had positive outcomes when teachers were educated to consider bolstering their lessons by resorting to the theoretical scope provided in this study.

While the findings of this research fulfil the proposed objectives, they do not establish new parameters for CLIL lesson planning. It is suggested that a longitudinal study following the same methodology could build upon these initial indications and provide more robust data to support educators in similar settings.

In conclusion, this study provides initial evidence supporting the integration of basic neuroscience principles into CLIL lesson planning. However, further research is necessary to strengthen these findings and provide educators with more comprehensive guidance for optimising learning outcomes through CLIL instruction.

ACRONYMS

4Cs: Content, Communication, Culture and Cognition

BICS: Basic Interpersonal Communicative Skills

CALP: Cognitive Academic Language Proficiency

CLIL: Content and Language Integrated Learning

CNE: Conselho Nacional de Educação (Brazilian National Education Council)

EFL: English as a Foreign Language

EU: European Union

FL: Foreign Language

IMBES: International Mind Brain and Education Society

IQ: Intelligence Quotient

L1: First Language (Language One)

L2: Second Language (Language Two)

MFB: Medial Forebrain Bundle

MRI: Magnetic Resonance Imaging

SUP: Separate Underlying Proficiency

1. CHAPTER 1: INTRODUCTION

Political and economic pressures are factors to be taken into account when addressing pre-conceived assumptions in the field of bilingualism and multilingualism. Garcia and Beardsmore (2009) illustrate how the construction of language policies was tied to power and dominance, as in the case of French, English, Portuguese and Spanish colonies. Dominant languages were assigned as official to the State as heritage languages were diminished – many of them to their complete extinction.

Honório do Couto (2014) explains that, in Brazil, the Portuguese language 'colonised' a continental territory at the expense of indigenous languages. Initially, contact between the Portuguese language spoken by the colonisers and the major indigenous languages originated a local variant named *Língua Brasilica* (Brazilian Language in free translation).

Brazilian Language disappeared by the end of the 18th century through a gradual process of language assimilation and attrition with Portuguese, although traits of this extinct language can still be perceived in the variety of Portuguese spoken in Brazil, as in the name of the Brazilian state *Paraná*, which means "river" in the native language.

One of the most influential factors that led to the weakening of this first Brazilian Language in the late 18th century was the prohibition of its use by the Portuguese administrator Marquis de Pombal.

But, if there was (and still is) genuine interest in constructing an image of monolingualism as the norm, ***what would be the most politically correct way to refute additive bilingualism in education policies?***

The answer may reside in something that became widely known and debated in a world where the COVID-19 pandemic recently struck. In the context of easy access to information through social media, misinformation was the wolf in sheep's clothing. Not even the shocking images of people dying in overloaded hospitals around the world were sufficient to restrain the wave of fake science discrediting preventive measures and vaccination.

As for bilingualism, Science responded to ideologies of assimilation and to economic factors that resulted in a detrimental view that has not been eradicated fully at present, despite the rise of supportive voices. On the contrary, it remains strong and continues to be propagated on many societal dynamics.

This study initially presents a historical perspective on bilingualism as a phenomenon reported in Science – from its negative implications to a new perspective of cognitive advantages enjoyed by bilinguals. It also places the developing bilingual brain into the promising scenario of the neuroscience of learning.

The approximation of these areas – bilingualism and neuroscience of learning - is addressed by the primary aim of the investigation proposed: to establish connections between the neuroscience of learning and pedagogical tools to which teachers can resort when planning lessons based on Content and Language Integrated Learning (CLIL).

The choice of CLIL as the bilingual education approach targeted in the present dissertation is because it has become an educational fashion in Brazil recently, being adopted in questionable manners by a number of schools that 'bought' the idea of CLIL as an easy and flexible solution to meet the demands of a growing market:

> […] CLIL has become a buzzword in Brazilian private schools. The country has experienced rapid and significant growth in the area of English language immersion-style education, a format lending itself to the CLIL approach, anchored in a marketable perspective of international and intercultural education (Landau, J. et al., 2021, https://link.springer.com/chapter/10.1007/978-3-030-70095-9_13#citeas, retrieved on July 9th 2023)

The apparent flexibility of the approach and lack of regulation of bilingual schools in Brazil, until recently, allowed for distortions in the implementation and execution of CLIL-based programmes.

Part of the present study is dedicated to discussing the onset and development of CLIL over the last three decades as well as the principles of the approach as they appear to be reflected in some basic fundamentals of the neuroscience of learning. That leads to the research question:

Can the neuroscience of learning corroborate or refute CLIL (Content and Language Integrated Learning) principles applied in primary school lesson plans?

In an attempt to offer some contribution to this area of interest, the present dissertation looked at an educational setting in Brazil where a CLIL-based bilingual programme has been put into practice. Brazilian primary school teachers figured as participants in the study that focused on the planning and delivery of their CLIL lessons to students from 1st to 5th grade, which corresponds to the pathway of primary education in the country.

The research question then unfolds into the following objectives:

- To identify if findings in the neuroscience of learning can support teachers when planning CLIL lessons for young learners and how it can be done.
- To identify if the delivery of CLIL lessons, planned upon a basic knowledge of the neuroscience of learning, showed to be more effective when compared to their previous practices.
- To investigate if the understanding of the processes of learning and second language acquisition reveals what is more effective as pedagogical tools in primary classrooms.
- To analyse what elements of the CLIL approach are found to be favourable to the learning process from the perspective of neuroscience.
- To collect evidence that indicates whether or not the functions of the prefrontal cortex and the limbic system should be regarded in the designing of lesson plans to optimise learning in primary CLIL classrooms.

The following chapters will be developed to address these objectives.

Chapter 2 brings the theoretical scope of the research upon which the research tools were constructed. An intersection between the areas was attempted through an overview of the evolution of neuroscience and learning as an independent (rather incipient) field of interest and the examination of CLIL advancements over the last decades.

From the theory presented, the study moves forward into empirical practices, presented in Chapters 3, 4 and 5. By documenting lesson observations in experimental and control groups, as well as considering the individual perceptions of the teachers, the present research sought empirical evidence to support a theoretical scope that connects CLIL

and cognitive development. Ultimately, Chapter 6 will offer conclusions and reflections on the overall outcomes of the research.

2. CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

Myths and beliefs surrounding bilingualism and bilingual education still penetrate society, influencing a family's choice regarding raising its children bilingually. In a broader context, public educational policies for bilingual education (or to assure the absence of it) are also constituted and delivered to cope with the interests of particular groups.

It is plausible to affirm that anyone can find some sort of information in science to sustain viewpoints in favour of or against bilingualism. One may assume that, generally, in scientific research, divergent standpoints emerge from a rich universe of methodologies, influential scholars, and institutions.

In this chapter, one will be situated historically in the fields of the neuroscience of learning and Content and Language Integrated Learning (CLIL). Besides looking at how a view on the bilingual brain shifted from detrimental effects to positive cognitive gains, a correlation between CLIL fundamentals and what is reported to be crucial for learning from a neuroscience perspective will be made.

2.2. Neuroscience and Learning

The approximation of the fields of neuroscience and education dates back to the late 1990s. The emergence of such an area of interest coincides with the appearance and enhancement of technologies that allowed scientists to 'observe' how the different brain structures respond to a diversity of stimuli. To mention one example, Magnetic Resonance Imaging (MRI) is one the most widely used non-invasive methods to assess brain activity while participants are exposed to specific tasks (De Smedt, 2018).

> Neuroimaging studies also allow us to understand learning at the biological level, which adds a new level of analysis to educational theory, for example in models on the acquisition of school-taught skills, such as reading and mathematics. This has the potential to complement as well as extend the existing knowledge that has been obtained on the basis of psychological educational research, and this new level of analysis might lead to a more complete understanding of learning (De Smedt, 2018, p. 8).

De Smedt (2018) refers to a number of academic journals (e.g., Mind, Brain, and Education; Trends in Neuroscience and Education; Educational Neuroscience), as well as to master's degree programmes in prestigious institutions (e.g., Harvard, Bristol, London, Leiden) and to scientific societies, such as the International Mind Brain and Education Society (IMBES) to illustrate the growing relevance of this field.

However, in the words of Howard-Jones (2008, p. 119, brackets added), "this enthusiasm [with neuroscience and education] also brings with it dangers, as evidenced by the long-running success of entrepreneurs in constructing and promoting unscientific and unevaluated 'brain-based' pedagogy."

In a more recent study, Howard-Jones (2014) points out that distorted scientific facts have commonly been used to justify inefficient pedagogical practices. He refers to widespread unscientific ideas as "neuromyths", attributing the coined term

to Professor Alan Crockard (1980). Howard-Jones (2014) refines the term "neuromyth" applied in the field of education by resorting to the definition given by the UK's Organization of Economic Co-operation and Development (OECD):

> "[Neuromyth is a] misconception generated by a misunderstanding, a misreading or a misquoting of facts scientifically established (by brain research) to make a case for use of brain research in education and other contexts" (Howard-Jones, 2014, p. 817, brackets added)

The table below exemplifies how neuromyths impact teachers of different cultures and backgrounds and can, in turn, be reflected upon educational practices.

Myth*	Percentage of teachers who "agree" (rather than "disagree" or "don't know")				
	United Kingdom (*n* = 137)	The Netherlands (*n* = 105)	Turkey (*n* = 278)	Greece (*n* = 174)	China (*n* = 238)
We mostly only use 10% of our brain	48	46	50	43	59
Individuals learn better when they receive information in their preferred learning style (for example, visual, auditory or kinaesthetic)	93	96	97	96	97
Short bouts of co-ordination exercises can improve integration of left and right hemispheric brain function	88	82	72	60	84
Differences in hemispheric dominance (left brain or right brain) can help to explain individual differences amongst learners	91	86	79	74	71
Children are less attentive after sugary drinks and snacks	57	55	44	46	62
Drinking less than 6 to 8 glasses of water a day can cause the brain to shrink	29	16	25	11	5
Learning problems associated with developmental differences in brain function cannot be remediated by education	16	19	22	33	50

*The table shows some of the most popular myths reported in four different studies from the United Kingdom[3], The Netherlands[1], Turkey[4], Greece[2] and China[7]. In all studies, teachers were asked to indicate their levels of agreement with statements reflecting several popular myths, shown as "agree", "don't know" or "disagree". The table shows the percentages of teachers within each sample who responded with "agree".

Table 1: Prevalence of neuromyths amongst practising teachers in five different international contexts. Source: Howard-Jones, 2014, p. 818.

Neuromyths have also been largely propagated when bilingualism is concerned. Misleading information has intentionally been spread out in contexts where language was forcibly minoritised to its complete extinction as a strategy to impose dominance and power, as seen in the processes of colonisation by European empires in South America.

2.3. Neuroscience and Bilingualism

As illustrated above, neuroscience research has benefited from advancements in technology. Studies in the field of bilingualism and bilingual education have also resorted to the tools available to corroborate theories once based majorly on empirical work. Understanding how fixed standpoints and scientific investigation in bilingualism and bilingual education have shifted toward a more positive bias over the last decades is essential for a more critical interpretation of the research available in this area.

Intellectual disadvantages of bilinguals over monoglots prevailed in science from the early 1800s to 1960s. Evidence to support this negative view was particularly linked with results of IQ (intelligence quotient) scores achieved through standardised testing that would demonstrate a tendency of bilinguals to be significantly out-passed by monolinguals when intelligence was regarded (Baker and Wright, 2017).

Such results fed widespread theories that labelled the bilingual speaker as an inferior individual, as he/she would be doomed to underperform in relation to so-called 'normal' monolingual beings. Hence, bilinguals were often considered 'mentally confused', as if two languages co-existing and operating simultaneously would hinder the processing capacity of the brain.

Baker and Wright (2017) make direct reference to the University of Cambridge Professor Laurie (1890) to illustrate the dominant attitude with regard to bilingualism at the time. Rephrasing his words would certainly not give the reader the same impactful impression that his original assertions may cause:

> If it were possible for a child to live in two languages at once equally well, so much the worse. His intellectual and spiritual growth would not thereby be doubled, but halved. Unity of mind and character would have greater difficulty in asserting itself in such circumstances. (Laurie, 1890, p. 15, cited in Baker and Wright, 2017, p. 132)

The turning point from a negative towards a positive view of bilingualism is marked by the research of Canadian scientists Peal and Lambert (1962). In 15 out of 18 IQ tests conducted by them, their findings suggested advantages for bilinguals over monolinguals. In the other three tests, results indicated equality. The researchers found that bilinguals have greater mental flexibility; in other words, they can think more abstractly, hence being superior in concept formation as they are less reliant on words (Baker and Wright, 2017).

From Peal and Lambert (1962) to the present, much has been added, modified, updated and even questioned in the theoretical scope of science related to bilingualism and (neuro)cognition.

2.3.1. The Balance or Balloon Theory

The operation of two (or more) languages in the brain resulted in different theories that, in turn, exerted significant influence on curriculum organisation and decisions towards promoting or discrediting bilingual education.

Baker and Wright (2017) qualify the Balance Theory as an "outdated" reasoning about language storage in the brain. According to this hypothesis, the acquisition of an additional language would necessarily happen at the expense of another. Similarly to the functioning of a balance beam scale, the brain would tend to equilibrate limited storage space for languages. As one language would grow in proficiency, the other one would forcibly decrease in order to liberate space, the former movement being related to the upward displacement of the scales plate and the latter with the plate going down.

As for the Balloon Theory, the idea is the same, although the metaphor is constructed with alternative images. Space for two languages in the brain could be compared with two balloons being inflated inside the head. In this case, air can be considered as language proficiency. Filling one balloon with air to its maximum capacity means deflating the other due to a lack of space inside the brain.

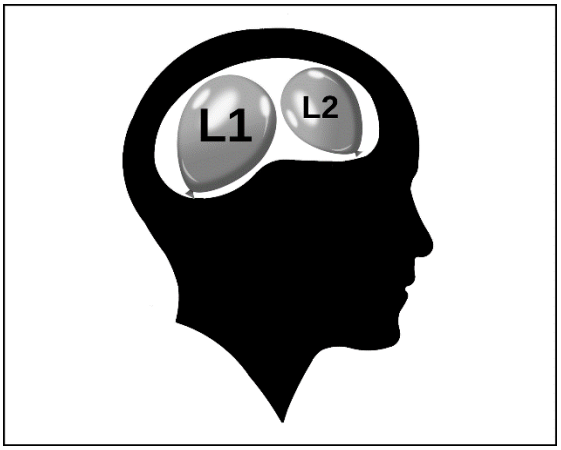


Figure 1: Balloon Theory graphic representation. Stock Images [edited]: https://www.canva.com

Cummins (1981) and Bialystok (2001) refute this theory arguing that no substantial research has set the ground for such a view. Contrarily, scientific evidence supports cognitive development firmly related to languages interactively working in the brain.

Baker and Wright (2017) develop their argumentation by deconstructing another widely spread equivocated belief, that of different languages being stored and activated in distinct areas of the brain. They state that "language attributes are not separated in the cognitive system, but transfer rapidly and are interactive," as when children are taught to multiply in one language and automatically transfer their knowledge to deal with mathematical operations of the same kind in a second language.

