Assessing academic language proficiency in meaning construction in Physics-Chemistry: a bilingual educational case study

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ABSTRACT: Research on bilingual education has gained increasing relevance in recent years, highlighting the need to investigate the linguistic processes involved in bilingual educational contexts. Academic language plays a pivotal role in Content and Language Integrated Learning (CLIL). This study aims to evaluate students' academic language proficiency in the cognitive-discourse elements and functions of the descriptive text genre within a content subject, specifically Physics-Chemistry, through the development of digital assessment tools. This empirical study was conducted at a bilingual secondary education center in Porto, Portugal, with a sample of 50 students. The results indicate that students' academic language competence in meaning construction within this content subject was optimal in listening comprehension skills and moderate in written expression. However, their academic language proficiency in vocabulary and grammar was comparatively lower. This discrepancy underscores the need for further development of the descriptive aspects of language, particularly vocabulary and grammar, to enhance students' ability to construct meaning in this disciplinary subject.
Keywords: bilingual education, academic language, CLIL, descriptive genre, disciplinary subject.

Evaluación de la competencia del lenguaje académico para la construcción de significado en Física-Química: un caso de estudio en educación bilingüe

RESUMEN: La investigación sobre educación bilingüe ha adquirido una creciente relevancia en los últimos años, destacando la necesidad de profundizar en el estudio de los procesos lingüísticos involucrados en los contextos educativos bilingües. El lenguaje académico desempeña un papel crucial en el Aprendizaje Integrado de Contenidos y Lenguas (AICLE). Este estudio tiene como objetivo evaluar la competencia del lenguaje académico de los estudiantes en las funciones cognitivo-discursivas del género descriptivo de una asignatura de contenido, específicamente física-química, mediante el desarrollo de herramientas digitales de evaluación. Este estudio empírico se llevó a cabo en un centro de educación secundaria bilingüe en Oporto, Portugal, con una muestra de 50 estudiantes. Los resultados indican que la competencia en el lenguaje académico de los estudiantes en la construcción de significado de la asignatura fue óptima en la destreza de comprensión auditiva y moderada en la expresión escrita. Sin embargo, su competencia del lenguaje académico en vocabulario y gramática fue considerablemente más baja. Esta discrepancia resalta la necesidad de desarrollar más profundamente los aspectos descriptivos del lenguaje, especialmente en lo relacionado con

el vocabulario y la gramática, a fin de mejorar la capacidad de los estudiantes para construir significado en esta disciplina.
Palabras clave: educación bilingüe, lenguaje académico, AICLE, género descriptivo, materia disciplinar.

1. INTRODUCTION

Bilingual education has long been a crucial component of educational institutions worldwide, aiming to facilitate the effective acquisition of a second language. Recent advancements in neuroscience have clarified the complex mechanisms involved in language acquisition, cognitive growth, and meaning construction in content subjects (Roussel et al., 2017; Pavón, 2018). According to Kuhl (2004), neuroscience research has demonstrated the remarkable neuronal flexibility of the brain, particularly during early developmental stages. This plasticity enables children to acquire multiple languages simultaneously. The role of language in schools has been redefined, emphasizing not only its importance for teaching and learning but also its critical role in shaping cognitive development (Council of Europe, 2010).

Bialystok (2017) highlights that, given the centrality of language in human experience and the strong links between linguistic and non-linguistic processing, it is not surprising that bilingualism affects brain functions. In this vein, Privitera et al. (2022) assert that bilingualism influences cognitive functions in a context-dependent manner, underscoring the nuanced interplay between language and cognition. Recent studies in cognitive neuroscience have further illuminated how bilingualism shapes the human mind, offering a diverse range of cognitive benefits that extend beyond linguistic abilities (Green & Abutalebi, 2013).

In this context, Beacco et al. (2015) argue that language is a fundamental element connecting knowledge across all curricular areas. This conceptualization of language in education is based on the premise that students must learn and use language not only generally but also for specific purposes and in diverse contexts (Coyle, 2015; Coyle, 2021; Vollmer, 2006). Moreover, there is a strong relationship between achieving linguistic proficiency and understanding content, which places language development as a high priority in education (Lorenzo, 2016). Language is not merely a tool for communication; in schools, it is an essential component for achieving cognitive maturity (Roldstad, 2005). It is indispensable for discovering, understanding, transmitting, disseminating, and storing knowledge.

