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A Model for the Integrated Study of Chemistry and English in the Bulgarian Secondary School

Synopsis

of a doctoral thesis for awarding the educational and scientific degree "doctor"

in a professional area – 1.3 Pedagogy of training in ...

(Teaching methodology in chemistry)

SUPERVISOR:

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The structure of the doctoral thesis reflects the logic of the conducted research: analysis of the theoretical concepts related to the topic; construction of a model for specialized teaching of Chemistry in English with the application of the CLIL methodology; conduct, analysis and interpretation of the results of the conducted training experiment. The dissertation has a total volume of 187 pages, and the content is structured as follows: an introduction, four chapters and a conclusion, followed by a list of references and appendices of 93 pages. The exhibition includes 36 tables and 26 figures. The cited literature includes 254 sources, of which 16 are in Cyrillic alphabet and 238 are in Latin alphabet.

The dissertation work has been discussed and heading for defense by the Departmental Council of the Department of Physical Chemistry (Educational and Scientific Laboratory of Chemical Education and History and Philosophy of Chemistry) of the Faculty of Chemistry and Pharmacy at the Sofia University "St. Kliment Ohridski". The departmental council was held on 29.01.2024 with protocol No. 1A. The defense of the dissertation work will be held on 31.05.2024. from 1 p.m. in the Conference Hall of the Faculty of Chemistry and Pharmacy at the Sofia University "St. Kliment Ohridski, 1 James Boucher Blvd. Defense materials are available to those interested in the Faculty of Chemistry and Pharmacy at the Sofia University "St. Kliment Ohridski", 1 James Boucher Blvd., room... .

CONTENT

INTRODUCTION

In response to the requirements of the dynamically expanding labour market for the competencies of potential workers, for instance: flexibility, speaking of foreign languages, creativity, organizational skills, health, environmental and cultural awareness, team-working etc., educational institutions are facing the problem of finding new approaches, methods and means to cultivate these skills in students.

On the other hand, globalization related to the mobility and migration of people, leads to the creation of dynamic multilingual and multicultural societies that needed members developed aforementioned competences. Among them, the need to master foreign languages and use them in different contexts stands out. This required rapid adaptation and corresponding changes in educational systems. This process also directly affects curricula and imposes the question "how should learners be prepared to meet the challenges of society and of rapidly growing labour market?"

One of the approaches used to acquire competences in this area is related to integrated learning of a second or additional language and of content other than language learning, known in educational practice as CLIL (Content and Language Integrated Learning).

According to the European Commission, Content and Language Integrated Learning (CLIL) is an educational approach where an additional language, for example a foreign, regional, minority, territorial or other national language, is used to enhance the simultaneous acquisition of both the subject and the language being studied (Eurydice 2006).

This dual focus is believed to propose a number of benefits to learners' language abilities, their motivation to learn, their active involvement in problem solving, increasing levels of concentration, metacognitive abilities, learning skills and autonomy, as well as promoting social awareness and intercultural understanding.

The idea of CLIL is well expressed by the following phrase: "using language to learn, learning to use language" (Marsh, 2000). In addition to learning the subject and the foreign language, this approach implies the use of programs that promote the formation of skills, and abilities in interpersonal communication, intercultural communication and intercultural understanding.

In Bulgaria, the CLIL approach has its history and it is related to the established practice in our educational system of teaching subjects through a foreign language in so called “language” schools. Its effective use, however, is related to a number of requirements aimed at adapting curricula; revision of the teaching methods and teaching materials; introduction of new approaches for evaluating the learning process and its results.

What has been said so far guides us in the direction of searching and building a relevant model of CLIL to be applied in the teaching of natural sciences, in particular in the teaching of Chemistry and environmental protection in English.

CHAPTER I. METHODOLOGICAL APPROACH AND DESIGN

This chapter outlines the relevance and significance of the research problem, the aim and the research questions, and the methods of data collection.

1.1. The research aim, objectives and the research questions of the dissertation

As already stated, CLIL is one of the current approaches in modern bilingual education. This approach makes it possible to develop and use a variety of learning strategies, apply innovative teaching methods and techniques, and increase motivation of learners. On the other hand, it provides an opportunity for learners to expand their intercultural knowledge and understanding, while improving their communication skills in a language other than their mother tongue.

As an educational approach based on the acquisition of competences, CLIL is extremely well accepted by educators in Europe and around the world. This sparked the author's research interest and determined the topic of the present dissertation.

The significance of the research is determined by the need to solve some problems in the educational system, namely:

• development of theory, methodology and state educational standards for integrated teaching of a general educational subject and a foreign language;

• the demand to include modern methods and means of training conducted in a foreign language;

• development of appropriate didactic materials corresponding to the current curricula,

• last but not least, the problem related to assessing the achievements of students in the conditions of learning a general education subject in a foreign language.