2.3.2. Common Underlying Proficiency Model

This model was proposed by Cummins (1981) in opposition to the Balloon Theory, also referred to as the Separate Underlying Proficiency (SUP) model. The Common Underlying Proficiency model conceives two languages as two icebergs seen above the water surface. They seem to be independent objects, but, underneath the surface, they are intrinsically merged into a common piece of 'ice', representing the processing system of the brain.

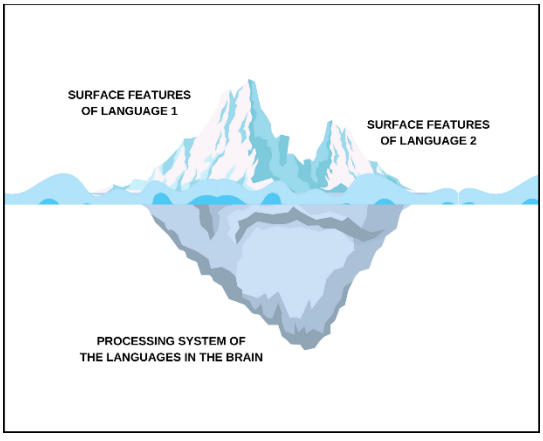


Figure 2: Common Underlying Proficiency Model iceberg representation. Stock Images [edited]: https://www.canva.com

In conclusion, languages are *perceived* as separate entities outwardly, but their processing in the brain is complex and entangled, sharing the same central operating system. Hence, talking, reading, writing, and listening, regardless of the language being used, emerge from the same central 'processor', and the cognitive system is positively affected as a whole when more than one language is stimulated. However, an insufficiently developed second language will prevent the brain from functioning at its best.

This theory seems to be supported by more recent findings, such as the ones demonstrated by Bialystok et al. (2007). In their work on the delay in the onset of dementia symptoms related to bilingualism, they state that, far from being two different pieces operating independently in the brain, languages are ***interdependent***. Such interaction results in enhanced cognitive processing and inhibitory control in children and older adults.

2.3.3. The Threshold Hypothesis

Cummins (1976), subsequently supported by studies by Bialystok (1988), Dawe (1983), Galambos and Hakuta (1988), Ricciardelli (1992), and Clarkson and Galbraith (1992), investigated the causal relation involving cognition and levels of bilingual proficiency. It has been demonstrated that until higher levels of language proficiency are attained, cognitive benefits cannot set in.

In his Threshold Hypothesis, Cummins (1976) attempted to respond to claims of studies indicating that bilingualism would adversely affect school progress. By reviewing a robust body of studies, Cummins concluded that difficulties would gradually be overcome if children were consistently exposed to experiences where they had to cope with both languages. In the long run, it would lead to a process of cognitive growth. On the other hand, those children who failed to cope with difficulties in dealing with their two languages would experience detrimental cognitive effects. In his own words:

> If the level of competence which a bilingual child attains in L1 and L2 mediates the effects of his bilingual learning experiences on cognitive growth, then in immersion or bilingual education programs there may be a threshold level of L2 competence which pupils must attain both in order to avoid cognitive disadvantages and allow the potentially beneficial aspects of becoming bilingual to influence their cognitive functioning (Cummins, 1976, p. 24)

Baker and Wright (2017) raise the issue of delayed achievements in education by children attending immersion schools (e.g., immigrants), adding another facet to the Threshold Hypothesis. Not only will cognitive benefits be prevented due to low language proficiency, but school performance will also suffer the impacts of a child not being able to cope with the necessary language to succeed in the academic context, at least until students develop some degree of linguistic competence. In this perspective, **dual language** programmes that allow students to operate in both languages from the beginning may be more efficient.

Criticism is placed on the Threshold Hypotheses since establishing precisely the levels at which the thresholds are reached is a complex task. Chin and Wigglesworth (2007) point out that even though levels of language proficiency can be measured, one would still not be able to indicate where the lines to be surpassed must be drawn on the scale.

Yelland, Polland et al. (1993) also oppose the postulations of Cummins (1976) by presenting findings that show cognitive advantages being perceived even in children who were subjected to minimal exposure to an additional language. In these cases, evidence showed that word awareness and reading superiority were attained temporarily.

Baker and Wright (2017) sustain that a purist view of the Threshold Hypothesis may also be used as an instrument to justify the already-antiquated thesis of *semilingualism*. To cite the researchers:

> Furthermore, the threshold theory is related to the discredited construct of semilingualism and does not account for the dynamic nature of bilingualism. It also tends to suggest that language needs to be developed to a high level before high levels of cognition can be activated. It thus fails to understand the more complex, interactive nature of language and thinking (Baker and Wright, 2017, p. 160).

Cummins (1979) himself built upon his threshold theory, reviewing and developing further studies. One of the most influential propositions accounts for differentiation in language use for children in two contexts:

BICS (Basic Interpersonal Communicative Skills): at this level of conversational language proficiency, communication takes place in contexts where basic social interaction emerges, such as greetings, playground language, and operational phrases one may resort to connecting with peers. In these contexts, the language produced demands lower abstraction and complexity. It is suggested that at least two years of exposure to a second language are necessary to achieve this level. However, variables such as quality of exposure, sources of language input, and frequency of use may cause the outcomes to differ from the initial expectations.

CALP (Cognitive Academic Language Proficiency): by attaining this level, students will be able to produce more complex and sophisticated language, having achieved a higher degree of proficiency in literacy skills (e.g., language required to construct academic essays). It may take five to seven years for one to reach the CALP level, also depending on the many factors to which reference was made in the previous paragraph to accelerate or delay this process of development (Cummins, 1979).

Baker and Wright (2017) highlight that the apparent oversimplification of the process of language acquisition as an absolute dichotomy has caused critiques such as the ones presented below:

a) The BICS and CALP theory proposes a linear development pathway, **suggesting** that oral communication is more likely to occur in contexts of low cognitive demand. **This may be incorrect**. For instance, situations in which one negotiates to convince the interlocutor by presenting oral argumentation to support a divergent viewpoint may require high cognitive processing in the brain.

b) Bilingual competence is constantly evolving in a dynamic and complex relationship that is influenced by various factors, such as sociocultural background, exposure to certain linguistic domains, and politics.

A more elaborated distinction, proposed by Cummins (1981), places cognitive demand and contextual support in two perpendicular continua (**Figure 3**), thus forming four quadrants, each representing a different level of cognitive processing for effective communication. For a clear understating of the scheme, one can benefit from the following differentiation:

a) ***Cognitively demanding communication*** requires higher processing skills from the brain than ***cognitively undemanding communication***. For instance, a conversation about an unfamiliar topic (cognitively demanding) will occur with less ease than an informal chat with a friend (cognitively undemanding).

b) ***Context Embedded Communication*** is given by the presence of contextual hints that may facilitate communication, such as a bilingual classroom prepared with visual support materials or a teacher using gestures when teaching. Diametrically opposed to it, ***Context Reduced Communication*** refers to situations where the interlocutors have reduced contextual clues, for example, a conversation on the phone where interlocutors are deprived of "reading" each other's facial expressions and body language.

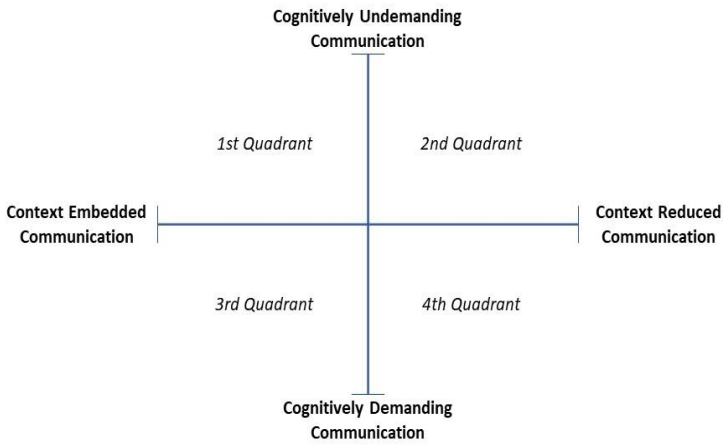


Figure 3: Cummins' Quadrants **(1981)**

One should notice that *Context Embedded Communication* **will not** necessarily be less cognitively demanding. For example, children being exposed to a second language for the first time may find it difficult to decode language even if they are surrounded by contextual clues in the classroom environment. This situation could well be placed in the third quadrant. In that case, regardless of being a conversational context, communication may result in high cognitive processing.

It is also **untrue** to suggest that *Context Reduced Communication* will always be more cognitively demanding. For instance, friends exchanging text messages on the phone will be deprived of visual resources and body language to communicate. Still, familiarity with the topic and the use of informal language will make communication flow with ease. In this case, the scenario described could be allocated in the 2nd quadrant.

The four quadrants reveal that to assess cognitive demand, one must go beyond considering oracy and literacy skills as a fixed order of increasing complexity.

In this view, the context needs to be regarded. In other words, BICS and CALP can occur in either context-embedded or context-reduced communication scenarios.

Baker and Wright (2017) address the relevance of Cummins's four quadrants in lesson planning and task designing:

> […] the four quadrants helped teachers consider the linguistic and cognitive demand of various classroom tasks and learning experiences and the kinds of **scaffolding** that would be needed to help students successfully participate and complete these tasks (Baker, 2017, p. 163).

2.4. The bilingual brain

The aforementioned models account for representations of language *storage*, language *development,* and language *processing* in the bilingual brain. Modern technology has attempted to support, refine or refute some of the classic postulations involving bilingualism and cognition, although caution is needed in assuming that neuroimaging results are absolute and flawless. Research based on neuroimaging identifies areas being activated in the brain when bilinguals engage in specific tasks (Baker and Wright, 2017).

Hull and Vaid (2007) found that activation in both cerebral hemispheres was more pronounced in fluent bilinguals than in the majority of right-handed monolinguals, who tended to show more activity in the left hemisphere when language was used. This finding supports a general agreement among researchers that two languages are active even when just one is being used (Baker and Wright, 2017).

Activation in the frontal area of the brain has also been observed when bilinguals switch or select languages (Rodriguez-Fornells et al., 2005).

Age of language acquisition also seems to be a factor of influence in the development of the brain. Research by Michelli et al. (2004) indicated an increase in grey matter associated with learning a second language. Although this benefit was found in both early and late bilinguals, when compared to a matched sample of monolinguals, the study showed that grey matter had greater density in early bilinguals.

Intriguing conclusions achieved after the employment of neuroimaging in research on multilingualism are also subject to criticism for many reasons. De Bot (2008) points out that researchers who have carried out the majority of the studies have only recently developed an interest in this field. The practical implication of this is that extensive research is still needed for more reliability in further results.

By citing Li (2013), Baker and Wright (2017) conclude that neuroimaging presents a "visible consequence of thinking but does not reveal the complex operation of the mind" (Baker and Wright, 2017, p. 141).

2.5. Benefits of Bilingualism

If not irrefutable, one can certainly assume, in the face of consistent scientific evidence, that cognitive benefits are enjoyed by balanced bilinguals. Besides findings previously addressed in this writing, reference to other researchers is worth making, as they corroborate the more recent research in the field of bilingualism. Their conclusions show that bilinguals:

- are better at dealing with complex mathematical and spatial problem-solving (McLeay, 2003);
- show superiority in scientific problem-solving (Kessler and Quinn, 1982);
- are ahead of monolinguals in developing concepts of numbers due to their high level of attentional control as, from an early age, they need to be attentive to which language is being spoken (Bialystok and Codd, 1997);
- tend to present lower rates of memory loss due to ageing (age 60 and above) in comparison with monolinguals (Bialystok, Craik, et al., 2014; Schroeder & Marian, 2012);
- are benefited from a delay in showing signs of dementia due to ageing (Bialystok, Craik & Freedman, 2007) and in the commencement of symptoms of Alzheimer's disease, four years later than the occurrence in monolinguals (Bialystok, Craik & Luk, 2012; Bialystok, Poarch, Luo & Craik, 2014; Craik, Bialystok & Freedman, 2010).

Inferences that seemed to be logical in the early research, indicating a prevalence of detrimental effects associated with bilingualism, have been constantly demystified as research evolves, showing the complexity of the bilingual brain and the cognitive gains emanating from its functioning.

It is prudent to acknowledge that methodological fragilities still require refinement and retesting, given the relative recentness of scientific approaches devoted to the investigation of bilingualism as a multifaceted cognitive phenomenon. In this perspective, advancements in neuroimaging may deepen the understanding of the bilingual brain.

Recognising the validity of studies conducted in this period of the additive effects of bilingualism should serve to support the promotion of bilingual education as a right for all children. But there is a pathway to be walked through so that science and politics can coexist in a collaborative relationship, as scientific knowledge may impact society mainly through the implementation of public policies.

2.6. The Content and Language Integrated Learning (CLIL) approach

The organisation of Europe as an economic unit led to the need to construct a continent that was more connected in terms of educational policies. In that sense, the planning of language teaching and learning was notably a concern of the European Commission in the early 1990s, when studies were sponsored aiming to develop innovative methods for foreign language instruction (Eurydice, 2006).

The European Commission is the EU's politically independent executive arm. It is alone responsible for drawing up proposals for new European legislation, and it implements the decisions of the European Parliament and the Council of the EU.

Marsh (2020) states that the term Content and Language Integrated Learning (CLIL) was presented in this context by the then-commissioned group of scholars and policymakers, of which he was a member, as a disruptive approach regarding strategies for language instruction in the curriculum.

According to the researcher, the initial move of the study group was to look at the best practices in language learning worldwide and to critically understand the general scenario in that area. After three years of study, the main findings were:

- Subject teaching was separated and fragmented in the schools;

- Language teaching was primarily done through grammar-based instruction;
- The learning goals were not aligned with the global competencies to real-life needs;
- There was a significant difference in the number of hours of language instruction depending on the country - from over a thousand hours to drip-feeding models in countries like Brazil;
- Textbooks also varied in quality, especially when the focus was on genuine content. In Finland, for example, genuine content was widely used for language instruction, whereas in Mexico, it was minimal. Surprisingly, fake content was also found in those textbooks, sometimes driven by political interests;
- Teachers evaluated that there were not enough hours of instruction in the curriculum devoted to learning an additional language. Moreover, they felt isolated and eager to connect with other areas in the school to improve the overall outcomes.

In the face of the issues to be dealt with, it became visible that renovations in the approach toward language instruction were necessary. Marsh (2020) explains that the group wanted to demystify that language learning was difficult and could only be achieved by certain young people. The idea, based on the most efficient practices they had observed around the world, was to promote content-driven language learning.

CLIL was an initiative to foster a dual-focused educational approach in which the additional language was used for the learning and teaching of **both** content and language. Marsh (2020) clarifies that "the term was looked at very carefully in terms of not pretending that this is something completely new, a new whiz way to learn languages, but a term that would be inclusive in bringing together teachers of different subjects" (Marsh, 2020, 28:54).

In 1995, one of the first pieces of legislation was approved to promote CLIL initiatives among the Member States of the European Union – the 1995 Resolution of the Council. It referred to the teaching of subjects through the medium of additional languages and the improvement of teacher training for bilingual contexts, encouraging the "exchange of high education students working as language assistants in schools, endeavouring to give priority to prospective language teachers or those called upon to teach their subjects in a language other than their own" (Eurydice, 2006, p. 8).