Neuroscience research has also explored the phenomenon of code-switching, where bilingual individuals seamlessly switch between languages (Grosjean, 2010). This ability aids in meaning construction and can enhance comprehension of the content subjects being studied. The concept of Language Across the Curriculum (LAC) (Vollmer, 2006) emphasizes the importance of integrating language with the content of all subjects in bilingual educational contexts. This approach posits that language development should be prioritized across all disciplines, not just in language-focused subjects. As Vollmer (2006) notes, the linguistic dimension of learning has often been underestimated, yet it is a foundational pillar for constructing meaning in all academic fields.

To ensure that all students have the opportunity to acquire knowledge and develop their full potential through academic language, it is essential to investigate the relationship between academic language and content (Pavón, 2018). One challenge in considering language as a fundamental component of learning is that national curricula often address its acquisition

only through formal education (Lorenzo, 2016). As a result, the academic dimension of language has not received sufficient attention and is not explicitly taught, as it is assumed to develop organically through contact with content subjects (Coyle, 2015).

Another challenge is that students often struggle to develop the L2 language skills required to meet the demands of various content subjects taught in the classroom (Lorenzo & Trujillo, 2016). This issue is particularly significant in bilingual education programs, as students cannot learn effectively in classrooms without adequate academic language proficiency (Roussel et al., 2017). Furthermore, teachers, especially content specialists, may not always be aware of the importance of the language they use in their lessons for meaning construction or its impact on developing students' academic language proficiency (Coyle et al., 2015; Halbach, 2018; Raitbauer et al., 2018).

The central aim of this research is to evaluate students' acquisition of academic language and its role in shaping meaning construction within the specific subject of "Physics-Chemistry" in a bilingual education program.

2. INFLUENCE OF THE ACADEMIC LANGUAGE PROFICIENCY ON MEANING CONSTRUCTION IN CLIL

A key aspect of bilingual education systems, where subjects are taught in a foreign language, is the influence of academic language skills on students' ability to comprehend and construct meaning in disciplinary subjects. According to Beacco et al. (2015), there is a consensus that proficiency in the language used in school is not sufficient on its own; instead, mastery of a specialized form of that language, referred to as "academic language use," serves as the most reliable foundation for success in education and subject learning. This underscores the critical role of academic language in facilitating a deeper understanding and greater engagement with content in bilingual educational settings.

Effective CLIL integrates content, communication, cognition, and culture to enhance the educational experience and support the use of language for meaning-making, as highlighted in Coyle's 4Cs framework (Coyle, 2008). This approach emphasizes the importance of students improving their language skills while acquiring sophisticated knowledge of subject material—both of which contribute to their overall academic and cognitive development (Ostovar-Namaghi & Nakhaee, 2019). Notably, improved learning outcomes across various subjects are closely associated with academic language proficiency in CLIL contexts.

Recent studies (Fajardo Dack et al., 2020; Lasagabaster & Doiz, 2015) indicate that students proficient in the academic language associated with their content subjects tend to perform better academically, demonstrating enhanced comprehension and retention of complex content. Moreover, by engaging with both language and content, CLIL not only facilitates the acquisition of subject-specific knowledge but also promotes cognitive skills such as critical thinking and problem-solving, enriching students' educational experiences (Coyle, Hood, & Marsh, 2010). However, a more nuanced understanding of academic language in CLIL contexts is still required, as challenges persist—particularly regarding students' varying levels of language proficiency and the integration of language skills with subject matter (Dalton-Puffer, 2007; Nikula et al., 2016).

The interdisciplinary approach of CLIL connects it to various educational theories and models of language acquisition. According to Marsh and Frigols (2012), CLIL provides

a comprehensive framework for understanding the complexities of language learning in educational contexts by incorporating ideas from constructivist learning theories, psycholinguistics, and second language acquisition. These theoretical perspectives allow for a deeper exploration of the relationship between language proficiency and cognitive processes in the classroom, reinforcing the importance of academic language development in achieving meaningful learning outcomes (Fajardo Dack et al., 2020).