The specific characteristics of the CLIL approach make it a useful concept as a framework for understanding, analysing and improving the teaching and learning of Chemistry in English in the Bulgarian secondary school. These characteristics and the listed problems are the foundation of the reasons for choosing the research field and the basis for formulating **the main aim** of the research:

Development and experimental application of a theoretically grounded model of integrated teaching of chemistry and foreign (English) language (CLIL) curriculum content to ensure the formation of chemistry and foreign language knowledge and skills of students in language secondary schools, as well as to create interest to studying the subject of chemistry in English.

The research questions that arose are:

1. What are the existing practices for integration of content and language learning in our country and in other European countries?

2. Which theories underlie learning in a CLIL environment?

3. What components should the CLIL model include, according to the specifics of teaching natural sciences and chemistry in particular?

4. How can the CLIL model be applied to specific Chemistry curriculum?

5. What is the students' attitude towards the created CLIL-environment of learning Chemistry in English?

The research questions are broad in scope, allowing for the development of new and alternative explanations, both during the study and in future research.

The main objectives of the study derive from the formulated aim and research questions:

Theoretical objectives:

1. Description of the CLIL approach and its application in practice through analysis and interpretation of literary sources.

2. Determination of key components of the CLIL approach and the possibilities for its implementation in the Bulgarian secondary school through a comparative analysis of conceptual models and good pedagogical practices existing in the literature sources.

3. Building a model for CLIL application in accordance with analyzed legal educational documents for the 10th grade in Chemistry and environmental protection and in English language learning.

Practical objectives:

1. Selection of educational goals through analysis of legal educational documents (Chemistry and environmental protection curriculum and English curriculum for 10th grade).

2. Development of teaching materials and aids for informational and methodological provision of the constructed model.

3. Organization and implementation of a pedagogical experiment to verify the applicability and effectiveness of the proposed model.

4. Carrying out statistical processing of data from conducted tests, surveys and observations with 10th grade students and analysis of the results.

5. Revealing prospects for future research.

To realize the set aim and related research questions and objectives, the following research methods are provided:

Theoretical methods- analysis of literary sources on the research problem; analysis of normative documents (educational standards, curricula) and search for intersections between them, with an attempt to build a curriculum of an integral nature in chemistry and English for the 10th grade; pedagogical modeling - building a CLIL model and its specification for teaching chemistry in English, on the example of the section "Practical aspects of chemistry in the field of materials".

Empirical methods - survey - to determine the attitude of students to study chemistry in English; testing - for control and evaluation procedures of students' achievements; monitoring – for deeper analysis and tracking of student progress; statistical methods - for processing and verifying the reliability of the results obtained during the dissertation research.

The research was conducted in several stages:

1. Preliminary stage – analysis of documents (international and national), research and analysis of literary sources and the practical experience of teachers abroad and in Bulgaria; development of pedagogical experiment methods and guidelines, preliminary survey related to students' attitudes to studying chemistry in English;

2. Theoretical stage – selection and formulation of leading ideas, approaches and principles; development of structural components of the content; adapting a theoretical model; development of a CLIL-lesson planning matrix and teaching materials aligned with the Chemistry Teaching Model in English.

3. Experimental stage – approbation of the model in teaching Chemistry in English in secondary school to prove its applicability;

4. Concluding stage – collection, processing, analysis, interpretation and summary of the results of the pedagogical experiment and of the research as a whole, and formulation of conclusions.

The dissertation work is structured in four chapters:

Chapter one examines the research concept of the dissertation - aim, objectives, scope, relevance and significance, as well as the methods used to collect data.

The second chapter is presented the theoretical foundations of CLIL in terms of defining and outlining the main directions in which the approach is developed. Attention is drawn to the particularities of the methodology, as well as to the philosophical theories that underlie it. Some of the advantages and limitations of CLIL and its application in the natural sciences are also outlined.

The third chapter presents the results of a preliminary survey among 10^{th} grade students of 32 Secondary Language School "St. Kliment Ohridski" - Sofia, regarding their opinion on studying Chemistry in English. These results served to create a CLIL model tailored to the specifics of chemistry as a subject.

The specification of the developed model is described based on a thorough analysis of the Chemistry and environmental protection and English language curricula in the 10th grade - general education, with the aim of finding elements that would contribute to their integration. Also there, arguments are given for choosing the age group, the specific learning content to which the model is applied and a CLIL lesson planning matrix based on the proposed model is proposed. Didactic materials and types of tasks are presented - linguistic and on the considered chemical content, being tied to the components of the model, which are realized when solving them.

The fourth chapter examines the organization of the pedagogical experiment and the tools used. An analysis of the results obtained from the conducted pedagogical experiment is presented. Guidelines for further improvement of the developed model for the application of CLIL in the teaching of Chemistry in English in the Bulgarian secondary school are outlined. The main findings of the data analysis of the overall study are described in the concluding part of the dissertation.