2.6.1 Outcomes and setbacks in over 20 years of CLIL

Recently published research by Goris et al. (2019) attempts to analyse evidence collected in different European countries regarding the efficacy of L2 acquisition through CLIL-based instruction versus language-driven teaching. The researchers pointed out that the lack of longitudinal studies aiming at investigating CLIL-instruction outcomes gives rise to distrust from "critical voices" in the educational field. In an effort to "fill that void", their work compiled two decades of longitudinal studies dedicated to examining the effects of CLIL instruction on linguistic skills in Primary and Secondary education.

Settings where English was offered as the additional language were a common target of the studies analysed.

Although the present research does not aim to look in-depth into the positive outcomes of CLIL, indications of the approach efficacy are relevant in validating the pertinence of the topic discussed in this work. The tables below (**Table 2 and Table 3**), extracted from Goris et al. (2019), illustrate the range of longitudinal research pieces corroborating the positive effects of CLIL in primary and secondary education:

Table 2: Results for primary education. Source: Goris et al., 2019, p. 680.

Country	Authors	Year	Primary education						Longitudinal CLIL effects per measured scale				
			Publication	Data collecting times	CLIL subjects	N CLIL	N Control	Age at T1	Overall proficiency	Vocabulary	Grammar	Reading fluency	Listening
Netherlands	Van der Leij et al.	2010	Acquiring reading and vocabulary in Dutch and English	2 in 1 year	Reading	23	23	8	_	Significant	_	None	_
Spain	Agustín-Llach and Alonso	2014	Vocabulary growth in young CLIL and traditional EFL learners	3 in 3 years	Natural science	58	49	9–10	_	None	_	_	_
Spain	Agustín-Llach	2015	Age and type of instruction in lexical development	3 in 3 years	Natural science	68	61	9–10	_	None	_	_	_
Spain	Pladevall-Ballester and Vallbona	2016	CLIL in minimal input contexts: A longitudinal study of primary school learners' receptive skills	4 in 2 years	Science Arts & crafts	138	149	9–10	_	_	_	None	Negative

Table 3: Results for secondary education. Source: Goris et al., 2019, pp. 681-682.

Country	Authors	Year	Secondary education						Longitudinal CLIL effects per measured scale				
			Publication	Data collecting	CLIL subjects	N CLIL	N Control	Age at T1	Overall proficiency	Vocabulary or idioms	Grammar	Reading comprehension	Listening
Sweden	Sylvén	2010	Teaching in English or English teaching?	3 in 2 years		99	264	15–16	_	None	_	_	_
Austria	Gierlinger and Wagner	2016	Revisiting CLIL-based vocabulary growth in secondary education	2 in 1 year	Geography History Chemistry	39	48	14	_	None	_	_	_
The Netherlands	Admiraal et al.	2006	Evaluation of bilingual secondary education in the Netherlands	16 in 6 years	History, geography	584	721	12	_	None	_	_	_
The Netherlands	Verspoor et al.	2015	The effects of English bilingual education in the Netherlands	3 in 1 year	50% of the curriculum	Grade 1: 83 Grade 3: 74	Regular 84 Control 49 Regular 68 Control 41	12 14	None	None	_	_	_
Netherlands	Goris et al.	2013	Effects of the CLIL approach to EFL teaching: A comparative study	2 in 2 years	50% of curriculum	Netherlands 37	Netherlands 47	12	_	None	Significant	None	_
Germany					history, geography	Germany 50	Germany 47	13	_	None	None	None	_
Italy					modules	Italy: 45	Italy: 37	14	_	Significant	Significant	Significant	_
Germany	Dallinger et al.	2016	The effect of CLIL on students' English and history competences	2 in 1 year	History	483	NonCLIL1: (SS) 354 NonCLIL2: (DS) 444	13	None	_	_	_	Significant
Germany	Rumlich	2017	CLIL theory and empirical reality	2 in 2 years	1 increasing to 3 subjects	503	NonCLIL1: (SS) 473 NonCLIL2: (DS) 182	12–13	None	_	_	_	_
Spain	Pérez-Vidal and Roquet	2015	CLIL in context: Profiling language abilities	2 in 1 year	Science	50	50	12–14	_	Significant	Significant	Significant	None

Country	Authors	Year	Secondary education						Longitudinal CLIL effects per measured scale				
			Publication	Data collecting	CLIL subjects	N CLIL	N Control	Age at T1	Overall proficiency	Vocabulary or idioms	Grammar	Reading comprehension	Listening
Spain	Roquet and Pérez-Vidal	2017	Do productive skills improve in CLIL contexts?	2 in 1 year	Science	50	50	12–14	_	None	None	_	_
Spain	Gené-Gil et al.	2015	Development of EFL writing over 3 years in secondary education	4 in 3 years	Science or social science	30	20	13	_	None	Significant	_	_
Spain	Gené-Gil et al.	2016	A methodology for longitudinal research on EFL written production	4 in 3 years	Science	30	30	13	_	None	None	_	_
Spain	Alonso et al.	2008	Plurilingual education in secondary schools: Analysis of results	2 in 2 years	20–25% of the curriculum	Group 1: 67 Group 3: 44 Baccalaureate:48	Group 1: 20 Group 3: 20 Baccalaureate: 30	12 14 16	Undecided	_	_	_	_
Spain	Ruiz de Zarobe	2008	CLIL and foreign language learning	3 in 3 years	Social science English literature	CLIL1: 24 CLIL2: 36	29	14–15	None	None	None	_	_
Spain	Merino and Lasagabaster	2018	The effect of CLIL programmes' intensity on English proficiency	2 in 1 year	CLIL− : 3.4 CLIL+ : 8.4	CLIL− 208 CLIL+108	77	11–12	Significant	_	_	_	_
Spain	San Isidro and Lasagabaster	2018	The impact of CLIL on pluriliteracy development	3 in 2 years	Social science	20	24	14–15	Significant	_	_	_	_
Spain	Pérez Cañado and Lancaster	2017	The effects of CLIL on oral comprehension and production	3 in 1 year and 6 months	2 subjects	12	12	15–16	Oral skills Significant	_	_	_	_
Spain	Pérez Cañado	2018	CLIL and educational level: A longitudinal study on the impact of CLIL on language outcomes	2 in 1 year 2 in 6 months	Arts, Maths Science PE Technical Social/Natural sciences	1033	991	Primary: 11–12 Secondary: 15–16	Significant	Significant	Significant	Significant	Significant

Note. SS: Same School; DS: Different Schools.

The overall conclusions of Goris et al.'s (2019) meta-analysis of the longitudinal studies listed above are favourable to CLIL as a pedagogical tool in primary and secondary school settings. Nevertheless, the researchers advise that further developments in scientific research in this field are necessary, given that an unequivocal indication of EFL (English as a foreign language) higher proficiency of CLIL students in comparison to non-CLIL counterparts cannot be asserted over a certain period of time. Although it is acknowledged that the acquisition of L2 is positively affected by CLIL, the selectiveness of CLIL instructional programmes and the way experimental and control groups are compared are potential biasing factors.

Additionally, the samples and hours of instruction taken into account in their analysis varied greatly in numbers, and the countries where the research pieces were conducted were limited. Bearing these limitations in mind, Goris et al. (2019) summarise their findings:

> The focus of the present review was to investigate if CLIL has met its promise of providing a better EFL learning approach. The answer is by no means negative, but the degree to which it is positive varies. High EFL-proficiency countries with elitist and highly selective CLIL, such as the Netherlands and Germany, have gained little on the testing scales. In Spain, however, a low EFL proficiency country, the CLIL approach was planted in fertile soil (Goris et al., 2019, p. 695).

Finally, the positive outcomes reported in Spain, where EFL-low proficiency used to be the norm, were seen by the researchers as a positive precedent for the implementation of CLIL practices in low EFL-proficiency countries, which is the case in Brazil.

Previous studies had already reported positive effects of CLIL in L2/FL learning outcomes, as shown in Dalton-Puffer (2008, 2009) and Ruiz de Zarobe (2011). Perez-Cañado (2012) indicates the positive impact of CLIL instruction is pronounced in global communicative competence, on receptive skills, speaking, morphology, vocabulary (particularly technical and semi-technical terms),

writing (fluency and lexical and syntactic complexity), creativity, risk-taking, and emotive/affective outcomes (learner motivation).

2.7. Key features of CLIL as a pedagogical approach

Although CLIL is an umbrella term that embraces different forms of bilingual instruction, key principles of the approach are commonly presented in the work of different scholars dedicated to it.

Genesee and Hamayan (2016, p. 31) present a list of eight principles of CLIL, as follows:

1. Additional-language instruction is more effective when integrated with content instruction.
2. Explicit and systematic language instruction is important.
3. Student engagement is the engine of learning.
4. Both languages should have equally high status.
5. The first language can be a useful tool for learning the additional language and new academic knowledge and skills.
6. Classroom-based assessment is critical for programme success.
7. All children can become bilingual.
8. Strong leadership is critical for successful dual-language teaching.

According to Coyle (2018), applying the basic principles of CLIL implies enabling ***deep learning*** to take place.

The researcher points out that educators working with the approach must consider the additional language in the learning process. She elaborates on this thinking by explaining that, besides being used primarily as a communication tool, language should be seen as a ***triptych*** when learning is concerned:

a) Language ***of*** learning: basic terms students will need to understand and resort to when dealing with specific topics; it requires the language teachers to focus more on functional language than on grammar rules, even though students will be reflecting upon grammatical features by being exposed to genuine content and language. For instance, they can learn *past tense* by using phrases to refer to the results of a science experiment rather than memorising a list of irregular verbs conjugated in *the past tense*.

b) Language ***for*** learning: it is the language repertoire students will need to thrive in class when having to communicate with their teachers and peers for cooperative work, asking questions, presenting conclusions, discussing, debating and so on. It is the functional language necessary for them to participate actively in the learning environment.

c) Language ***through*** learning: it is the ultimate result of the language acquisition process through CLIL, as it refers to the language learned when students are engaged in the work with subject-related tasks. New knowledge leads to linguistic development as one will need to conceptualise and discuss new

matters that are likely to require new and, eventually, more sophisticated language.

Coyle, Hood and Marsh (2010) proposed a tool kit aimed at the implementation and operation of CLIL practices in educational settings. In their work, the authors discuss the importance of creating a culture of dialogue among diverse areas in schools, the necessity of a personalised model of CLIL to meet the specific needs of the institution and, most importantly, for the purpose of this research, a planning map for a CLIL unit, based on the critical principles of the approach. A good starting point for CLIL educators would be to include the **4Cs framework** rationale in the designing of CLIL lesson planning.

The **4Cs** in the "4Cs framework" can be unfolded into ***Content***, ***Communication***, ***Culture*** and ***Cognition***.

Content refers to the progression and advancement in receiving new information, processing it and, consequently, learning new skills. **Communication** results from the interaction between the players involved in the process of teaching/learning and is crucial for language development. As for **Cognition**, it entails the set of tools and strategies to be used in class to challenge students to engage in problem-solving and reflection so that they can construct their learning actively. Finally, **Culture** is also crucial, as CLIL-based teaching also intends to develop a sense of appreciation toward a pluricultural world (Coyle et al., 2010).

Although the 4Cs are described as different entities, the researchers highlight their interconnected nature, exemplifying that the choice of tasks to deliver a lesson on a particular topic is not only related to **content**, as it may be convenient to understand what works best in making students **cognitively** engaged throughout the lesson.

> Effective content learning has to take account not only of the defined knowledge and skills within the curriculum or thematic plan, but also how to apply these through creative thinking, problem solving and cognitive challenge. Young people not only need a knowledge base which is continually growing and changing, they also need to know how to use it throughout life (Coyle et al., 2010, p. 29).

The premise of having students cognitively engaged in the tasks to achieve the desired learning outcomes is a central value postulated by CLIL pioneering authors in this field, such as the ones mentioned above. Cognition is a fundamental principle of the approach as well as a vast area of interest in neuroscience. Thus, it is plausible to assume that this overlaying intersection should orient discussions henceforth in the present work.

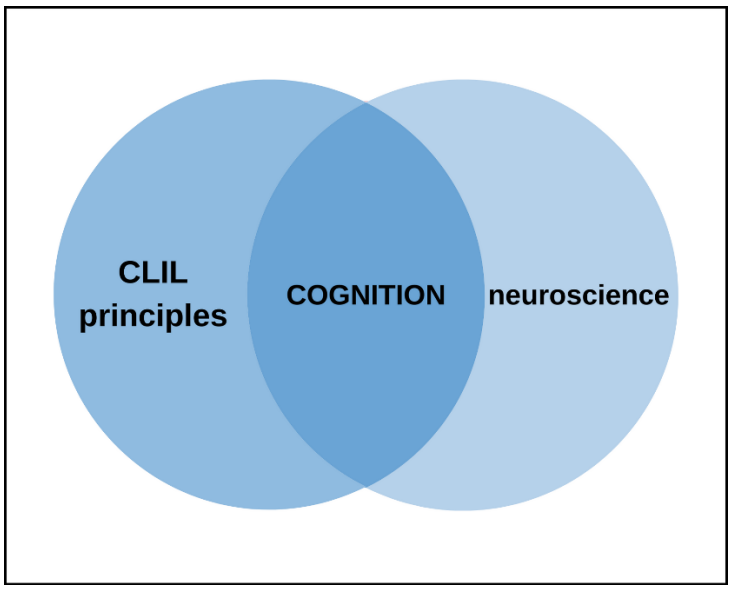


Figure 4: Cognition as an intersection of CLIL and the neuroscience of learning.

2.8 The neurobiology of learning

In examining the learning process from a neurobiological perspective, it is worth understanding the basic principles of learning as a physiological event. M Arruda (2022) summarises this process in a didactic yet comprehensive way. According to him, the power of intellect and geniality does not depend on the number of neurons available but on the richness of its connections. Figure 5 is a simplified illustration of a neuron in activity based on M Arruda's (2022) presentation given at the "Congresso Aprendar Criança" (Learning Child Congress, in free translation). The event is periodically organised by one of the pioneering scientific communities in Brazil focused on the neuroscience of learning – Comunidade Aprender Criança – formed by a multi-professional body of members sharing interests and actively working in the medical and educational fields.

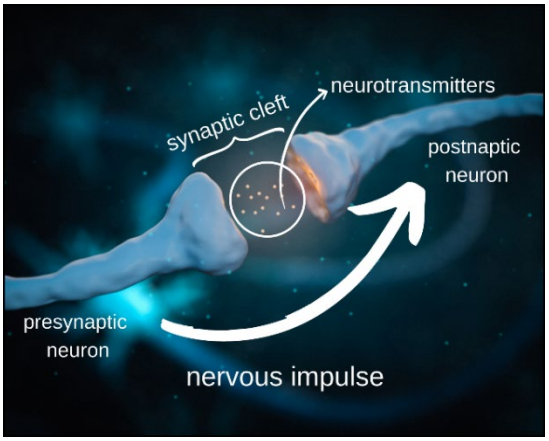


Figure 5: Neuron structures engaged in the conduction of a nervous impulse. Stock Images [edited]: https://www.canva.com

The scheme presented above is a helpful visual aid for understanding neuronal activity that ultimately leads to learning. One should be aware that neurons operate in interconnected networks, but the illustration of a single cell is more appropriate for a didactical approach. A description complementary to the image is provided below:

1. **Stimuli** (ascendent and descendant) fire the **nervous impulse** that propagates from the **presynaptic neuron** toward the **postsynaptic neuron**. Sinapsis is the term used to refer to the 'union' of the neurons, and the gap between them is called the **synaptic cleft**.