This theoretical perspective highlights the necessity of integrating language skills and content knowledge to ensure comprehensive cognitive development. The coexistence of cognitive mastery of academic language and basic interpersonal communication skills is widely regarded as essential for understanding the relationship between students' existing language proficiency and the variety of language they need to produce to use academic language competently. This concept clarifies the interrelation between the language students already possess and the academic language required for constructing meaning in educational contexts. Fostering language awareness in students and equipping teachers with the necessary training to support this awareness could undoubtedly contribute to a more effective integration of language and content across all subjects (Pavón, 2018).

3. METHODOLOGY

3.1. Objectives

This study is part of the competitive project (KA203-5248A159): "Towards an Integrated Bilingualism Model", funded by the European Union through SEPIE. The participating entities in this project include the University of Porto (Portugal), the *Santos Mártires* Foundation (Córdoba), Eurolingue Schools (Palermo), and the University of Córdoba. The project focuses on developing a language proficiency assessment model tailored to academic subjects in bilingual education. The present study examines the relationship between academic language proficiency and content comprehension in CLIL (Content and Language Integrated Learning) contexts within secondary bilingual education in Porto (Portugal). Specifically, the aim of this research is to evaluate students' proficiency in academic language, focusing on the cognitive-discourse elements and functions characteristic of the descriptive text genre, as well as how these elements and functions influence their ability to acquire and express disciplinary knowledge in the subjects of Physics and Chemistry. To achieve this, the study focuses on four key objectives:

1. To analyze students' mastery of academic grammar and vocabulary as fundamental tools for understanding and expressing disciplinary knowledge.
2. To assess the development of students' listening skills, which are essential for processing and comprehending scientific concepts.
3. To evaluate students' ability to produce accurate and coherent written content.
4. To assess students' overall academic language proficiency in constructing meaning within the subject of Physics-Chemistry.

3.2. Context and participants

Participants for this study were recruited from a bilingual school located in Porto, Portugal. The sample comprised 50 secondary school students of Portuguese nationality, all of whom were enrolled in a bilingual program where a CLIL (Content and Language Integrated Learning) approach was implemented. The study specifically focuses on secondary bilingual students whose first language is Portuguese and who use English as the language of instruction for content-based subjects. The participants' ages ranged from 13 to 14 years old, and their English proficiency levels were B1 (intermediate) according to the Common European Framework of Reference for Languages (CEFR). Each participant's academic language proficiency was evaluated within the context of bilingual Physics and Chemistry lessons.

3.3. Procedure

In this analytical research, a quantitative paradigm was applied. Data collection took place during the first quarter of the 2022/2023 academic year. The research was carried out in different phases, with the initial phase involving the design of the tests. In the early stages of the process, three of the most recognized language tests measuring academic language (Cambridge for Schools, Aptis for Teenagers, IELTS, and TOEFL) were analyzed to determine whether they specifically addressed the measurement of academic language proficiency in the context of discourse genres. Subsequently, various possibilities regarding the subject matter, Physics and Chemistry, were explored to ensure alignment with the academic content of subjects taught in Portugal. Furthermore, different options were reviewed concerning the materials and activities that could be used for each of the tests.

The next step in the process was to design the structure of the tests in terms of language levels, types of skills to be measured, textual genres to be analyzed, and types of activities. A compilation of selected activities that could best adapt to the intended measurement was carried out, with the additional consideration that this battery of activities also provided information on their suitability for use as pre-task, task, or post-task activities. Subsequently, a template was prepared with the test structure, indicating the tasks and assigning the textual genres to be measured in the subjects of Physics and Chemistry, as well as including information on the linguistic skills (grammar and vocabulary, listening, and writing) and the types of activities. The final structure of the tests was developed, incorporating the linguistic elements and the content of the subject matter. Once the tests were prepared, they were converted into a digital format.

Finally, the next phase involved the creation of evaluation criteria and scoring tools. A rubric was created that specified the scores for each activity in each test and subject. This rubric allowed for the recording of students' linguistic competence in relation to the specific text genre and linguistic skill being assessed. To ensure the proper functioning of the technical elements, a pilot test was conducted in bilingual schools. The main aim of this pilot test was to verify that all the technical components were working correctly, as well as to evaluate the estimated time required to complete the test and the level of difficulty for the students. To further facilitate the completion of the test, an explanatory video was produced to provide students with clear instructions on how to complete the test.