CHAPTER II. CONTENT AND LANGUAGE INTEGRATED LEARNING (CLIL) – HISTORY, ESSENCE AND CHARACTERISTICS

II.1. History of CLIL

The European Union, uniting 28 countries at present, faces the reality of existing as a multilingual space. This is also the reason to look for appropriate educational approaches, methods and means to achieve multilingualism among the citizens of the community. Over the past 30+ years, a number of programs promoting foreign language learning and intercultural awareness have been launched, such as the Erasmus programs related to higher education, Grundtvig focused on adult education and the Lingua program dealing with the teaching and learning of European languages. They are only part of the Socrates program and were created with the aim of promoting and supporting the learning of foreign languages. In 2007, the Socrates program was replaced by the Lifelong Learning Programme, which continued until 2013. The Comenius Programme, on the other hand, focuses on primary and secondary education and focuses on organizing of visits abroad in order to promote the interest of the people in studying the culture and life, and hence the languages, of other nations of the community. It is part of the Erasmus+ program. This program, since its creation in 2013, combines all the programs listed above and several new ones.

Historically, the CLIL approach was proposed during workshops organized within the framework of the "learning languages for European citizenship" scheme held between 1983 and 1996 under the supervision of politicians from different countries, researchers and with the participation of teachers and learners (Coyle, 2007; Coyle, Hood & Marsh, 2010; Marsh, 2002). A group of language experts has been given a task to examine developing practices that integrate non-linguistic content with language learning in European schools (Coyle, 2002; Coyle et al., 2010; Eurydice, 2006; Marsh, 2002, 2008). As a result of their efforts, the CLIL methodology emerged (Eurydice, 2006). CLIL is receiving special attention in Europe. The idea of "teaching content through a foreign language" was published as an outcome of the Council of Europe's 12B workshop, held under the title "Learning and teaching general education subjects through a foreign language". Thus, the general term "content and language integrated learning" (Content and Language Integrated Learning) was introduced for the first time (European Council, 1995). Each country decides how to implement the approach by developing its own educational and language policy. This also explains the wide variety of "CLIL practices" in European countries. Some countries include a foreign language and a regional, minority or territorial language in addition to the state language, in others CLIL is provided in a foreign language and another state language. Finland is the only country where the CLIL approach is used to teach three types of language (foreign language, other state language and territorial language). In a third group of education systems, only one type of foreign language is used in the application of the CLIL approach, but there are also countries where CLIL is not applied et all. The application of CLIL in Bulgarian educational practice has not been fully researched. The research found publications on the topic in the field of higher education (Arnaudova, 2014; Pancheva & Antov, 2017) and secondary education (Danailov & Tafrova-Grigorova, 2014; Aleksieva, 2019). It should also be noted here the participation of the Bulgarian Stefka Kitanova, a Biology and Chemistry teacher in 164 Secondary Language School, who is part of David Marsh's team, which developed in the period 2004-2007 the CLIL matrix (The CLIL Quality Matrix), which is one of the variations of this approach applied by teachers in Europe (Marsh, 2007).

II.2. CLIL – definitions and peculiarities

The definitions of CLIL and the diverse interpretations of this approach in Europe show that it is understood in different ways by its proponents. In addition to being internally ambiguous, the term CLIL is

not clearly defined compared to other approaches that integrate foreign language and content teaching. The review of literature sources shows that there is a lack of consensus in scientific circles as to what CLIL actually is. Some authors (Wright & Boun, 2015) carefully avoid a precise definition, using the acronym as an independent concept. Others define CLIL as an umbrella term, mainly used in Europe, for bilingual or multilingual education, where a foreign language (L2) is used to learn a subject and where both language and content are learned with an emphasis on their integration (Baker, 2014). A similar opinion is expressed by Heras & Lasagabaster, according to whom CLIL is an approach in which an additional language is used to teach and learn subjects with a dual focus on language and content (Heras & Lasagabaster, 2015). According to Ioannou-Georgiou (2012), CLIL is a double-focused approach to learning and teaching, in which a general education subject is taught through a foreign language, with a double focus on subject knowledge and competence on the one hand, and on the other, knowledge acquisition and formation of foreign language skills. In general, CLIL is based on a competence-based approach to learning. Coyle, Hood & Marsh (2010) define CLIL as an educational approach that uses a variety of language-supporting methodologies, resulting in a dual-focused form of learning that pays attention to both language and content. They state that 'CLIL is not a new form of language learning, nor is it a new form of general education. It is an innovative fusion of the two' (Coyle et al., 2010). According to Cenoz (2015), integrated subject-language learning is the accepted term for the practice of combining the learning of academic content with the learning and use of an additional language. Coonan (2007) asserts that CLIL is an educational path, more or less long, characterized by strategic, structural methodological choices aimed at providing non-linguistic double integrated learning - language and non-linguistic content - by students who learn through a foreign language.

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II.3. Key components of CLIL – content and language

In CLIL, the very phrase 'content and language integration' refers to seeing language and content as separate entities in their own right. Focusing on the integration of these two components necessitates explaining what is actually meant by 'language' and 'content' in the context of teaching in a CLIL environment.