2. When reaching the **synaptic cleft**, the **nervous impulse** will be carried to the **postsynaptic neuron** by 'chemical messengers' called **neurotransmitters**.

3. **Neurotransmitters** will carry the impulse from one cell to the other through a mechanism of 'keys upon locks'. The **presynaptic** neuron vesicles release **neurotransmitters** onto the **synaptic cleft**.

4. These **neurotransmitters** (keys) will bind to **receptors** (locks) located in the postsynaptic neuron. When enough ion channels open, the **postsynaptic cell depolarises**, and **the impulse continues** along the neuron.

As mentioned above, neurons are interconnected, forming complex neuronal networks responsible for all brain functions. The synaptic connections, as well as neurons, can change over time. This phenomenon is called **neuroplasticity**:

> Neuroplasticity is activity-driven and follows the "use-it-or-lose-it rule". Frequently used synapsis are strengthened while rarely used connections are weakened or eliminated. New activities generate new connections. Changes in synaptic strength can be temporary [short-term memory] or long-lasting [long-term memory] depending on the intensity and reoccurrence of the signal the synapse receives (Alila Medical Media, 2018, 0:55-1:10, [video] brackets added).

Neuroplasticity is the basis of learning, as it is essential for the creation of functional brain circuits. Despite not being a phenomenon limited by age, it is more pronounced in the developing brain of children. It is the capacity of adaptation and transformation of the brain in structural terms to incorporate new learning in response to repetitive and strong stimuli. Long-term memory depends on this structural change that favours the connections of the dendrites through their expansion and mutual approximation (M Arruda, 2022).

In 2010, University of Calabria researcher Yen-Ling Teresa Ting published a scientific paper in the International CLIL Research Journal. The article "CLIL appeals to how the brain likes its information" seems to be a relevant contribution to this study, as the professional background of the researcher mentioned inarguably serves as a credential that allows her to transit over the areas of neuroscience and education. Ting has accumulated roles as a human neuroanatomy instructor, neurobiology researcher, and EFL CLIL-Science Instructor throughout her professional career.

Her study correlates the cortical brain structures to students' behaviour when attending lessons. To follow her rationale, one should be informed of the three levels of processing that occur in the brain when sensory inputs are received. Sensory input is the external stimuli (mechanical, chemical or electromagnetic) perceived by sensory organs that will be processed by the brain to generate a physical response.

The primary level involves the five senses. Damages in the area where this level of processing takes place will lead to malfunctioning of motor response, even if anatomical structures remain intact. For example, after a stroke affecting the left primary visual cortex, the right visual field will be affected.

The secondary level of processing affects perception. If damage to these areas occurs, the patient will be able to see a certain object but may be unable to tell what it is or even perceive it in motion.

Finally, and most importantly for the purpose of this study, is the highest level of cognitive processing called **executive control (executive function)**. The brain area that manages this function is the prefrontal cortex, known as the most evolved brain region, as it coordinates highly complex information processing, gathering sensory input from all five senses, interpreting information and evoking behaviours that distinguish humans from other primates (Ting, 2010).

> Executive function and self-regulation skills are the mental processes that enable us to plan, focus attention, remember instructions, and juggle multiple tasks successfully. Just as an air traffic control system at a busy airport safely manages the arrivals and departures of many aircraft on multiple runways, the brain needs this skill set to filter distractions, prioritise tasks, set and achieve goals, and control impulses. (Center on the Developing Child at Harvard University, 2015, https://developingchild.harvard.edu/science/key-concepts/executive-function/, retrieved on Jan 4, 2023)

According to the Center on the Developing Child at Harvard University (2012), children are not born equipped with the set of capacities called executive function and self-regulation. Hence, for them to thrive when faced with challenges such as keeping their focus on a task, prioritising attention and filtering distractions, it is crucial to understand how their social interactions will be strengthed or undermined. The graph below shows how executive function skills develop throughout life:

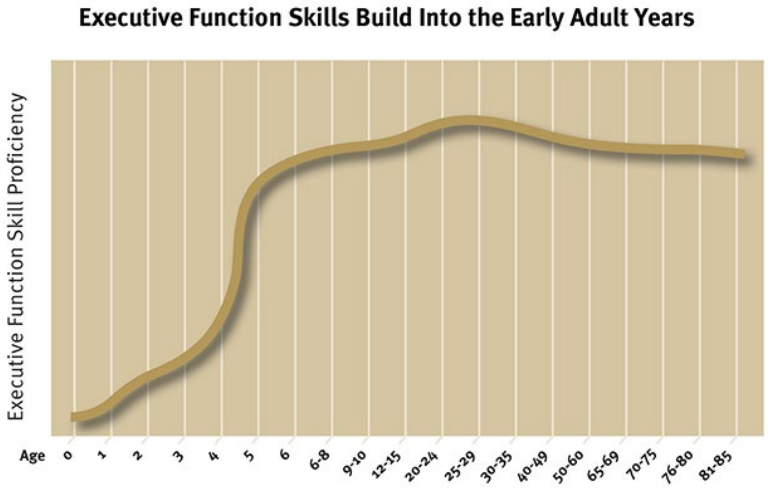


Figure 6: Executive Function Skills Build Into the Early Adult Years. Source: Executive function: skills for life and learning, a report published by the Center on the Developing Child at Harvard University, 2012, p. 1)

Understanding the basic functioning of brain processes related to learning, albeit recognising the limitations of the present research in deepening discussions on an extremely complex and intricate scientific field, will be helpful as discussions unfold in the educational world. Henceforth, one should be familiar with the terminology and concepts that will be referred to more frequently.

2.9 The intersection of CLIL practices and the neuroscience of learning

Hietaranta (2015) argues that much of what has been reported on CLIL efficacy relies on the fact that the approach aligns with cognitive mechanisms crucial for learning. She refers to the fact that human brains are equipped to forget things occasionally as a safety strategy against an overload of information processing. Therefore, the most meaningful experiences may strengthen **long-term memories,** whereas unimportant information tends to fade away.

Lasting memories that are on the basis of learning experiences would then be provided by the instruction of relevant content. As an 'additional gain', the learning of meaningful language, at the word or even utterance levels, would be bolstered as language is associated with a tangible world.

As demonstrated above, **cognition** is a key term when neuroscience is brought into discussions on CLIL. According to Schumann (1994):

> Cognition might reasonably be conceived as consisting of the perception of stimuli, the emotional appraisal of these stimuli, attention to the stimuli, representation of the stimuli in memory, and the subsequent use of that information in behaviour (Schumann, 1994, p. 231-232).

Schumann (1994, p. 232) considers that "**affection** and **cognition** are distinguishable but inseparable". That is, stimuli must be assessed by the brain as emotionally significant to influence attention and memory (Mishkin & Appenzeller, 1987). Marsh (2020) confirms the central role of emotion in designing CLIL strategies, as "emotions drive attention, and attention drives learning and memory, and if either of those is out of sync, then it's very hard to achieve successful language learning" (Marsh, 2020, 17:59-18:06).

Renowned neuroscientist Stanislas Dehaene (2022), in his recent publication "É assim que aprendemos: por que o cérebro funciona melhor do que qualquer máquina" (This is how we learn: why the brain works better than any machine [free translation]) refers to four pillars of learning, that apply universally to all ages, these being: 1. Attention, 2. Active engagement, 3. Feedback, and 4. Consolidation.

As seen previously, the four pillars mentioned by Stanislas are at the grassroots of CLIL. Attention is triggered in a CLIL lesson through the exposition of meaningful content that is materialised by conceptualisations in the additional language. Hence, new words and expressions are more likely to be 'stored' in the long-term memory, as opposed to units of language to which attention was not given, and that, in turn, will not reach profound conceptual representations to form semantic memories.

Having students pay attention to what is needed for a lesson will heavily depend on the strategies to which the teacher resorts. To plan effective approaches, the tutor needs to consider that raising attention is proportional to inhibiting distractions. The prefrontal cortex governs this capacity (executive function).

However, if the prefrontal cortex is not fully developed by the age of 20, how can one 'train' an immature brain to gradually intensify responses based on executive function? The response to this question seems to find a correlation with the observations of Italian paediatrician and educator Maria Montessori (1870-1952), who, way before the advancements of neuroscience, documented the increase of concentration as children

engaged in practical activities. Once again, the practical aspects of CLIL align with neuroscientific knowledge.

> One of the best ways for teachers to intentionally draw attention to language is in the context of meaningful interaction about content. It is during such teachable moments that students are motivated to use the language and so are well positioned to notice how otherwise hard-to-notice language features play an important role in making meaning (Lyster, 2007, cited in Genesee and Hamayan, 2016, p. 34).

The second pillar of learning proposed by Dehaene (2022) suggests that passive brains produce no learning. According to him, **active engagement** is necessary so that learners can raise hypotheses to tackle problems through exploration (guided or free) and test them in the external world. Active engagement is deeply dependent on attention and motivation, as one learns if goals are clear enough to trigger commitment to accomplish them.

Ting (2010) proposes reflections on how students' motivation affects learning. Knowing that executive control is developing in the young brain, how can pupils engage in tasks that are uninteresting and lack meaning? According to the researcher, the prefrontal cortex, responsible for governing executive control, needs to be genuinely 'motivated' to engage in a task proposed by the teacher in the classroom. Otherwise, other 'demands', such as sitting upright, looking interested, and hoping for a good grade, will 'steal' processing work from the prefrontal cortex that, in turn, will not attend to the new input (desired by the teacher) long enough, so that it has a chance to become a long-term memory (Ting, 2010, p. 10).

Motivation seems to be a key factor in CLIL lessons (see Genesee and Hamayan, 2016; Coyle et al., 2010), as problem-solving-based tasks, the conceptualisation of the study objects and other issues related to its investigation, as well as social interactions with peers will be central when teachers deliver their lessons.

> CLIL can offer learners of any age a natural situation for language development which builds on other forms of learning. This natural use of language can boost a learner's motivation towards, and hunger for, learning languages: `It is this naturalness which appears to be one of the major platforms for CLIL's importance and success in relation to both language and other subject learning' (Marsh, 2000, p. 5).

Coyle et al. (2010) suggest that understanding the tools to raise motivation and lower anxiety is crucial to the efficient designing of CLIL materials. Marsh et al. (2020) see motivation as an effective dimension of learning, affirming that a positive environment that favours high self-esteem, low anxiety, and positive attitudes will directly impact the performance of learners. Ting (2010) provides five questions that one should ask oneself when expecting to motivate others. They are based on cognitive "filters" proposed by Scherer (1988):

> the **novelty filter**: is this information new? 2) the **pleasantness filter**: is this input enjoyable? 3) the **relevance filter**: what does this have to do with my goals – do I need it – is it significant? 4) the **cope-ability filter**: can I understand this? 5) the **self/social-image filter**: will knowing this make me 'cool'? (Ting, 2010, p. 11, bold format added).

The planning of resources to be used in class will determine students' motivation (or lack of it) to learn. In that sense, a CLIL learning environment is beneficial as a variety

of stimuli (linguistic and non-linguistic) targeting the learning of a new concept, idea or skill, will be used as resources for instruction. This multifaceted source of stimuli can fire neuron clusters at such an intensity that new learning pathways (dense neuron connections) are likely to emerge (Hietaranta, 2015).

In considering stimuli as strategies to promote attention and motivation, it is valid to raise the issue of what implications it may have in preparing CLIL lessons. Initially, one should be aware of the nature of induced stimuli. R. Arruda (2022) classifies stimuli into two main categories: a) **Ascendant stimuli** and b) **Descendant stimuli**.

Ascendant stimuli are less cognitively demanding, being processed in the reticular formation and the thalamus. It filters subconscious sensory input, these being visual (e.g. banners, flashcards, videos), sound (e.g. teacher tone of voice, noise in the school halls, etc.) and synesthetic experiences (e.g. having students change positions in the classroom, working with students on the floor). Contrasting stimuli seem to keep the brain alert, thus resulting in higher concentration. For instance, a blackboard full of text will be less effective than a PowerPoint presentation elaborated with images and videos illustrating the topic.

Descendant stimuli demand higher cognitive processing, being processed in the prefrontal cortex and the parietal cortex. It involves conscious input and decision-making. In this case, students need to be aware of the relevance and usefulness of the content proposed by the teacher. Additionally, the chances of success are higher if they find the topic fun and related to something with immediate application.

R. Arruda (2022) adds that retrieving students' previous knowledge when introducing a new topic is another helpful strategy to ignite descendant stimuli. Yet, CLIL's theoretical basis advocates for **scaffolding** as an indispensable element of the approach:

> [Scaffolding] means that the learner will need to be supported in developing skills such as those required for pair work, cooperative group work, asking questions, debating, chatting, enquiring, thinking, memorising and so on. Unless learners are able to understand and use language which enables them to learn, to support each other and to be supported, quality learning will not take place (Coyle et al. 2010, p. 37, brackets added).

Scaffolding students's learning is central to CLIL practices, as the conception of CLIL as a pedagogical approach derives from a socio-constructivist school of thought rather than from models where pupils are expected to learn passively through loads of information delivery. In CLIL contexts, interaction with teachers, peers and educational resources will allow learners to expand their knowledge through meaningful experiences. The teacher is placed in the position of the mediator/facilitator, modulating the tasks to accommodate students' needs and capacities.

It is up to the teacher to assess how cognitively demanding a task is, in terms of content and language, to decide what resources should be provided so that learning is carried out within a motivating environment. In other words, tasks should neither be too easy nor too difficult. Hence, higher-order levels of cognitive processing will be reached along with the progressive advancement of the challenges proposed in class (Coyle et al., 2010).

Deepening into the idea of scaffolding learning, one needs to consider that dealing with ***error*** is inherent to the teaching duty. When mediating (or facilitating) challenges that will result in strong experiences, in turn, intense neuro-connections that result in effective learning, the educator will come across students' making mistakes. In the face of this reality, **feedback** is the third pillar of learning.

Dehaene (2022) affirms that quality and pertinence in the feedback given will determine the speed of learning. Feedback generates intense activity in the brain. By contradicting the learner's point of view on something that was mistakenly predicted, a surprise factor triggers intense neuro-activity. In response to it, internal representations of the external world will change, resulting in learning. Hence, when sensorial input gets repetitive, or patterns become predictable, neuroactivity decreases. Conversely, if the brain is 'surprised' by an unpredictable event, stimuli are propagated among neuronal networks in an attempt to assess the incoming information. In a CLIL lesson, feedback is the element of surprise that will take the brain out of its 'comfort zone'.

Dehaene (2022) argues that effective feedback entails neutrality, that is, not labelling or judging the learner, and comprehensive information that will equip the student (scaffold) to identify precisely the deviations that led to the error. From that perspective, relying on traditional grade-report-based feedback is a useless tool for learning. In his own words: "setting a clear learning goal and allowing the students to get to it gradually, without dramatising inevitable errors, are key success factors" (Dehaene, 2022, p. 301, free translation).

Coyle et al. (2010) advise that teachers should continuously give feedback on language errors, being cautious not to halt the flow of content communication when students are talking about a topic. Instead of resorting to 'on-the-spot' corrections all the time, which can undermine pupils' confidence in the long run, frequent language issues can be gathered to be addressed in 'language clinic' lessons. According to them, feedback on language should always be given in a contextualised perspective, demonstrating to the student that language 'lapidation' will help them communicate their ideas more efficiently.