4. RESULTS

4.1. Data analysis

The presented data compile the results of the tests corresponding to the assessable items or skills (grammar, vocabulary, writing, and listening) in the descriptive genre. The results were calculated based on the values obtained by the students in the different items or skills assessed within the descriptive genre of discursive functions in the subject of Physics-Chemistry. For this purpose, all values below 0.5 are considered unsatisfactory, while values equal to or above 0.5 and up to 1 are considered satisfactory. The data regarding the difficulty and discrimination indices, as well as reliability, were obtained from the administered test. The purpose of the difficulty index is to ensure that the test is aligned with the required level and provides relevant and sufficient information for our objectives.

Table 1. *Difficulty index*

IF (DIFFICULTY INDEX)	INTERPRETATION
> 0.9	Very Easy
0.61 - 0.89	Easy
0.4 - 0.6	Moderate
< 0.4	Difficult

The aim of the discrimination index is to ensure that the questions effectively discriminate between more competent candidates and those with more limited competence.

Table 2. *Discrimination Index*

RPBI (DISCRIMINATION INDEX)	INTERPRETATION
> 0.4 or more	Discriminates very well
0.30 - 0.39	Discriminates well
0.20 - 0.29	Does not discriminate well
0.00 - 0.19	Does not discriminate - Review
Negative	Does not discriminate - Eliminate

In addition, internal consistency indices (Cronbach's alpha) were calculated to ensure that the results were reliable and that the measurement error was within acceptable parameters.

Table 3. *Cronbach's alpha*

CRONBACH'S ALPHA	RELIABILITY
0.53 or less	Null reliability
0.54 - 0.59	Low reliability
0.60 - 0.65	Reliable
0.66 - 0.71	Very reliable
0.72 - 0.99	Excellent reliability
1	Perfect reliability

4.2. Results of grammar and vocabulary skill

Table 4. *Statistics of grammar and vocabulary skill*

GRAMMAR/VOCABULARY SKILL SCORE	
Valid	50
Missing	0
Mean	0,45
Median	0,4
Mode	0,4
Std. Deviation	0,18

The average score of 0.45 in grammar and vocabulary suggests that a significant portion of the sample scored slightly below 50% on the corresponding assessment. This data indicates that a considerable number of students encountered challenges in accurately using grammatical structures and vocabulary in context. The median score of 0.40 reveals that 50% of the students scored at or below this level, suggesting that most students exhibited similar proficiency levels in grammar and vocabulary. The frequent occurrence of 0.40 as the most common score further supports the trend of clustering around this performance range. A standard deviation of 0.18 reflects moderate variability in scores, indicating some heterogeneity in grammar and vocabulary competence. Given that most scores fell below the midpoint of the scale, it can be inferred that a significant percentage of students faced difficulties in using grammar and vocabulary within the evaluated context.
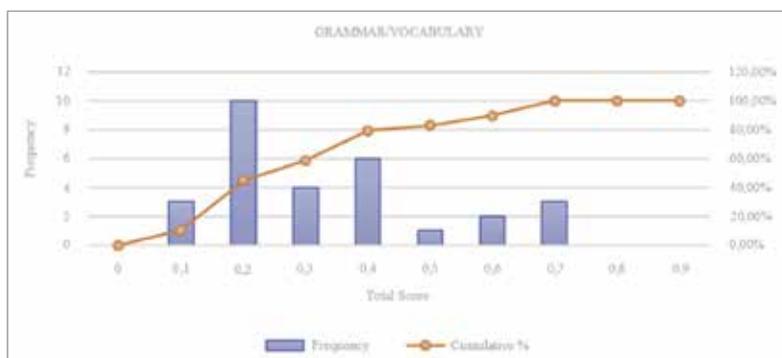

Figure 1: *Histogram of grammar and vocabulary results*

The histogram provides a visual representation of the grammar and vocabulary assessment results. The horizontal axis (labeled 'Total Score') shows the minimum (0) and maximum (1) possible scores, while the left vertical axis (labeled 'Frequency') shows the number of students in each score range. The orange line (labeled 'Cumulative Percentage'), read from the right vertical axis, shows the cumulative percentage of students relative to the total, while the blue bars represent the frequency of scores. The histogram and cumulative percentage analysis reveal a clear trend: most students performed below 50% on the

grammar and vocabulary assessment. Specifically, over 70% of students scored below 0.5, with 50% of students scoring between 0.2 and 0.4. This indicates that the most of of the sample faced significant challenges in mastering the grammatical structures and vocabulary assessed. The cumulative percentage line confirms that no students achieved high proficiency, and the overall trend suggests the need for targeted educational interventions to address the widespread difficulties observed in the evaluated context.