II.3.1. Defining "content"

The research carried out shows that according to a large part of the supporters of CLIL as an approach, the leading is the content. Coyle et al. (2010) argue that content is at the heart of CLIL and is what distinguishes it from existing approaches to language teaching. This is obviously different and new because academic content is not traditionally taught in a foreign language. Content, according to Wolff (2010), is identified with general education subjects or natural science disciplines. Barwell (2005) suggests using the term subject area rather than content, as the latter can be seen simply as a product of contextualised teacher-learner interaction. He also argued that if language is only a means of learning, not only is its status

reduced in integration, but also a rather false message may be conveyed, namely: language is devoid of content (Barwell, 2005). We support the view of researchers that one of the main pillars of integrated content and language learning is that languages are best learned through content that is meaningful to learners, i.e. in a context that meets the needs of learners. On the other hand, content is central to students' language and literacy development. It is also a way to improve communication skills that are acquired through purposeful communication (Snow, Met & Genesee, 1989; Cummins, 1983).

In this sense, practical activities offer unique opportunities to learn a language in an authentic environment. Thus, the study of natural sciences through laboratory experiments and development of projects in the target language includes the assimilation of knowledge about the world and its understanding, as well as the expansion of language competences.

II.3.2. Defining “language “

From the perspective of language and in the context of sociocultural theory, most researchers are adamant that language plays a functional role in CLIL because it serves as a means of learning a subject included in general education, i.e. language is seen as a vehicle for communication and for learning (Coyle et al., 2010; Cammarata, 2009). This view of language is linked to the concept of communicative competence (Hymes, 1972; Novotná, & Pípalová, 2008; Dalton-Puffer, 2009).

Here is the place to pay attention to the so-called language triptych proposed by Coyle (2007b). The triptych presents three interrelated aspects of language learning: *language of learning* includes the learning of key words and phrases necessary for mastering the content; *language for learning*, which focuses on the vocabulary students will need to complete classroom tasks, such as participating in a debate or organizing and presenting information. These two forms can be predicted and therefore planned. The third aspect of the language triptych is the language acquired through learning (*language trough learning*) and refers to the so-called unpredictable language learning occurring in the course of the cognitive process in which students are engaged and can neither be predicted nor planned in advance. Overall, the triptych can be seen as seminal in the integration between content and language. Here we also pay attention to the obligatory language for mastering a certain content, proposed by Cloud, Genesee & Hamayan (2000), namely: terminology of the subject, special expressions, the different meanings of words, syntactic features, language functions that prevail in a specific area of the lesson content (inform, determine, analyze, classify, predict, deduce, explain, justify, etc.). These five language features are necessary for students to gain knowledge, ask questions, explain with understanding, demonstrate language mastery, and prepare for further learning in the content area being studied an important point when considering foreign language acquisition in a CLIL setting is the role of the mother/native language (L1) in this process. The practice around the world, and in our country, shows that the moderate and structured use of the mother tongue in natural science classes, and in particular in chemistry classes taught in English, leads to a better assimilation of the educational content of the subject. This relieves the tension and provides students with the confidence they need to overcome the dual challenge of mastering the content of a subject like chemistry, for example, traditionally defined as 'difficult' and 'incomprehensible', and in a foreign language, which creates a serious cognitive challenge for them.

When asked whether CLIL is primarily content or language oriented, Coyle at al. (2010) respond that CLIL is not simply another step-in language teaching or a new development in the methodology of the general education subject studied in that language. They see CLIL as a fusion of the methodologies of the general education subject and of the language, leading to an innovation that is emerging as the education of modern times. They assert that CLIL is an approach which is neither language learning alone nor subject learning alone, but is an amalgam of both and is related to the process of convergence - the merging of elements that were previously fragmented (Coyle at al., 2010).

As already noted, the development of CLIL goes not from theory to practice, but rather from practice through the analysis of particular experiences, to theoretical generalizations. As a result, a number of researchers point out that the pace of practical application of CLIL is far ahead of the pace of theoretical conceptualization of this approach. However, this does not mean a complete absence of any theoretical basis.

Many CLIL researchers refer to Vygotsky's (1978, 1986) sociocultural theory, cognitive psychology and studies within bilingual education (Coyle et al., 2010; Dalton-Puffer, Nikula & Smit, 2010; Järvinen, 2007). A similar opinion is shared by Marsh & Frigols Martín (2013), who, taking into account the fact that the nature of CLIL is interdisciplinary because it is not based on a single evidence or theory, assert that several areas are applicable to the language component of the CLIL approach. As such, they point to the theories of second language acquisition, psycholinguistics and foreign language learning, and as for the pedagogical principles underlying CLIL, these are, according to them, the theories of constructivism and cognitivism. There are also researchers who consider CLIL in the light of postmodernism.

According to Dontzov (2017), it is possible to indicate six pedagogical theories that form the fundament of CLIL, regardless of the specific models of its application, namely: Sociocultural theory and Vygotsky's Zone of Proximal Development (1978, 1986), Bloom's Taxonomy, (Bloom, Anderson & Krathwohl, 2001), Multiple Intelligence Theory (Gardner, 1983), Common Core Competency Theory (Cummins, 2000) and Second (Foreign) Language Acquisition Theory (Krashen, 1981). Each of the theories mentioned by the author is related to the six characteristics of CLIL defined by Mehisto, Marsh & Frigols (2008), namely -*multimodal input, authenticity, active learning, safe learning environment), strategies supporting learning (scaffolding) and collaboration*. These characteristics, apart from being well connected to the theories, also provide a clear direction for the organization of learning in a CLIL environment. This is the reason why we present them briefly.