Although the idea is to provide feedback whilst caring so as not to foster an intimidating environment in the classroom, one must be aware of the dangers of not addressing language errors properly. Dodson (1995) states that students in bilingual settings may gist the ideas communicated by the educators; however, it does not guarantee accurate language learning at vocabulary and syntax levels. Speech fluency can sometimes be performed by "fluent speakers of incorrect speech". The ultimate 'side-effect' of an over-lenient approach to error correction is the fossilisation of language strategies and structures that will become ineradicable. This tends to happen with those bilingual individuals who, despite low language proficiency, can make themselves understood, in turn, being operational bilinguals (Dodson, 1995).

> Great focus should be placed in schools on correct L2 speech right from the outset. The precise meanings of those sentences with which pupils have difficulty should be given through pupils' L1, followed by interpretation and substitution practices at medium-oriented level. Pupils should be encouraged to find out from teachers the correct way or ways of expressing sentences they might need […] (Dodson, 1995, p. 125).

Coyle et al. (2010) state that assessment and feedback in CLIL lessons should comprise a multitude of domains: content-specific matters, language targeted at dealing with the content, language used for social interactions within the classroom, to communicate ideas and to help others, and the advancements of the students at the individual level; that is, betterment of their knowledge and skills in relation to their previous state. These values align with the principles of **Assessment for Learning (or Formative Assessment)**, as opposed to **Assessment of Learning** (Summative assessment).

A document launched by the Assessment Reform Group in the UK in 2002 about Assessment for Learning suggests that formative evaluation should establish clear learning goals that students will pursue at the beginning of the lessons and the success criteria of the tasks. Besides that, peer and self-assessment should be regarded in the evaluation process, and the feedback given should always be sensitive to foster motivation and self-esteem.

The saying "practice makes perfect" could well illustrate the last pillar of learning proposed by Dehaene (2022). The researcher advocates for the **repetition** of content as the key to **consolidating** new information, thus promoting learning. One should notice that, from this point on in the present study, the pillar of **consolidation** will be referred to as **repetition.** This is because Dehaene (2022) divides **consolidation** into two fields: **repetition** and quality **sleep**. Although sleep plays a crucial role in the learning process – even regular short naps are proven to benefit long-term memory retention – it does not seem to be applicable in the context of a lesson plan, which happens to be the focus of the present research.

As for repetition, he uses the example of children being literate. Initially, great effort is placed on decoding a sequence of symbols (graphemes) to match them with their corresponding sounds (phonemes) that will, in turn, produce other sounds when combined with the subsequent letters. After a period of approximately three years of revisiting and repeating the processes, the reading skill is automatised, and the brain areas that were then activated (prefrontal and parietal) are no longer bothered, as subcortical areas responsible for routine behaviours will exert that function. By alleviating the duty of the brain areas devoted to attention, the processing of incoming information will occur more efficiently.

One can see that the theory presented regarding interventions for optimal learning processes based on the operational capabilities of the brain conveys the core CLIL principles. For Ting (2010), CLIL represents an opportunity to switch from pedagogical practices that assume learners as passive receptors of content to a constructivist, more motivational approach that has a positive impact on their learning of subject content and language:

> As children explore, inquire, ponder and solve, so do learners in such CLIL classrooms. CLIL can go far beyond merely "teaching content and language simultaneously" and become highly coherent with the "neuroscience of learning". Although teachers can neither implant electrodes in Johnny's MFB nor perform amygdalectomies, being aware of how certain brain structures process input (or not) may contribute to more effective classroom practice (Ting, 2010, p. 14).

3. CHAPTER 3: METHODOLOGY REVIEW

3.1. Introduction

The present study is the result of a cross-sectional research employed to gather initial evidence to corroborate or refute the idea that applying basic principles of neuroscience in the CLIL lesson plans of a bilingual primary education programme could bolster the effectiveness of educational tools and strategies aimed at better learning.

The data were collected through the **review of literature** presented previously, **lesson observations**, **self-evaluation interviews** with an experimental group, and subsequent data triangulation aimed at meeting the research objectives.

3.2. Context of Study

The setting where the study took place was a primary education CLIL/bilingual programme in a Brazilian mainstream school, Colégio Santa Úrsula. As explored in the introduction, Content-and-Language-Integrated-Learning (CLIL) programmes and materials have proliferated in Brazil over the last half-decade. Many schools, such as the one where the present research was conducted, started offering bilingual education programmes complementary to their national curricula.

Colégio Santa Úrsula structured its programme by implementing the instruction of school subjects according to the Cambridge International Education Curricula in the English language. Frequent demands coming from the school community drove the initiative to offer a bilingual pathway of studies. In 2017, the programme's pedagogical basis was designed with CLIL as its core approach.

Enrolment in the programme is optional, and being part of it is a decision of the families who consider bilingual/international education beneficial to their children in the long run. About 15% of the entire student body adheres to the programme.

The present study focused on pedagogical practices utilised in primary education (Years 1 to 5 in Brazil). For this specific group, Colégio Santa Úrsula's bilingual programme consists of 12 hours and 30 minutes of instruction in English weekly, of which 4 hours and 15 minutes are dedicated to language instruction, meaning instruction to the development of four language skills (listening, speaking, reading and writing), and 8 hours and 15 minutes are divided into lessons where the English language is the medium of instruction. The subjects taught in English are Mathematics (3 hours/week), Science (3 hours/week), Global Perspectives (1.5 hours/week) and Digital Literacy (45 minutes/week).

As for the profile of the students in the programme, most of them come from monolingual backgrounds, i.e. Portuguese-speaking families, and their contact with the additional language occurs mainly at school, other than media products and occasional events such as travelling on vacation breaks. As Portuguese is the 'comfort-zone' language for them, especially for the youngest, teachers are

expected to provide stimuli and opportunities to put the additional language into use as much as possible for communication among peers.

3.3. Sample

Six CLIL teachers and a programme leader participated in the research. All of them are native Portuguese speakers, proficient in English (CEFR level B2 or above), with college degrees in education and extension courses in bilingual education. These professionals were observed while teaching lessons to students in Years 1 to 5 in their specific subject areas: mathematics, science, and global perspectives. Three teachers composed the control group, as they had no instructions provided by the researcher. The other three figured as the experimental group, as they were 'educated' to apply the theoretical scope of the present research in the elaboration of their lesson plans.

Adopting the role of an observer was the programme leader, who was instructed by the researcher to mark the structured questionnaire provided according to her perceptions.

The itinerary below was followed:

	May 10th	**May 11th**	**May 12th**	**May 17th**	**May 18th**
13:30 to 15:00	Teacher 1E Global Persp. 4th grade 14 students	Teacher 2E Science 1st grade 18 students	Teacher 3E Mathematics 2nd grade 14 students	Teacher 2C Science 5th grade 11 students	Teacher 3E Mathematics 3rd grade 15 students
15:30 to 17:00	Teacher 1C Global Persp. 4th grade 12 students	Teacher 2C Science 1st grade 18 students	Teacher 3C Mathematics 2nd grade 11 students	Teacher 2E Science 5th grade 6 students	Teacher 3C Mathematics 3rd grade 15 students

*Teachers 1E, 2E, and 3E comprise the experimental group. Teachers 1C, 2C, and 3C belong to the control group.

One should note that teachers were grouped in pairs according to their area of expertise. Teachers 2C, 2E, 3C and 3E were observed twice, whereas teachers 1C and 1E were observed once. This is because the weekly workload of instruction per area remained the same for the application of the present research. Additionally, five stages (Years 1 to 5) were observed in two shifts and taught by three pairs of teachers. Thus, inevitably, one pair would be observed once.

3.4. Instructional session

An instructional session was delivered to the teachers of **the experimental group**. They were provided with the theoretical scope of the present research in a five-hour session that took place on May 6th 2023. The objective was to make them aware of the intersection demonstrated between the fundamentals of the CLIL approach and the pillars of learning through a perspective of neuroscience.

Once the session was finished, the experimental group was asked to apply the knowledge recently acquired in the construction of lesson plans that would,

ultimately, turn into a lesson delivered. It was highlighted that it was desirable to observe the pillars of learning proposed by Dehaene (2022): ***attention, active engagement, repetition (consolidation) and feedback*** when planning tools and interventions throughout the lesson.

The teachers in the control group had no access to the theoretical scope of the present study. They were asked to prepare their lessons as usual, keeping the same lesson topic and learning objectives as their peers in the experimental group.

3.5. Field observation and questionnaires

The present researcher developed lesson observation forms to establish parameters for comparison between the groups in areas relevant to the present research's object of study (see forms in Appendices 8.2 and 8.3). The forms were intended to assess the efficacy of the teachers' tools, strategies and resources when delivering their CLIL bilingual lessons. Based on the theoretical scope presented in the review of literature, with an emphasis on the pillars of learning proposed by neuroscientist Stanislas Dehaene (2022), the observation form presented a Likert scale with numbers 1-5 corresponding to the observer's level of agreement to statements that unfolded from the main areas observed. For each statement, the observer was asked to mark points as illustrated below:

(1) Strongly Disagree	**(2) Disagree**	**(3) Neither Agree nor Disagree**	**(4) Agree**	**(5) Strongly Agree**

Two observation forms were available to the observer: one focusing on the efficacy of strategies performed by the teacher and another to assess the student's response to them. Hence, what the observer judged as potentially efficient pedagogical tools applied by the teachers could then be contrasted with the students' responses to them. This dual-way observation considers that the level of efficacy depends not only on the optimal stimuli provided by the educator but also on the students' responses.

The lessons were observed by the educational programme leader/coordinator. The researcher previously instructed her to clarify any unfamiliarity with the topics and terms present in the form. She could also resort to the researcher throughout the course of observations whenever doubts arose.

As the observation forms were marked, an arithmetic average score was determined for each area. The higher the score, the more efficient the strategy performed by the teacher was considered to be and, consequently, the more likely the stimuli resulted in long-lasting memory retention and learning, hypothetically.

3.6. Teachers' self-evaluation

As the teachers finished their lesson delivery, they were individually interviewed by the researcher. They responded to a semi-structured interview to provide their perceptions on whether the knowledge acquired in the instructional session impacted their lesson planning and delivery. The interview form is available in Appendix 8.1.

3.7. Ethics

All phases of the research involving third parties resulted in the collection of data that was properly stored according to the University of Wales Ethics Committee guidelines. Prior to the beginning of any intervention with participants, consent forms were made available to collect their expressed authorisation and willingness to take part in the study. In these documents, the main objectives of the research were stated, and the present researcher provided contact information through which any participants could drop out of the study at any time. Copies of the consent forms are provided in Appendices 8.4 to 8.7.

Four participant profiles were directly involved and expressed their consent: a) Colegio Santa Úrsula, legally represented by its president; b) Six teachers divided into control and experimental groups; c) the CLIL/bilingual programme leader and d) 134 students that were present in the lessons observed. As all the students are minors, consent forms were sent to parents, and only those who returned the documents expressing their formal agreement with the lesson observation had their children included in the study.

3.8. Conclusion

The present study was conducted through an ***experiment*** technique.

An approximation of CLIL and the neuroscience of learning was initially needed through theoretical scrutiny of both areas to establish the premises for the experiment. After that, participant teachers took part in the study through the phase called 'instructional session'. It consisted of sensitising the sample in the experimental group by 'educating' them to plan and deliver their lessons within the theoretical framework offered. This particular approach was necessary to indicate potential discrepancies or similarities between control and experimental groups.

The study gathered the experimental group's perception of the instructional session as a driver of their behaviour through self-evaluation forms. If the experimental group had not perceived any new knowledge acquired during the session that they could add to their customary practices, there would have been no basis for comparison with their peers.

Regarding the reliability of the research instruments, inherent issues needed to be considered. The first issue was related to the lesson observations. The leader/coordinator of the educational programme was designated as the observer to avoid interference in classroom practices and in the behaviour of teachers and students. The researcher, who is also the principal of the school, assumed this strategy to prevent anxiety and disruption, as the role of the principal in Brazil is culturally associated with reprimands and correction.

To make observation forms more objective and less susceptible to cause deviation when replicated, the areas observed were subdivided into statements that reflected possible situations in the lessons that would well accommodate the core theoretical

viewpoints. The statements were classified on a scale that allowed for quantitative analysis of the data.

The research tools were designed to ‘measure’ perceptions based on fixed assertions. Hence, they can be extended to further research beyond the delimitation of the present work; that is, in other settings, with different subjects at different times. By applying such a method, the researcher endeavoured to satisfy the criterion of ***external validity***. Nevertheless, the aspect of ***internal*** validity should be based on the assessment of the “appropriateness of the measuring instruments and the soundness of the research” (Sapsford and Evans, 1979, p. 261).

4. CHAPTER 4: RESULTS

4.1. Introduction

The results described originated from two distinct research tools presented in Chapter 3: teachers' self-evaluation and lesson observations. The data collected will be described in detail throughout the upcoming sections, mirroring the sequential order in which the research tools were applied.

4.2. Lesson planning and delivery

After delivering the planned lesson, the teachers in the experimental group were required to respond to a self-evaluation form where questions about the instructional session were asked to assess the **perception** of the impact of this formation workshop on their work (the self-evaluation form is available in Appendix 8.1). Below, the questions asked, and their responses are reported.

Question 1: After the instructional session on neuroscience and CLIL, administered on May 6th, do you feel your lesson planning was impacted in relation to your previous practice?

To that question, three possible responses were presented: a***) Yes, it was positively impacted***; ***b) Yes, it was negatively impacted***; and ***c) I did not notice any significant impact***.

All teachers responded affirmatively, indicating that their lesson planning had been positively impacted by the instructional session. In that case, a follow-up open question was asked:

Question 2: How was your lesson planning positively impacted? What were the changes observed in relation to your previous practice?

Below is a list of perceptions extracted from their full answers, from which redundant/similar statements were excluded:

a. more sources were used [to plan the activities];
b. the lesson plan had a greater variety of activities;
c. more practical activities were included;
d. the lesson was more organised;
e. less concern about accomplishing book-oriented activities;
f. more feedback was planned.

After reflecting on the process of lesson planning, the teachers were also asked about the impacts of the instructional session on their lesson delivery:

Question 3: After the instructional session on neuroscience and CLIL, administered on May 6th, do you feel your lesson delivery was impacted in relation to your previous practices?

To that question, three possible responses were presented: a***) Yes, it was positively impacted***; ***b) Yes, it was negatively impacted***; and ***c) I did not notice any significant impact***.

The teachers in the experimental group stated that their lesson delivery ***was positively impacted***. By giving this response, the form unfolded into the open question:

Question 4: How was your lesson delivery positively impacted? What were the changes observed in relation to your previous practices?

Their perceptions were classified to group similar thoughts as well as to eliminate redundant/similar statements. The list below is what resulted from this classification:

a) Students were more engaged and motivated, participating more during the lesson;
b) Activities/stimuli were more varied;
c) Students drilled keywords without noticing the repetition;
d) Students showed confidence in using specific vocabulary;
e) Activities that demanded a physical response, e.g. jumping, were added;
f) Topics were more meaningful to students;
g) Feedback was provided more frequently;
h) More practical activities were included.

4.3. Lesson observations

As described previously, the lesson observations were marked by the observer according to a Likert scale ranging from 1 to 5. The effectiveness of strategies employed by the teachers and the students' responses to them were marked in two separate observation forms (observation forms are provided in Appendices 8.2 and 8.3).