4.3. Results of listening skill

Table 5. *Statistics of Listening Skill*

LISTENING SKILL SCORE	
Valid	50
Missing	0
Mean	0,73
Median	0,78
Mode	0,78
Std. Deviation	0,14

This report evaluates students' listening skills based on the statistical data provided. Measures such as mean, median, mode, and standard deviation are used to interpret students' listening performance, identify trends, and highlight areas for improvement. The mean score of 0.73 indicates that, on average, students performed at a relatively high level in listening comprehension, suggesting a strong understanding of spoken content. With a median of 0.78, half of the students scored below this value, and half scored above, indicating that most students perform consistently around this higher score. The mode, also 0.78, was the most frequently occurring score, further supporting that a significant number of students achieved this level, indicating consistent listening proficiency among the majority.The standard deviation of 0.14 reflects a relatively small spread around the mean, suggesting that most students' scores are close to 0.73. This consistency implies that there are few outliers, with most students achieving similar listening scores.
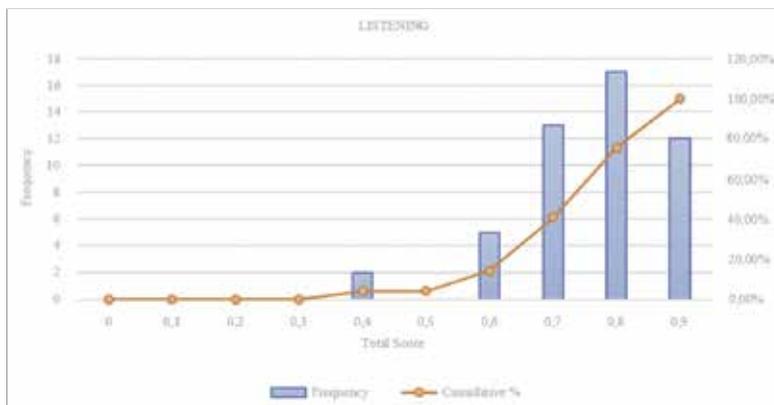

Figure 2: *Histogram of listening results*

The histogram and cumulative percentage analysis indicate that listening skills were relatively strong across the sample. Specifically, over 70% of students scored between 0.6 and 0.9, reflecting an intermediate-to-high level of listening proficiency. The relatively low frequency of students in the 0.0 to 0.3 range suggests that most individuals had a solid understanding of listening tasks, though there was still a small group who faced difficulties. Overall, the results suggest that listening is a stronger area for this group of students, but there is still room for improvement, especially for those in the lower score ranges. The analysis highlights the importance of continuing to develop listening skills in educational contexts, with a focus on supporting students who scored lower in this area.

4.4. Results of writing skill

Table 6. *Statistics of writing skill*

WRITING SKILL SCORE	
Valid	50
Missing	0
Mean	0,60
Median	0,6
Mode	0,6
Std. Deviation	0,21

This report evaluates the students' proficiency in writing skills using statistical measures such as mean, median, mode, and standard deviation. The mean of 0.60 suggests an average level of writing proficiency among the students, indicating that while some students demonstrate competence, there is room for improvement across the group. The median, also 0.60, shows that half of the students scored below this level and half scored above it, meaning that the majority are clustered around this moderate score. The mode of 0.60, the most common score, further confirms a consistent level of performance at this proficiency level across the group. The standard deviation of 0.21 indicates a moderate spread of scores around the mean, suggesting some variability, with some students performing better or worse than the group average.
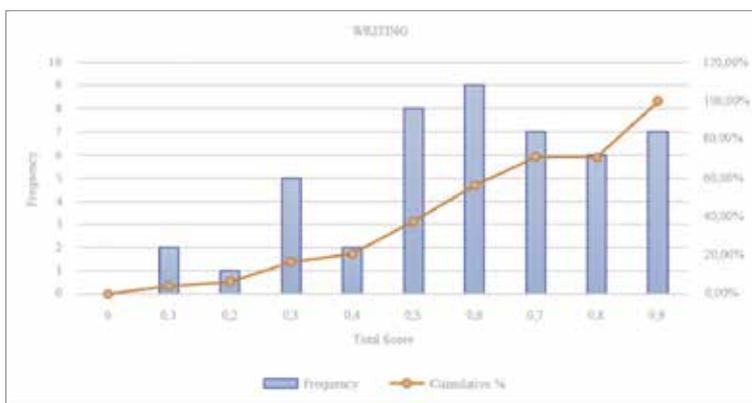