According to the authors, the concept of multimodality is associated with the integration of different learning subjects, the planning of learning through cross-curricular topics and projects, as well as different sources through which information is received. Authenticity refers to the use of authentic materials, cases and content during CLIL lessons. This means that teachers have the opportunity to look at specific aspects related to students' lives and interests, to use material on current topics from the media, to allow students to ask for help with the language when they need it. Active learning shows that students are placed at the center of the educational process and are responsible for their learning. In other words, students should be given greater opportunities to engage in classroom activities while teachers participate as facilitators.

In the field of active learning, it is the teacher who must provide students with more opportunities to communicate - written and spoken in the target language according to the content of the subject. A safe learning environment is associated with various strategies used to stimulate students' confidence in the actual application of language and its use in learning the specific learning content. It is done by using a variety of activities, building students' confidence to experiment with language and content, targeting access to authentic learning materials and environments, increasing students' language awareness, and more. Scaffolding refers to the various methods that teachers use to help students increase their level of perception and understanding of both language and content and improve their skills in order to achieve educational goals. Learning a subject in a foreign language is a difficult task and feedback in this case is important. Teachers provide the support learners need "to take the next step, not just get along comfortably." Finally, collaboration is defined as teachers' attempts to collaborate with other teachers, parents, the local community and other related stakeholders to effectively design and deliver their CLIL lessons (Mehisto et al., 2008).

The specified characteristics are the focus of the research in the dissertation work and are related to the main theories on which we emphasize - sociocultural theory and constructivism.

II.4.1. Sociocultural theory and CLIL

The importance of language for learning is the focus of Vygotsky's sociocultural theory. The idea put forward by its creator is that "every teacher of a specific subject (content) is also a language teacher" (Steinmüller & Scharnhorst, 1987). This understanding affirms the importance of the special role of the language used by the subject teacher, since content is always mediated through language.

Sociocultural theory views communication, reflection, and learning as related processes in knowledge construction and language development (Vygotsky, 1986; Bruner, 1978).

Language-content integration occurs when learners focus on language-focused conversation as well as content-focused conversation.

It is through these interrelationships that learners begin to engage in tasks that require more complex language emerging from the connections in the curriculum (Kong, 2009). Other authors note, however, that "language learning can be accidental and mistakes may never be corrected" (Pica, 2002). In turn, this can affect learners as they will learn new learning content without to receive language feedback and support, so it is imperative that both components of integration complement each other. It is quite natural to conclude that in order to make progress in the acquisition of both the learning content and the target language, students should receive adequate and timely support and feedback. In the learning process, the teacher is the one who temporarily helps learners while performing various tasks so that in the future they can become autonomous and work independently. Support can be in the form of asking questions, activating prior knowledge, creating a motivating context, encouraging participation, offering advice and feedback. It may also involve adapting materials to meet the needs of learners while promoting mental abilities of higher order students and engagement with cognitive content (Hall, 2010; Lyster & Ballinger, 2011). Here we also pay attention to another important aspect directed at the cognitive development of students, and it is related to Vygotsky's (1978, 1986) theory of the "zone of proximal development". He views cognitive development and knowledge acquisition as a social construct that develops with social cooperation and argues that full-fledged cognitive development depends precisely on the "zone of proximal development" (ZPD), where people construct new knowledge through social interaction. According to him, the skills an individual acquires through cooperation with others go beyond what the individual can achieve alone. In the process of cooperation, language is used to regulate the cognitive activities of the individual on the one hand and, on the other, to respond to the demands of social interaction. During this social interaction, language has a dual function: it is used as a "thinking tool" to regulate internal cognitive processes and a "learning tool" in order to acquire information and skills (Vygotsky, 1986).

II.4.2. CLIL in the light of constructivist ideas

Constructivism is based on the already mentioned sociocultural theory of learning and understands learning as a process in which individuals construct new ideas or concepts, building on their previous knowledge and/or experience.

One of the principles of CLIL is related to the development of knowledge, which is why cognitive constructivist theory plays an important role in it. The idea of considering CLIL as a type of constructivist learning is based on the assumption that its methodology requires the active construction of one's own knowledge and personal meanings for the learner (Wang, 2011).

As practice shows, lessons with CLIL application usually contain situations or tasks with different types of cognitive challenges, in which the active participation of students is required. The emphasis shifts from the teacher to the learners, who are given the opportunity to reach the new knowledge themselves. Here again we draw attention to the main characteristic of CLIL - participation of learners in constant social

interaction in the form of discussions or exchange of ideas through cooperation or teamwork, which increases the benefits of learning in a CLIL environment.