The observation forms were designed considering four critical areas for learning (according to the theoretical basis of the present study) that were applicable in the context of a lesson. These were **attention, active engagement, repetition (consolidation) and feedback**. Each area unfolded into statements to make the marking criteria more reliable and objective. Hence, stability and minimal deviation were expected in the data collected in different lessons.

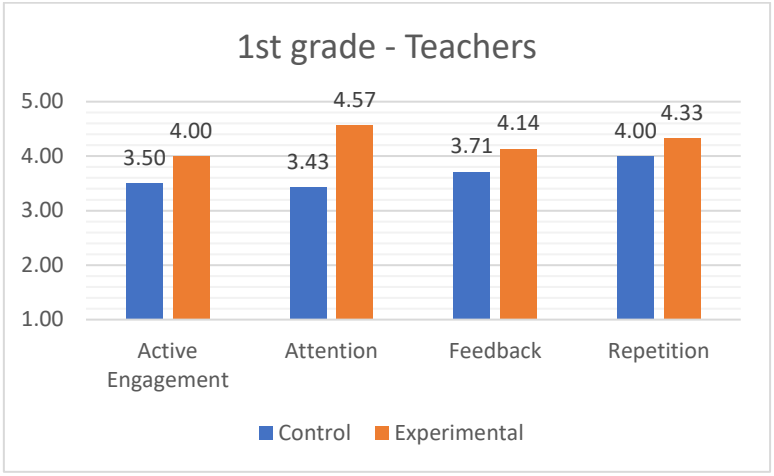
To evaluate **attention,** for example**,** the observer was provided with the following statements in the 'teacher's strategies' form.

- Teacher talk time is well-balanced with practical tasks so that the group doesn't show boredom.
- The lesson sequence is intuitive to students, resulting in few interventions by the teacher to provide clarifications or explanations.
- Teaching the necessary language supports the presentation of new content, allowing students to follow the lesson well.

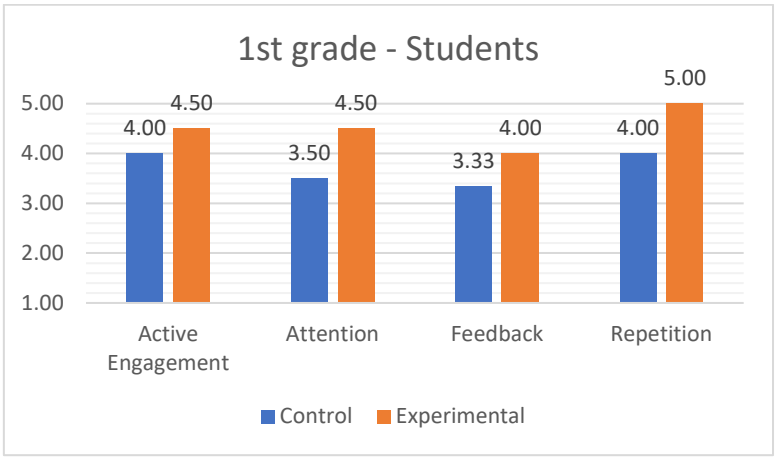
- The teacher resorts to attention triggers to get the group back on track whenever attention deviates due to external distractions.
- A variety of resources/materials is put into practice, keeping students alert and focused on tasks and explanations. Examples of materials and resources: whiteboard, PowerPoint, flashcards, toys, videos, songs, puppets, models etc.).
- Resources and materials support the learning of both content and language.
- The teacher modulates his/her body language and tone of voice to gain students' attention as soon as deviation from the lesson aims is perceived.

Each of the statements was marked on a Likert scale ranging from strongly disagree (1 point) to strongly agree (5 points), 3 points being equivalent to neutrality.

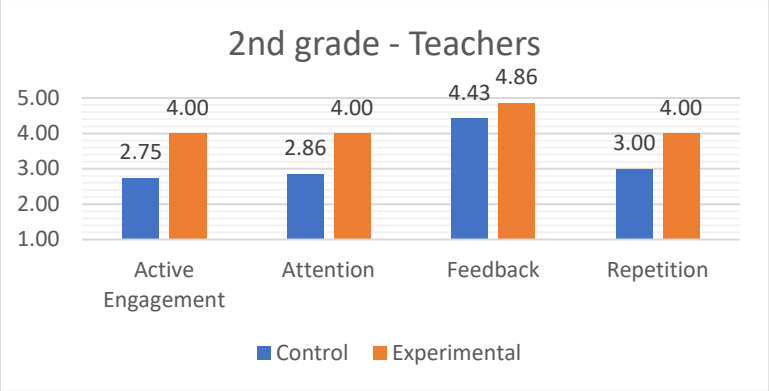
Graph representations of the results were generated from the **total scores** obtained in each area observed. The total score is the arithmetic average obtained from the sum of points/marks divided by the number of statements in each of the four areas. The higher the score, the more efficient the teaching/learning process is, in theory.



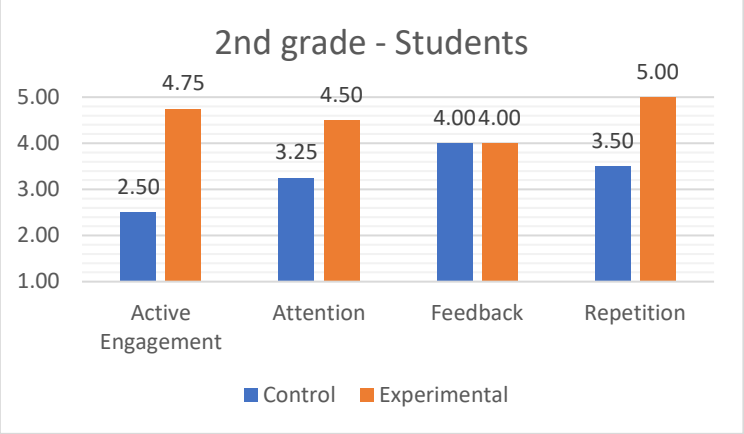
Graph 1. 1st-grade teacher strategies' performance
Subject: Science / Lesson: Our amazing senses (hearing and smell)
Students in the exp. group: 18 / Students in the control group: 19



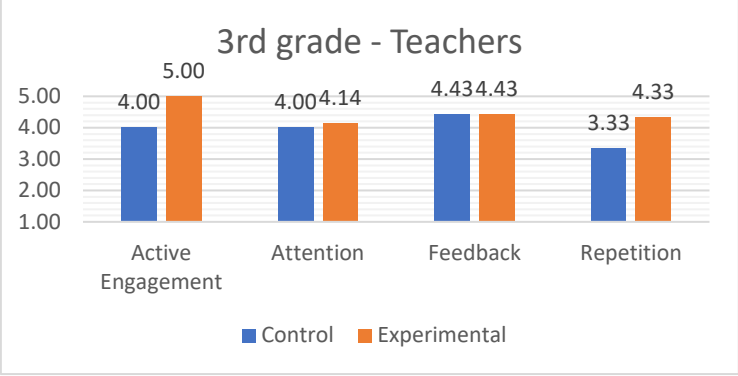
Graph 2. 1st-grade students' response to strategies/stimuli
Subject: Science / Lesson: Our amazing senses (hearing and smell)
Students in the exp. group: 18 / Students in the control group: 19



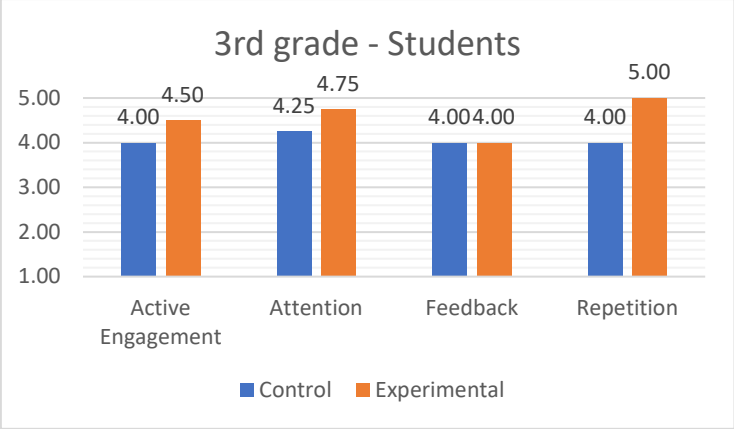
Graph 3. 2nd-grade teacher strategies' performance
Subject: Mathematics / Lesson: Multiplication
Students in the exp. group: 15 / Students in the control group: 14



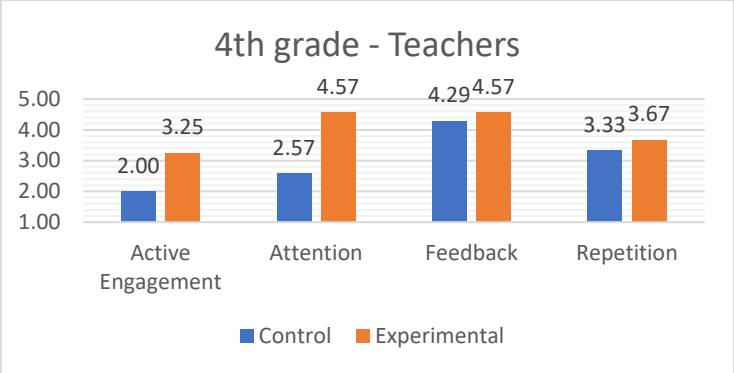
Graph 4. 2nd-grade students' response to strategies/stimuli
Subject: Mathematics / Lesson: Multiplication
Students in the exp. group: 15 / Students in the control group: 14



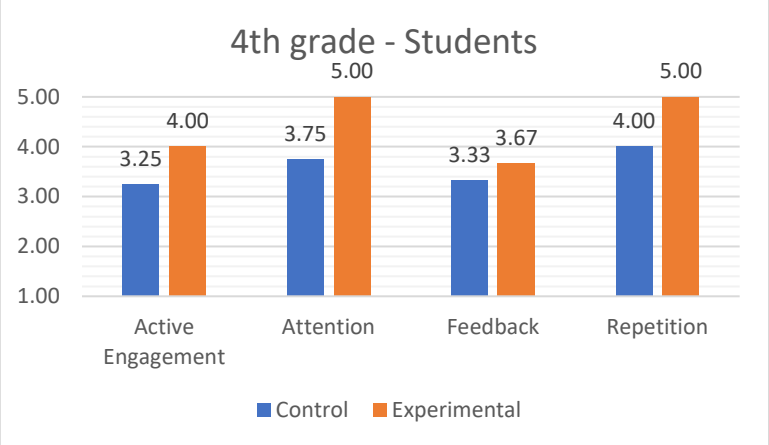
Graph 5. 3rd-grade teacher strategies' performance
Subject: Mathematics / Lesson: 2d shapes and perimeter
Students in the exp. group: 15 / Students in the control group: 15



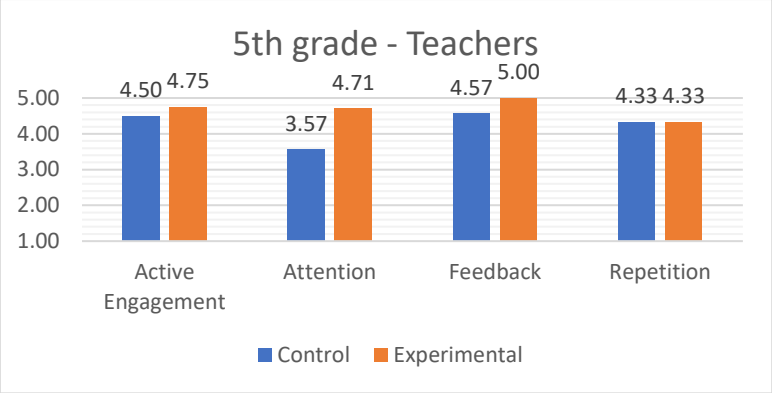
Graph 6. 3rd-grade students' response to strategies/stimuli
Subject: Mathematics / Lesson: 2d shapes and perimeter
Students in the exp. group: 15 / Students in the control group: 15



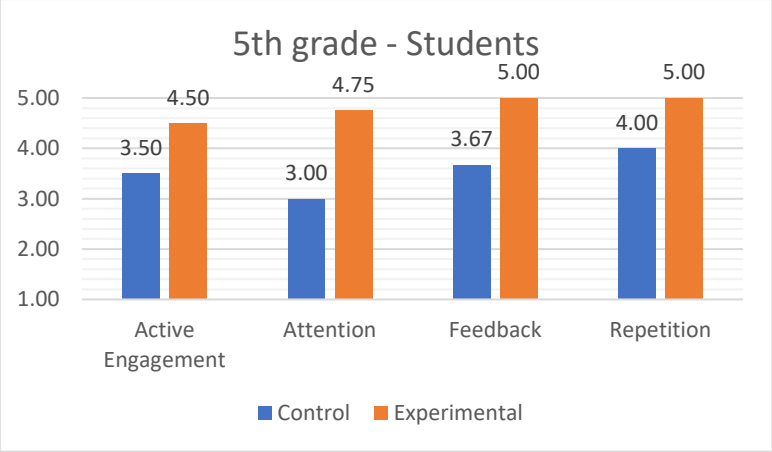
Graph 7. 4th-grade teacher strategies' performance
Subject: Global Perspectives / Lesson: What makes a healthy lifestyle?
Students in the exp. group: 14 / Students in the control group: 12



Graph 8. 4th-grade students' response to strategies/stimuli
Subject: Global Perspectives / Lesson: What makes a healthy lifestyle?
Students in the exp. group: 14 / Students in the control group: 12



Graph 9. 5th-grade teacher strategies' performance
Subject: Science / Lesson: Parts and functions of the digestive system
Students in the exp. group: 7 / Students in the control group: 11



Graph 10. 5th-grade students' response to strategies/stimuli
Subject: Science / Lesson: Parts and functions of the digestive system
Students in the exp. group: 7 / Students in the control group: 11

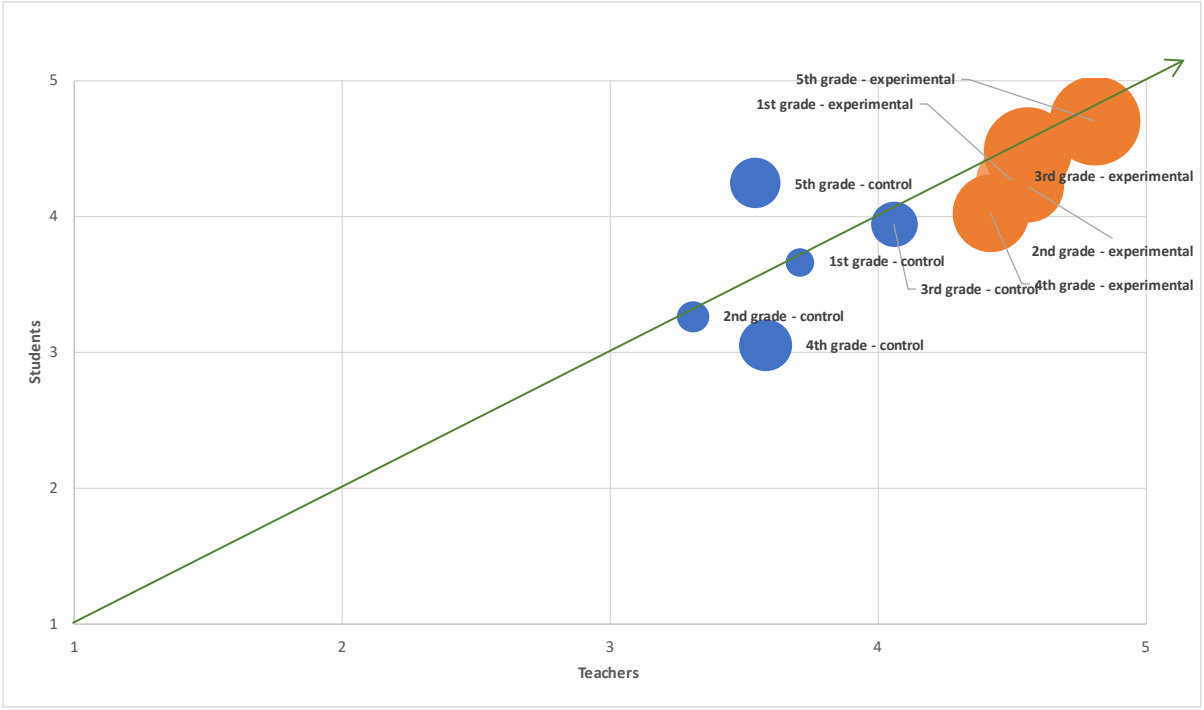
4.4. Conclusion

The data collected must be divided and analysed on two fronts: **perception of improvement** in the pedagogical practices applied by the experimental group and **perception of achievement** in the lessons observed.