Figure 3*: Histogram of writing results*

The histogram and cumulative percentage analysis suggest that writing skills were generally strong among the students, with over 70% of students scoring between 0.4 and 0.7. The concentration of scores in the mid-range reflects intermediate proficiency, and the frequency of students scoring higher suggests that most students performed well in writing. However, a small proportion of students (around 20%) still scored below 0.3, indicating that some students struggled significantly with writing.

4.5. Results of global academic language results in the descriptive genre

The descriptive statistics of the overall test provide a comparison of the total results obtained by all students, with specific focus under the heading Descriptive Statistics of the Total Test and Skills, where items 3 and 4 present the outcomes related to the use of discourse functions measured through four targeted activities. These discourse functions were assessed based on their application across all test items using a 4-point scale:

1. Not Achieved category.
2. Inconsistent category.
3. Consistent category.
4. Achieved category.

Table 7. *Difficulty and discrimination indexes*

SKILLS	IF	R PBI
Listening	0,70	0,40
Grammar and Vocabulary	0,35	0,50
Writing	0,40	0,60

The difficulty indices show results of around 0.35 for items 2 and 3, indicating that the level experienced by the students was moderate and generally aligned with their competence, which is satisfactory from the perspective of the design of these items. As for item 1, it shows a value of 0.7, indicating that the difficulty encountered by the students was lower than that of items 2 and 3 in addressing this skill. Regarding item discrimination, we can observe that all three items exceed the value of 0.40, which is considered an optimal level of discrimination for the correct functioning of the items.

Table 8. *Reliability Statistics*

RELIABILITY	
alpha	0,7132
# of items	3

The reliability data also show that the questions generally designed for the three skills correctly measure the information for which they were designed. The Cronbach's alpha is around 0.7, which is considered reliable for a test, although it is true that the number of items is limited by the design of the test, in this case only 3 items, but with a significant depth of content.

Table 9. *Descriptive Statistics of the Test*

STATISTIC	GRAMMAR/VOCABULARY	WRITING	LISTENING	GRADE
Mean	0.4510204	0.6041667	0.734898	1.7422
Median	0.4	0.6	0.78	1.815
Mode	0.4	0.6	0.78	1.68
Variance	0.0335194	0.0478993	0.0196944	0.2412332
Standard Deviation	0.183083	0.2188591	0.1403367	0.4911549
Range	0.8	0.8	0.52	2.51

This report presents an analysis of the overall grade score, which combines the results of the grammar and vocabulary, writing and listening comprehension assessments. The aim is to assess overall academic performance and to highlight the distribution and variability across the student cohort. The overall grade score of 1.7422 suggests that, on average, students perform at a moderate level across all competencies. While listening is particularly strong, lower performance in grammar and vocabulary and writing contributes to a relatively moderate overall score. This suggests that while some students excel in listening, there is room for improvement in their writing skills. The median of 1.815 and the mode of 1.68 are both higher than the mean, indicating a slightly positive skew in the distribution of scores. This suggests that a proportion of students perform better than the average across the combined skills, with a concentration of students scoring above the mean but still below the upper limits of the scale. It highlights the presence of a group of students who are relatively more proficient in the skills assessed. The variance of 0.2412 and the standard deviation of 0.4911 indicate considerable variability in the grade scores. This high level of dispersion indicates a significant difference in student performance, with some students performing very well and others struggling, particularly in grammar, vocabulary and writing. This suggests that while a proportion of the class may be proficient in several areas, there is a significant gap in overall academic performance. The range of 2.51 for the grade score is the largest, further illustrating the wide variation in overall student performance. This wide range underlines the idea that while some students excel in all areas, others struggle in several skills, particularly in writing, grammar, and vocabulary.
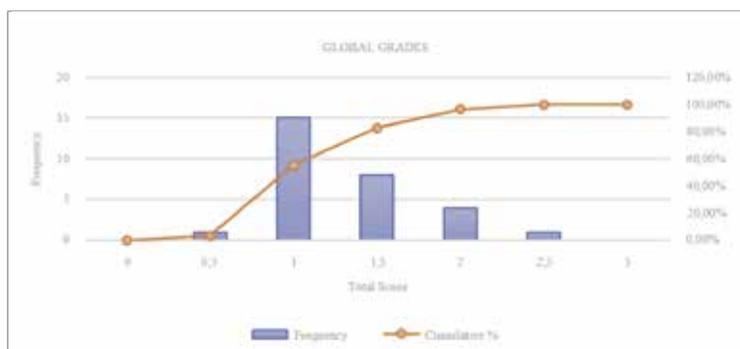
Figure 4: *Histogram of global academic language results*