Bruner (1986), drawing on the work of Vygotsky, advanced the idea of discovery learning. Learning is therefore an active process and requires active learners who learn by doing. For Bruner and others of his followers, the concept of applying strategies to support learning (scaffolding) is extremely important within the process of active learning. It is the support given to the learner to help him perform activities and solve problems. This support is gradually withdrawn so that learners can eventually become independent (Bruner, 1986).

Teachers, familiar with constructivist approaches to learning, provide students, taught in a CLIL environment, with strategies that support their autonomous learning. Therefore, a good CLIL teacher in their practice pays attention to creating a stimulating learning environment that enables the realization of positive emotional state of learners (Jensen, 2005).

Along with what has been said, here we also pay attention to the possibilities of project-based learning as an effective strategy for the application of CLIL and one of the manifestations of constructivism.

We see it as an excellent opportunity to integrate learning content and a foreign language, as well as an opportunity to develop key competencies by engaging students in activities related to exploring their own lives and the surroundings.

Participation in projects developed in the target language, according to Lauder (2008), contributes to:

• integration of language and skills;

• the use of functional language dictated by the topic being researched or studied;

• providing opportunities for students to use a foreign language outside the boundaries of the language class.

• providing a variety of stimuli aimed at different learning styles, learners and levels (Lauder, 2008).

It is obvious that CLIL has the potential to develop learners' autonomy by constructing their own knowledge, by applying a wide range of techniques, which fully fits the ideas of constructivism.

Overall, the study shows the complex nature of CLIL and the range of varieties under which it is applied. The theories, the basic principles that are found in it are also diverse. All this points to its multi-layered nature, which of course makes it difficult to create a unified theory that reflects its specific characteristics.

II.5. Advantages and limitations of CLIL methodology

A significant body of research on CLIL points to a number of its benefits. Some of the researchers found greater student motivation in the learning process (Pavesi, Bertocchi, Hofmanová, & Kasianka, 2001; Scot & Beadle, 2014), according to others, students taught while using this approach, reach higher language competence (Coyle, 2010; Marsh, 2008). Research focusing on teachers indicates more opportunities for their professional development and better collaboration among them (Clegg, 2007; Dalton-Puffer, 2007; Vasquez, 2010). There are also studies that find greater involvement of parents in their children's education (Naves, 2009; Jeynes, 2005). Multiple benefits of learning in a CLIL environment are related to a more fluent use of language and acquiring a wider vocabulary, as well as reaching higher levels of motivation. It is believed that spending the necessary time in a foreign language class would lead to increased language competence (Coyle, 2006; Marsh, 2012; Juan Garau & Salazar Noguera, 2015).

Researchers of the CLIL approach point out the following advantages:

• development of both - lower and higher order thinking skills, according to Bloom's taxonomy;

• building of intercultural knowledge, understanding and communication skills;

• improvement of language competences and fluency in verbal communication;

• development of intercultural interests and relationships;

• provision of an opportunity to study the subject/content from a different perspective;

• provides learners with a longer exposure to the language by using a variety of methods and forms of learning activity (Wolff, 2002; Dalton-Puffer & Smit, 2007; Dalton-Puffer, 2011, etc.).

The aforementioned authors consider, however, that the lack of didactic and informational materials and the increased workload of teachers and learners related to the implementation of the approach are its two main disadvantages.

As a disadvantage of the approach, researchers point to the risk that the educational standards of the studied subject will be lowered due to the students' poor command of the foreign language (Escobar Urmeneta & Evnytskaya, 2013); in turn, teachers may be underprepared to teach in CLIL programmes, usually due to insufficient use of the foreign language (L2). The lack of clearly set goals and objectives also exposes problems to the full implementation of CLIL, which requires a greater commitment on the part of national education systems in Europe (Dalton-Puffer, 2011).

Other limitations of the methodology identified by the researchers relate to:

• the prohibition or excessive use of the mother tongue (L1) in the CLIL classroom;

• misunderstanding of the learning content by the students, because the teacher speaks mainly in the foreign language (L2);

• using mainly the native language (L1) by the teacher or using only translation as practically the only strategy to be understood;

• unbalanced integration of content and language;

• insufficiently well-planned strategies to deal with the special challenges usually encountered in learning in a CLIL environment;

• the strategies chosen for teaching the foreign language are inappropriate for a CLIL environment, such as following traditional methods of teaching foreign languages;

• insufficient planning and minimal use of the target language;

• the lack of synchronization between the used program, the learning skills and the personal characteristics of a large part of the students;

• poor cooperation between teachers of the subject studied in a foreign language and teachers of a foreign language in the planning of teaching units in CLIL, as well as in the assessment of language skills in cases of joint teaching in a CLIL environment; (Coyle et al., 2010; Marsh, 2012; Dalton-Puffer, 2011; Escobar Urmeneta & Evnytskaya, 2013).

Last but not least, the insufficient information provided to parents about learning, which in most cases leads to unrealistic expectations regarding the results of language learning, also arises as a problem.

Obviously, the approach provides great opportunities and can largely satisfy modern pedagogical demands compared to traditional teaching methods, but there are also serious challenges that must be overcome.