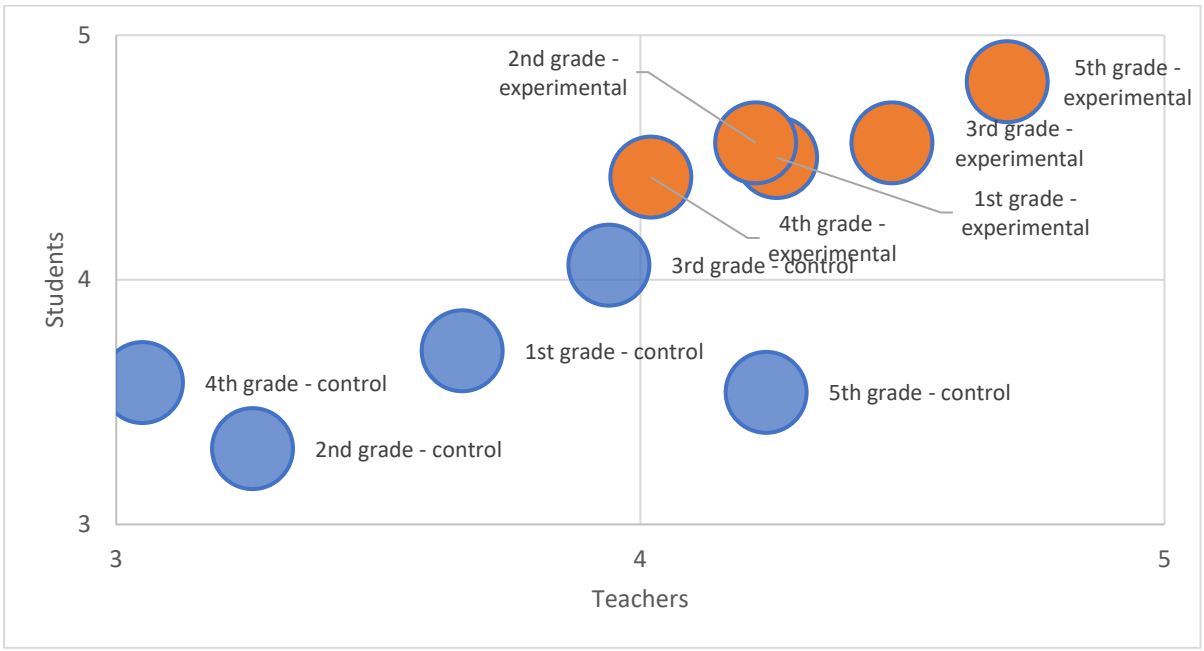
By looking at the perceptions that experimental group teachers reported regarding the instructional session, it is plausible to affirm that it achieved its objective, as the phases of lesson planning and delivery were said to have been affected positively by the theoretical scope of the research.

They seem to have acquired pre-requisite knowledge to apply basic principles of the neuroscience of learning in their CLIL lesson through the formation workshop offered.

The second facet of the data is the information collected through the lesson observations. Graph 11 triangulates data collected in the observation forms meant to assess teacher strategies' performance and students' responses to strategies/stimuli applied in class. It considers a global performance score by adding up the general scores obtained in the four critical areas observed.



Graph 11. Global performance quadrants



Graph 12. Global performance quadrants: cut-out view with a focus on the area where the scores were concentrated

The performance markers were concentrated in the four quadrants at the top right end of the graph, as all global scores reached above three points on the same scale from 1 to 5. Their dislocation to the upper right indicates better achievement of learning objectives for the lesson and, consequently, greater potential for effective learning of **subject content and additional language**. In Graph 11, one should notice that the arrow departing from the base indicates increasing performance. That is because the

axes produce coordinates from the scores obtained by crossing the observation of teachers' performance and the students' responses to those strategies. It became visible that the experimental group, represented by the orange markers, showed better performance in comparison with the control group, illustrated in blue.

It is also possible to infer that, although being surpassed by experimental group peers, teachers in the control group showed satisfactory performance, as all markers were above the line of neutrality, expressed by the number '3' in the lesson observation forms. It may suggest an adequacy of the methods employed by this group and/or positive outcomes of CLIL applied in its 'original' form.

5. CHAPTER 5: DISCUSSION OF RESULTS

The results achieved in this study show a potential impact on lesson planning and lesson delivery in CLIL approach contexts when teachers are instructed to reflect on incorporating strategies based on the neuroscience of learning.

In the small-scale work performed, the experimental group teachers' perception of their work seemed to have been modified after receiving instruction on the neuroscience of learning. The observer's judgement also indicated that classroom practices were elaborated in a way that ultimately positively impacted the students' responses.

The findings documented through the present research fulfil the objectives proposed; nonetheless, they are insufficient to establish new parameters for CLIL lesson planning. However, longitudinal research under the same methodology can add to these initial indications, resulting in more robust data to support educators working in similar settings.

6. CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

A final reflection on the achievements and pitfalls experienced as a result of the present work should depart from the proposed research question: ***Can the neuroscience of learning corroborate or refute CLIL (Content and Language Integrated Learning) principles applied in primary school lesson plans?***

A positive response to this query seems to have been found initially in the literature review phase, as a convergence between CLIL principles and neuroscience of learning can be identified in the literature concerning these areas. Basic theoretical frameworks upon which both fields are based seem confluent and complementary in many aspects. ***Not only are elements of the CLIL approach likely to be favourable to the learning process from the perspective of neuroscience***, but much of what is reported in neuroscience finds a direct correlation with CLIL pedagogical practices.

In practice, the empirical work demonstrated that applying the theory is feasible and likely to produce outcomes that are evidence of benefits perceived by the parties involved. Most importantly, data crossing considering not only observations based on the educator's performance but also how students responded to changes applied in their customary practices converged, indicating preliminary evidence that ***the understanding of the processes of learning and second language acquisition [on the part of teachers] reveals what is more effective as pedagogical tools in primary classrooms***.

Given the replicability of the research methods, further developments, such as a longitudinal study, can positively influence how teachers plan their resources and strategies in other CLIL contexts. Moreover, the broad use of CLIL in many countries justifies further developments of research aiming to contribute to the betterment of pedagogical practices.

In that case, an evaluation of students' performance through periodic testing over a longer period would be useful to validate the hypothesis that designing pedagogical practices as proposed in this study leads to **long-term memory retention and consequential learning**.

Furthermore, the review of literature revealed evidence that indicates that the functions of ***the prefrontal cortex and the limbic system should be regarded in the designing of lesson plans to optimise learning in primary CLIL classrooms***, responding to another research objective. Nevertheless, the most recent research conveys findings that sustain a notion of interdependence among different brain areas. Hence, fixing the observations in two specific systems that play a role in cognitive function might be a too reductionist goal for such complex processes.

However, in the view of Bialystok (1999; 2007), it is plausible to assert that a pronounced development of ***executive functioning*** is identified in bilinguals over monolinguals. “This is potentially an important claim because of the place of executive functioning in accounts of ***learning in cognition***” (Bialystok, 1999, p. 643).

A peripherical (rather important) outcome of the present work might be the transition of the research tools employed in the study, such as the observation forms and the instructional session, from within academia towards the grounds of bilingual schools.

> It is important to remember that the main agent of language acquisition is the child, who has at his/her disposal the innate capacity for language development and who deserves to enjoy the best conditions to put them into use. The role of bilingual schools is to offer the best opportunities so that L2 can thrive (Marcelino, 2020, free translation).

In 2020, the Brazilian National Education Council (CNE) approved guidelines for plurilingual education in Brazil. The present researcher participated in a discussion group organised by São Paulo Open Centre that contributed to a revision of this milestone document 'Diretrizes Curriculares Nacionais para a oferta de Educação Plurilíngue' (National Guidelines for the Offer of Plurilingual Education). In its initial version, reference was directly made to CLIL as a desirable pedagogical approach for Brazilian bilingual schools. The approved version withdrew the term CLIL from the body of the text; however, it maintained conceptual references (Mehisto, Marsh and Frigols, 2008; Rüschoff et al., 2015) that clearly influence the view of bilingual education in Brazil. As an example, when addressing the methodological curricula organisation design, the document states the following:

> Methodological choices must be compatible with the theoretical assumptions of this educational modality [bilingual education] in a way that these approaches allow **for the teaching-learning of content through a second language of instruction** (Brasil, 2020, free translation, brackets and bold added).

It seems that CLIL will remain a relevant object of discussion for those working in bilingual education settings in Brazil, these being school administrators, teachers, policymakers, etc. Extending research on Content and Language Integrated Learning is much needed, especially targeting the formation of educators. Borges and Medeiros (2022) confirm that the current undergraduate courses offered to teachers in Brazil do not seem to prepare them to work bilingually. In other words, these professionals tend to accomplish their initial formation without minimal knowledge of bilingualism and bilingual education. Regardless of their faulty preparation, many of them transition towards that field doomed to reproduce inefficient pedagogical practices based on myths and detrimental models.

Finally, from this perspective, it is hoped that the present dissertation and its following developments through broader and deeper studies may serve to support the formation of teachers willing to work in CLIL bilingual contexts.

The thoughts of Freire (1996) seem to be a fair closure for this work, as it summarises well the underpinnings sustained through the present research:

> What matters in the formation of educators is not the mechanic repetition of their practices but the comprehension of the value of feelings [of their students], [as well as] their emotions, wills, their insecurity to be overcome by certainty, the fear that generates courage as one is educated. […] No true teacher education can be alienated from the exercise of critical thinking that implies the promotion of naive curiosity towards epistemological curiosity, recognising the value of emotions, sensitivity, affectivity, intuition or guesswork. (Freire, 1996, p.39, free translation, brackets included)

As children are seen as individuals of a unique nature, educators have an opportunity to re-think their practices, shifting from a model of school that has been historically organised to form mass-production workers toward an environment where emotions, affection, differentiation and natural curiosity are central to the learning process. In that perspective, a technicist view on education does not seem to be a promising pathway to educate critical and independent thinkers. In the hands of childhood educators, the primary 'brain-crafters', there is a boundless potential to transform education through understanding cognitive development from early years.

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8. APPENDICES

8.1. Educator self-assessment questionnaire

Educator self-assessment questionnaire				
Notice: This interview will ask questions about lesson planning and delivery. When answering about lesson planning, please, focus on the strategies, approaches and tools you have proposed in your lesson plan. When answering about lesson delivery, please, focus on the outcomes (positive and negative) you observed from the strategies, approaches, and tools you planned previously.				
Teacher's full name:				
Lesson delivered (area/field and lesson title):				
Number of students in class:				
Have you participated in the instructional session on neuroscience and CLIL?				
(If **YES**) After the instructional session on neuroscience and CLIL, administered on May 6th, do you feel your lesson planning was impacted in relation to your previous practice?				
Yes, it was positively impacted.	**Yes, it was negatively impacted.**	**I did not notice any significant impact.**		
(If positively impacted) How was your lesson planning positively impacted? What were the changes observed in relation to your previous practice?				
(If negatively impacted) How was your lesson planning negatively impacted? What were the changes observed in relation to your previous practice?				
After the instructional session on neuroscience and CLIL, administered on May 6th, do you feel your lesson delivery was impacted in relation to your previous practices?				
Yes, it was positively impacted.	**Yes, it was negatively impacted.**	**I did not notice any significant impact.**		
(If positively impacted) How was your lesson delivery positively impacted? What were the changes observed in relation to your previous practices?				
(If negatively impacted) How was your lesson delivery negatively impacted? What were the changes observed in relation to your previous practices?				
Please, report strengths and weaknesses in your lesson planning and delivery. Consider your objectives (what you planned) and outcomes (what you achieved) and reflect on why your strategies have (or have not) worked as well as planned.				

8.2. Lesson observation form 1: Teacher's strategies attitudes in the lesson

1. Teachers strategies/attitudes in the lesson						
		(1) Strongly Disagree	**(2) Disagree**	**(3) Neither Agree nor Disagree**	**(4) Agree**	**(5) Strongly Agree**
Attention	Teacher talk time is well-balanced with practical tasks so that the group doesn't show boredom.					
	The lesson sequence is intuitive to students, resulting in few interventions by the teacher to provide clarifications or explanations.					
	Teaching the necessary language supports the presentation of new content, allowing students to follow the lesson well.					
	The teacher resorts to attention triggers to get the group back on track whenever attention is deviated due to external distractions.					
	A variety of resources/materials is put into practice, keeping students alert and focused on tasks and explanations. Examples of materials and resources: whiteboard, PowerPoint, flashcards, toys, videos, songs, puppets, models etc.).					
	Resources and materials support the learning of both content and language.					

	The teacher modulates their body language and tone of voice to gain students' attention as soon as deviation from the lesson aims is perceived.					
Active engagement	The practical task aims are achievable and connect well with the theory presented by the teacher.					
	Considering the group's age, practical activities are adequately constructed; they are neither difficult nor easy.					
	The organisation of practical activities allows for *scaffolding*. In other words, it is visible through practical tasks that higher 'stairs' of knowledge are achieved as the lesson progresses.					
	The teacher makes language tangible to the students during the work with practical tasks/experiments, as the concrete referential in the real world are directly related to the language attributed to them. Example: students pour a two-phased solution into a test tube. The verb 'pour', the object 'test tube', and the concept of a 'two-phased solution' are learnt as students manipulate this new language.					

Repetition	The teacher provides multiple opportunities for students to deal with new language through exposure and practice of vocabulary (words and expressions) and grammatical structures.					
	Language and content are revisited orally (in interactions with peers and the teacher) and through written tasks (in the class book, notebook and other printed materials).					
	The teacher plans tasks that favour the repetition of language and content in a diversified way. Students don't seem to realise they are reviewing and repeating topics they have already been exposed to.					
Feedback	Moments of feedback are well distributed throughout the lesson.					
	The teacher provides feedback on language as well as on the content satisfactorily.					
	Feedback is given at individual and group levels.					
	In giving feedback/correcting errors, the teacher never exposes the students' individual mistakes to the group.					
	The teacher's approach to correcting errors is mostly friendly.					