The histogram shows a moderate distribution of student performance across grade levels. Based on the data, the majority of students fall in the lower to middle range of grade scores, indicating that most students are performing at a moderate level. This suggests that students have a basic understanding of the academic competencies but face challenges in achieving higher levels of performance. A smaller proportion of students score in the higher range, reflecting those who demonstrate strong performance in all competencies, particularly in listening comprehension. A minority of students score in the lower range, indicating significant difficulties in all competencies. These students struggle with basic language structures, which affects their ability to comprehend and articulate scientific concepts accurately; they may also face challenges in using scientific language effectively.

5. DISCUSSION

The role of language in knowledge construction and the relationship between language and thinking are central to its importance in all subjects (Beacco et al., 2015; Halliday, 2004). In this context, the findings of this research provide valuable insights into the complexities of analyzing the academic language competence of CLIL (Content and Language Integrated Learning) secondary students, with a particular focus on their ability to comprehend and produce target discourse functions in Physics-Chemistry. The implications of these findings in relation to the specific research objectives are significant. Each test result was analyzed and interpreted individually to address the different aims of the study. Subsequently, a comparative analysis explores students' mastery of the cognitive discourse elements and skills of the descriptive text genre and their impact on the students' ability to acquire and articulate disciplinary knowledge within this content area.

With regard to the first specific research aim, this study examined students' mastery of academic grammar and vocabulary, which are fundamental tools for understanding and articulating scientific concepts in Physics and Chemistry. The data presented in Figure 1 illustrate that a minority of students demonstrate a solid command of grammar and vocabulary, enabling them to choose precise words, construct complex sentence structures, and apply grammatical conventions effectively in academic contexts. These students are better able to engage with scientific concepts and communicate disciplinary knowledge with clarity and precision. However, the findings also indicate that many students face significant challenges in mastering grammar and vocabulary, as evidenced by their limited ability to apply syntactic rules, select appropriate words, and use academic vocabulary effectively in scientific contexts. These findings highlight the importance of implementing targeted interventions aimed at improving students' grammar and vocabulary skills. In this regard, Harmon and Wood (2018) emphasize that academic vocabulary is an essential element present in the language of any discipline, posing a significant challenge for all learners. This vocabulary plays a crucial role in both the acquisition of knowledge and the development of critical thinking within specific fields (Snow, 2010). To address these challenges, it is essential to adopt strategies such as contextualized vocabulary acquisition, explicit instruction in academic language conventions, and targeted support for grammatical accuracy. By strengthening these aspects of language proficiency, students will be better equipped to understand and articulate complex scientific concepts, ultimately improving their performance in CLIL-based learning environments.

The second specific research aim was to assess the development of students' listening skills, which are necessary for processing scientific information in these disciplines. This is crucial because, as Vandelanotte (2021) points out, the ability to understand spoken language in a foreign language is strongly linked to academic achievement in CLIL. The data depicted in Figure 2 provide an overall positive picture, with notable strengths and some weaknesses. A significant proportion of students demonstrate a high level of competence in listening comprehension, indicating their ability to comprehend spoken academic content effectively. These students show a solid grasp of the main ideas in audio material, enabling them to follow and summarize key points. In addition, a significant number of students demonstrate advanced listening skills, such as identifying specific details and making inferences, which reflect a deeper level of understanding (Ahmadi, 2016). However, a smaller proportion of students face significant challenges in listening comprehension. They struggle to process detailed information, which hinders their ability to fully engage with the scientific material.