After reviewing the official legal study documentation in our country, the following limitations stood out:

• there is no legally guaranteed methodology for teaching a subject in a foreign language;

• lack of curricula for integrated subject and language teaching;

• there is not a sufficient number of trained teachers for general education subjects who have the necessary level of language proficiency - the purpose of which the training is conducted.

• there is a lack of specially developed materials reflecting the specificity of the dual focus of integrated subject and language teaching, which leads to an additional burden on teachers, to develop or search for appropriate materials themselves, and from there to low motivation for applying the approach on their part .

• the issue of assessment also comes to the fore – is content or language or both being assessed? There are no integrated State Education Standards (SES) for assessment when learning takes place in a CLIL environment.

Based on the review of literature related to the CLIL approach, we agree with the view of Cenoz, Genesee & Gorter (2013), who assert that it is time for CLIL scholars to "move from praise to a critical empirical study of CLIL in its diverse forms to better identify its strengths and weaknesses in different learning contexts.

II. 6. Natural sciences and CLIL

Science education has an important role to play in today's technology-oriented society. The scale of technology these days places demands on educational systems to build scientifically literate citizens. Science has its own language, terminology, meanings, the mastery of which represents a serious cognitive challenge. A scientifically literate person must understand and integrate scientific information, engage with, and make responsible decisions related to socially relevant scientific issues (Holbrook & Rannikmae, 2009; Hurd, 1998; Martins, 2014).

Tafrova-Grigorova (2013) states that: "A scientifically literate person is able to assess the benefit or risk of one or another scientific achievement, so there is every reason to hope that science literacy education will lead to an increase in trust in scientists , in science and its applications" and more "... in natural science literacy, the connection: science - technology - society is manifested in the sense of awareness that the development of science is a prerequisite for technological progress, which, in turn, is a prerequisite for the well-being of society" (Tafrova-Grigorova, 2013). According to other authors, science is part of modern culture and represents a way of thinking and understanding the world. The main obstacle in learning the sciences, according to a number of scholars, is the need to master the academic language they deal with, which is like learning a new language for learners (Wellington & Osborne, 2001).

When teaching in a CLIL environment, teachers can provide conditions for English to be used 'naturalistically' and studied during science lessons. Quite naturally in the science curriculum, literacy activities such as speaking, reading, writing and doing can also be emphasized (Pearson, Moje & Greenleaf, 2010). In this regard, some authors express the opinion that the science teacher is also a teacher of language(s), and that the teaching of these language skills should not actually be the sole responsibility of language teachers (Wellington & Osborne, 2001; Sanmartí, 2007). Other researchers have argued that when a science teacher is teaching using the CLIL approach, the degree to which the science teacher has command of the language depends on how well he can present the content accessible to the students. On the other hand, the use of this approach contributes to reducing the lecture type of teaching. This necessitates the need for general education teachers taught using CLIL to be engaged in a constant process of rethinking the way they teach, questioning their own strategies and methodology and thereby facilitating science learning and student performance in these disciplines (Blanchard, Masserot & Holbrook, 2014; Grandinetti, Langellotti & Ting, 2013).

On the other hand, we must point out that the command of foreign languages, although to a different degree, is also of utmost importance for people participating in scientific and general discussions. It is a fact that English is the language of the scientific community, and in this sense, understanding the role of language in science teaching and learning is important. Reflecting the language requirements of CLIL in science learning and the teaching practices associated with the application of this methodology can certainly improve teacher learning and prepare them to take on the challenge of this change. And as Duit (2007) concludes, this may also mean moving CLIL research into one of the largest areas of research - the teaching and learning of science.

Chapter Two Summaries

The review of the studied literature regarding the emergence, definitions, essence, distribution, features and philosophical theories at the basis of CLIL, give reason to draw the following conclusions:

• There are many definitions of CLIL, from the narrowly specialized to the very general. They all come together around the notion that CLIL is a dual-focused approach – both on subject content and language acquisition through content. It is an extremely flexible approach, existing in various forms and models around the world in accordance with the socio-political, economic and educational needs of the particular region.

• CLIL does not have a well-established methodology and attempts to define it have mainly resorted to theories of SLA (Second Language Acquisition Theory), socio-cultural theory and in particular communicative competence theory, educational and cognitive psychology, constructivism and studies within bilingual education and the influence of postmodernism. In this sense, the creation of a unified theory, taking into account the particularities of CLIL, is imperative.

• The pace at which the processes of globalization and technologization are developing these days impose requirements on the educational systems to contribute to the construction of scientifically literate individuals who are fluent in their native language and several foreign languages. The CLIL approach applied to the acquisition of natural sciences in a language foreign to the learners can adequately meet these requirements.

• The practice with the application of CLIL in our country (in particular in natural science education) has not been well researched, despite the over a hundred-year history of bilingual education in Bulgaria. For this purpose, it is necessary to develop a suitable model for the implementation of CLIL, taking into account the peculiarities of teaching and assessing the acquired competences, both in the field of natural sciences and in the foreign language.

• There is an imperative to broaden the scope of research, which is currently mainly focused on foreign language acquisition (mainly English) through the application of CLIL and targeting it to subject areas such as natural and social sciences.