	The teacher never halts the use of additional language to correct an error.					
	Students don't seem to feel intimidated or embarrassed when corrected by the teacher.					

8.3 Lesson observation form 2: Students' response to pedagogial tools/strategies

2. Students' response to pedagogial tools/strategies						
		(1) Strongly Disagree	**(2) Disagree**	**(3) Neither Agree nor Disagree**	**(4) Agree**	**(5) Strongly Agree**
Attention	When the teacher talks, most students focus on the topic being exposed.					
	Most of the students focus on the visual resources presented (whiteboard, PowerPoint, flashcards etc.).					
	In practical activities, most students follow the steps accurately, as instructed by the teacher.					
	The impact of external distractions is minimal; whenever distractions occur, the group quickly gets back to the lesson focus. *External distractions: comments/jokes deviating from the lesson topic, noises out of the classroom, students dropping materials etc.					

Active engagement	Most of the students seem to be excited when working on practical tasks.					
	Students show interest in participating in practical activities, such as daily routine songs and experiments.					
	When assigned a group task, students promptly engage and perform what is asked with very little deviation.					
	Students show excitement when accomplishing steps of the practical work.					
Repetition	Most students performed different tasks focusing on the same topics/content aimed for that lesson.					
	Students didn't bother having to deal with the same lesson topics repeatedly. (repetition is constructed in such a way that they don't even realise it is happening).					
Feedback	Students can recall the results of practical tasks.					
	Students can relate the results of practical tasks with their initial predictions, being able to compare and contrast the outcomes of their experiments.					

	By comparing and contrasting the outcomes of lesson tasks, students can present their conclusions accurately.					

8.4 Consent form for the educational institution

The 2nd of May, 2023
Ribeirão Preto, São Paulo, Brazil

To the Director-President of Colégio Santa Úrsula of Ribeirão Preto

This letter is to kindly ask for your support in collaborating with the final stage of the field research intended to be conducted at Colégio Santa Úrsula of Ribeirão Preto. The study aims to provide contributions to improving classroom practices in bilingual education settings. The research will also integrate the mandatory dissertation of the Master's Degree Programme in Bilingualism and Multilingualism, which I am part of at the **University of Wales Trinity Saint David in the UK**.

It is important to highlight that your consent will be necessary as lessons delivered to students enrolled at the institution under your presidency will be observed to document and analyse pedagogical tools and strategies to be put into practice by the teachers.

Students and teachers will not be named in the research, and all materials that may be collected (e.g. observation reports, quizzes, pictures and videos) will be treated properly to keep the identity of the students anonymous. If the collection of images and videos is necessary, they will not be publicised without covering/blurring the faces of the students involved. As mentioned, the research focuses on classroom practices, not the students themselves.

Six bilingual education teachers employed by the institution will be directly observed in the study. They will be formally invited to collaborate through an agreement term of cooperation, and their participation, upon signed agreement, is totally voluntary, exempting the institution from the payment of any additional remunerations and further labour obligations.

As for the participation of students, their parents and/or legal guardians will be notified and asked to present their written consent to the observation of the lessons where their children will be present.

Additionally, all data collected will be stored in accordance with the guidelines established by the University of Wales Trinity Saint David to guarantee the security and confidentiality of any potentially sensitive matters involving the research parts.
Results will be accessible to you upon the conclusion of the work. The institution can withdraw its participation/cooperation in the research at any time at its best convenience.

Information about the research:

Department:	AD1 Centre for Humanities and Social Sciences
Campus:	Carmarthen Campus (Distance)
Programme of Study:	Master of Arts: Bilingualism and Multilingualism
Director of Studies/Supervisor:	Dr Hywel Glyn Lewis
Indicative title:	Fundamentals of the neuroscience of learning to support Content-and-Language-Integrated-Learning-(CLIL)-based lesson planning in primary education: potentialising learning through a basic understanding of the brain in childhood.
Objectives of Research Activity	• To identify if findings in the neuroscience of learning can support teachers when planning CLIL lessons for young learners and how it can be done. • To investigate if the understanding of the processes of learning and second language acquisition reveals what is more effective as pedagogical tools in primary classrooms. • To analyse what elements of the CLIL approach are found to be favourable to the learning process from the perspective of neuroscience. • To collect evidence that indicates if the functions of the prefrontal cortex and the limbic system should be regarded in the designing of lesson plans to optimise learning in primary CLIL classrooms. • To indicate, by documenting lesson observations and interviews with teachers, if the delivery of CLIL lessons, planned upon a basic knowledge of the neuroscience of learning, showed to be more effective when compared to their previous practices.

Counting on your support and collaboration, I am grateful for your participation!
Sincerely,

_____

Rafael Henrique Bianchi

Declaration of consent (please fill in the form provided below):

I, _____,

legally responsible for Colegio Santa Úrsula of Ribeirão Preto, express my consent to the research aforementioned, in the terms presented. I declare that I have also received

a copy of the full research project, as presented in **APPLICATION FOR ETHICAL APPROVAL** to the University of Wales Trinity Saint David.

_____

(Signature and Institution Stamp)

8.5 Consent form for parents/guardians

The 2nd of May, 2023

Ribeirão Preto, São Paulo, Brazil

Dear parents,

This letter is to kindly ask for your support in collaborating with the final stage of a field research to be conducted at Colégio Santa Úrsula of Ribeirão Preto. The study aims to contribute to improving classroom practices in bilingual education settings. The research will also integrate the mandatory dissertation of the **Master's Degree Programme in Bilingualism and Multilingualism**, which I am part of at the **University of Wales Trinity Saint David** in the UK.

It is important to highlight that your consent will be necessary as a lesson delivered to your son/daughter will be observed to document and analyse pedagogical tools and strategies to be put into practice by the teacher.

Students will not be named in the research, and all materials that may be collected (e.g. observation reports, quizzes, pictures and videos) will be treated properly to keep the identity of the students anonymous. If the collection of images and videos is necessary, they will not be publicised without covering/blurring the faces of the students involved. As mentioned, the research focuses on classroom practices, not the students themselves.

Additionally, all data collected will be stored in accordance with the guidelines established by the University of Wales Trinity Saint David to guarantee the security and confidentiality of any potentially sensitive matters involving the research parts.

Results will be accessible to you upon the conclusion of the work.

Information about the research:

Department	AD1 Centre for Humanities and Social Sciences
Campus:	Carmarthen Campus (Distance)
Programme of Study:	Master of Arts: Bilingualism and Multilingualism
Director of Studies/Supervisor:	Dr Hywel Glyn Lewis

Indicative title:	Fundamentals of the neuroscience of learning to support Content-and-Language Integrated-Learning-(CLIL)-based lesson planning in primary education: potentialising learning through a basic understanding of the brain in childhood.
Objectives of Research Activity	• To identify if findings in the neuroscience of learning can support teachers when planning CLIL lessons for young learners and how it can be done. • To investigate if the understanding of the processes of learning and second language acquisition reveals what is more effective as pedagogical tools in primary classrooms. • To analyse what elements of the CLIL approach are found to be favourable to the learning process from the perspective of neuroscience. • To collect evidence that indicates if the functions of the prefrontal cortex and the limbic system should be regarded in the designing of lesson plans to optimise learning in primary CLIL classrooms. • To indicate, by documenting lesson observations and interviews with teachers, if the delivery of CLIL lessons, planned upon a basic knowledge of the neuroscience of learning, showed to be more effective when compared to their previous practices.

Counting on your support and collaboration, I am grateful for your participation!

Sincerely,

Rafael Henrique Bianchi

Declaration of consent (please fill in the form provided below):

I, _____, CPF _____,

legally responsible for the student _____agree

with his/her participation in the research aforementioned, in the terms presented.

_____

(Signature)

***This document has been provided in English and Portuguese. Both versions were written by the present researcher aiming to have the slightest deviation possible from one another.**

8.6 Consent form for teachers: control and experimental groups

The 2nd of May, 2023
Ribeirão Preto, São Paulo, Brazil

Dear teacher,

This letter is to kindly ask for your support in collaborating with the final stage of the field research intended to be conducted at Colégio Santa Úrsula of Ribeirão Preto. The study aims to provide contributions to improving classroom practices in bilingual education settings. The research will also integrate the mandatory dissertation of the Master's Degree Programme in Bilingualism and Multilingualism, which I am part of at the **University of Wales Trinity Saint David in the UK**.

It is important to highlight that your consent will be necessary as the observation of lessons delivered by you will be crucial to data collection. Moreover, your participation in an instructional session on a date still to be informed must be confirmed if you agree to participate as part of the research.

Students and teachers will not be named in the research, and all materials that may be collected (e.g. observation reports, quizzes, pictures and videos) will be treated properly to keep the identity of the students anonymous. If the collection of images and videos is necessary, they will not be publicised without covering/blurring the faces of the students involved. As mentioned, the research focuses on classroom practices, not on the students themselves nor on the performance of the teachers.

Besides yourself, five other bilingual education teachers employed by Colégio Santa Úrsula will be directly observed in the study. All professionals will be formally invited to collaborate through the present term of cooperation and consent. The data collected and analysed is not intended to critique your working methods nor to compare your practices to those of your co-workers.

Please be aware that your participation is voluntary, exempting your current employer from paying any additional remunerations and further labour obligations. You may be asked to be part of either the experimental or the control group. Further instructions will be provided to you upon agreement to take part in the research.

As for the participation of students, their parents and/or legal guardians will be notified and asked to present their written consent to the observation of the lessons where their children will be present.

Additionally, all data collected will be stored in accordance with the guidelines established by the University of Wales Trinity Saint David to guarantee the security and confidentiality of any potentially sensitive matters involving the research parts. Results will be accessible to you upon the conclusion of the work. You can withdraw your participation/cooperation in the research at any time at your best convenience.

Information about the research:

Department:	AD1 Centre for Humanities and Social Sciences
Campus:	Carmarthen Campus (Distance)

Programme of Study:	Master of Arts: Bilingualism and Multilingualism
Director of Studies/Supervisor:	Dr Hywel Glyn Lewis
Indicative title:	Fundamentals of the neuroscience of learning to support Content-and-Language-Integrated-Learning-(CLIL)-based lesson planning in primary education: potentialising learning through a basic understanding of the brain in childhood.
Objectives of Research Activity	• To identify if findings in the neuroscience of learning can support teachers when planning CLIL lessons for young learners and how it can be done. • To investigate if the understanding of the processes of learning and second language acquisition reveals what is more effective as pedagogical tools in primary classrooms. • To analyse what elements of the CLIL approach are found to be favourable to the learning process from the perspective of neuroscience. • To collect evidence that indicates if the functions of the prefrontal cortex and the limbic system should be regarded in the designing of lesson plans to optimise learning in primary CLIL classrooms. • To indicate, by documenting lesson observations and interviews with teachers, if the delivery of CLIL lessons, planned upon a basic knowledge of the neuroscience of learning, showed to be more effective when compared to their previous practices.

Counting on your support and collaboration, I am grateful for your participation!
Sincerely,

_____

Rafael Henrique Bianchi

Term of cooperation and consent (please fill in the form provided below):

I, _____,

currently employed as a bilingual education teacher by Colegio Santa Úrsula of Ribeirão Preto, express my consent to participate in the research aforementioned in the terms presented. I declare that I have also received a copy of the full research project, as presented in **APPLICATION FOR ETHICAL APPROVAL** to the University of Wales Trinity Saint David.

_____

(Signature)

8.7 Consent form for the programme coordinator

The 2nd of May, 2023
Ribeirão Preto, São Paulo, Brazil

Dear coordinator/department head,

This letter is to kindly ask for your support in collaborating with the final stage of the field research intended to be conducted at Colégio Santa Úrsula of Ribeirão Preto. The study aims to provide contributions to improving classroom practices in bilingual education settings. The research will also integrate the mandatory dissertation of the Master's Degree Programme in Bilingualism and Multilingualism, which I am part of at the **University of Wales Trinity Saint David in the UK**.

It is important to highlight that your consent will be necessary as you, as head leader of the bilingual programme, will conduct the observation of lessons delivered. Moreover, your participation in an instructional session on a date still to be informed must be confirmed if you agree to participate as part of the research.

Students and teachers will not be named in the research, and all materials that may be collected (e.g. observation reports, quizzes, pictures and videos) will be treated properly to keep the identity of the students anonymous. If the collection of images and videos is necessary, they will not be publicised without covering/blurring the faces of the students involved. As mentioned, the research focuses on classroom practices, not on the students themselves nor on the performance of the teachers.

Your role in the research will be the **observation of ten lessons delivered by six bilingual education teachers employed by Colégio Santa Úrsula**. You will be provided with the observation forms and instructions on how to fill them in previously.

All professionals will be formally invited to collaborate through the present term of cooperation and consent. The data collected and analysed is not intended to critique the professional's working methods nor to compare their practices to those of other co-workers.

Please be aware that your participation is voluntary, exempting your current employer from paying any additional remunerations and further labour obligations. You may be asked to be part of either the experimental or the control group. Further instructions will be provided to you upon agreement to take part in the research.

As for the participation of students, their parents and/or legal guardians will be notified and asked to present their written consent to the observation of the lessons where their children will be present.

Additionally, all data collected will be stored in accordance with the guidelines established by the University of Wales Trinity Saint David to guarantee the security and confidentiality of any potentially sensitive matters involving the research parts.

Results will be accessible to you upon the conclusion of the work. You can withdraw your participation/cooperation in the research at any time at your best convenience.

Information about the research:

Department:	AD1 Centre for Humanities and Social Sciences
Campus:	Carmarthen Campus (Distance)
Programme of Study:	Master of Arts: Bilingualism and Multilingualism
Director of Studies/Supervisor:	Dr Hywel Glyn Lewis
Indicative title:	Fundamentals of the neuroscience of learning to support Content-and-Language-Integrated-Learning-(CLIL)-based lesson planning in primary education: potentialising learning through a basic understanding of the brain in childhood.
Objectives of Research Activity	• To identify if findings in the neuroscience of learning can support teachers when planning CLIL lessons for young learners and how it can be done. • To investigate if the understanding of the processes of learning and second language acquisition reveals what is more effective as pedagogical tools in primary classrooms. • To analyse what elements of the CLIL approach are found to be favourable to the learning process from the perspective of neuroscience. • To collect evidence that indicates if the functions of the prefrontal cortex and the limbic system should be regarded in the designing of lesson plans to optimise learning in primary CLIL classrooms. • To indicate, by documenting lesson observations and interviews with teachers, if the delivery of CLIL lessons, planned upon a basic knowledge of the neuroscience of learning, showed to be more effective when compared to their previous practices.

Counting on your support and collaboration, I am grateful for your participation!
Sincerely,

Rafael Henrique Bianchi

Term of cooperation and consent (please fill in the form provided below):

I, _____, head of international education and responsible for the Bilingual Education Programme at Colegio Santa Úrsula of Ribeirão Preto, express my consent to participate in the research aforementioned in the terms presented. I declare that I have also received a copy of the full research project, as presented in **APPLICATION FOR ETHICAL APPROVAL** to the University of Wales Trinity Saint David.

_____
(Signature)