Figure 3 illustrates the findings related to the third specific research objective, which examines students' proficiency in producing accurate, coherent, and discipline-specific written concepts in physics and chemistry. The analysis reveals a generally moderate level of performance, highlighting both strengths and areas for improvement. A significant portion of students demonstrates satisfactory writing proficiency, as they are typically able to express their ideas in a structured and coherent manner, demonstrating an adequate understanding of academic writing conventions (Hyland, 2004). These students can organize their thoughts clearly, resulting in written work that is logical and easy to follow. However, the data also reveal that a notable group of students continues to face challenges in effectively conveying their ideas, which hinders their ability to write clearly and purposefully. Common challenges include difficulties with basic grammar, sentence structure, and conceptual expression, leading to inconsistencies and a lack of clarity in their written work (Leki, 2007). This highlights the need for targeted interventions aimed at improving both writing mechanics and conceptual articulation.

Finally, the fourth objective centers on evaluating students' overall academic language proficiency in constructing meaning, specifically within the context of Physics and Chemistry. The findings shown in Figure 4 indicate that the majority of students perform at a moderate level, reflecting a foundational understanding of academic competencies, while also highlighting the challenges they face in reaching higher performance levels. Although listening emerges as the area of greatest strength, writing scores remain moderate, leaving room for improvement. In light of these results, targeted interventions should focus on enhancing basic grammar and vocabulary skills to ensure that all students are able to achieve higher levels of academic performance.

6. CONCLUSIONS

Academic language proficiency is crucial for fostering cognitive development and content comprehension (Coyle et al., 2021; Pavón, 2018). In line with these findings, this study investigates the relationship between academic language proficiency and content comprehension in a Content and Language Integrated Learning (CLIL) context in Porto, Portugal. The general aim is to assess students' academic language proficiency, with a particular focus on

the cognitive-discourse elements and functions typical of the descriptive text genre, and to analyze how these elements affect their ability to acquire and articulate disciplinary knowledge in Physics and Chemistry.

The results indicate that students with higher levels of Cognitive Academic Language Proficiency (CALP) demonstrate a deeper understanding of the content, while students with moderate CALP face challenges in achieving higher levels of performance. However, a small proportion of students experience significant difficulties in all areas assessed, particularly in grammar and vocabulary. These students struggle to master basic language structures, which affects their ability to understand and communicate scientific concepts accurately. Targeted educational interventions to improve these skills are essential to ensure that these students can achieve higher levels of competence in the subject. Building on previous research, Kampen et al. (2021) highlight the need for teachers to balance content and language goals, fostering critical thinking and global perspectives to overcome the challenges of teaching scientific vocabulary while ensuring student motivation and success.

As noted by Granados et al. (2023), language support, particularly in secondary education, is crucial to improving overall academic success. Teachers should prioritise the development of students' academic language skills as well as content knowledge. Furthermore, Fajardo Dack et al. (2020) highlight the need for continuous assessment and feedback in CLIL environments to improve both language skills and content understanding. Similarly, Raitbauer et al. (2018) emphasise the integration of cognitive and linguistic aspects to maximise the benefits of CLIL, suggesting the development of methodologies that combine academic language and disciplinary knowledge. It is necessary to emphasise the role of student interactions in fostering discipline-specific vocabulary, recommending a collaborative approach to support vocabulary learning (Rieder-Bünemann et al., 2022).

The findings of this study have important implications for bilingual education programmes. Educational authorities should consider investing in teacher training programmes that focus on the integration of language and content objectives, as well as providing resources for targeted language support, especially for students with lower CALP levels. In addition, materials should be designed to explicitly address the cognitive-discourse elements required for understanding and producing subject-specific knowledge in bilingual contexts.

In conclusion, this research reaffirms the importance of integrating language and content teaching in CLIL programmes and demonstrates the need for better teaching of technical vocabulary and grammatical structures in order to improve students' academic language skills in meaning construction in bilingual settings. Collaboration between educators, linguists and policy makers is essential to ensure that CLIL programmes reach their full potential in promoting both academic and linguistic development.

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