CHAPTER III. DEVELOPMENT AND CONCRETIZATION OF A STRUCTURAL-FUNCTIONAL MODEL FOR IMPLEMENTATION OF INTEGRATED STUDY OF CHEMISTRY AND FOREIGN LANGUAGE IN THE BULGARIAN SECONDARY SCHOOL

Based on the reviewed models and practices of CLIL implementation, this part of the doctoral thesis presents an adapted model for integrating content and language in the teaching of Chemistry in English, including the following components: Content, Cognition, Communication (Communication), Cultural awareness (Culture), Key Competencies (key Competencies) and Collaboration (Collaboration), which, in our opinion, takes into account the specifics of teaching Chemistry in English.

The individual components of the model and the prospects for its implementation on a specific educational content "Practical aspects of chemistry in the field of materials" are described, based on the current curricula in Chemistry and environmental protection and in English for the 10th grade. An idea is proposed to integrate the outcomes of the two programs on the section under consideration, ensuring the realization of the dual objectives of the CLIL approach. On this basis, a CLIL lesson planning matrix is proposed and the features of each of its stages are discussed. Materials for learning in a CLIL environment are offered, as well as tools for evaluation and self-assessment of students' progress in the subjec area and in the foreign language comprehension.

III.1. Fundamentals for developing a model for integrated chemistry and foreign language learning based on the results of a preliminary survey among 10th grade students.

In order to develop a suitable methodology for teaching Chemistry in English in the Bulgarian secondary school, a survey was organized during the academic year 2019/2020 to evaluate the opinion and attitude of 10th grade students towards the study of general education subjects in English and in particular the study of chemistry in English (appendix III.1 in the dissertation). 157 of 10th grade students participated in the survey in one of the largest schools in Bulgaria, 32. Secondary Language School "St. Kliment Ohridski", city of Sofia. The results of the survey were presented in articles published in scientific journals (Bianco & Andonova, 2020; Bianco, Andonova & Buhagiar, 2021). The conclusions drawn on the basis of the obtained results are important and point to ideas for the development of a suitable model for the integrated study of chemistry and English.

The results of the survey are clear indicators of students' inclination to study Chemistry in English. The study participants, however, explicitly emphasized that the desire to study Chemistry in English could be encouraged if more complex terminology and scientific concepts were first explained in their native language. In addition, they express a desire to include more practical exercises, projects, discussions on current problems in science, which is also connected with the importance of acquiring key competences laid down in legislation and the ever-increasing tendencies to promote STEM education.

Acknowledging students' opinions and responding to their needs can increase motivation to learn and improve their skills both in the foreign language and in the general education subject.

The CLIL approach provides opportunities to learn chemistry from different perspectives.

Bearing in mind the general definition of CLIL given at the beginning of this paper, the results of the research carried out and the specificity of chemistry as a subject, we propose the following working definition of CLIL: "Acquisition of key competences through the integration of chemical content and three-dimensional language - mother/native language (L1), foreign language (L2) and scientific terminology in English'.

We believe that this definition would adequately reflect the nature of the activity carried out in CLIL chemistry classes in English and would meet the educational needs of the students.

III.2. Model of integrated study of Chemistry and foreign language

Conceptual framework

Various models of CLIL have been described in the literature. One of the most popular used in educational practice is based on the 4C's framework presented by Professor Do Coyle from the University of Aberdeen, Scotland. (Coyle, 1999, 2005). The framework identifies the key components of CLIL as Content, Communication, Cognition and Culture. She positions the first three at the vertices of a triangle to illustrate their mutual influence, and the 'cultural awareness' component is seen as the background to all interactions (Fig. III.1) (adapted from Coyle, Hood & Marsh, 2010).

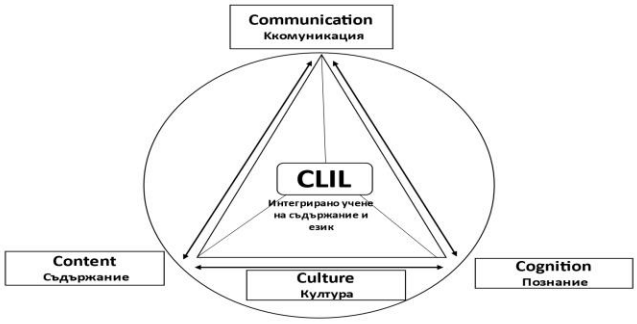

Figure III.1. Do Coyle's 4C's framework (adapted from Coyle, Hood & Marsh, 2010)

In accordance with the aim of the present study and the research questions, we consider this model as the basis of building a conceptual framework for the application of CLIL in learning natural sciences and in particular in the teaching of Chemistry in English, taking into account its peculiarities. In this regard, new components have been added - Collaboration and Key Competencies. Thus, the 4C's model is extended to 6C's. With the additions made, we believe that not only can different aspects of teaching Chemistry in English be covered, but also a full-fledged integral teaching will be realized, which is the aim of CLIL (Fig. III.2).

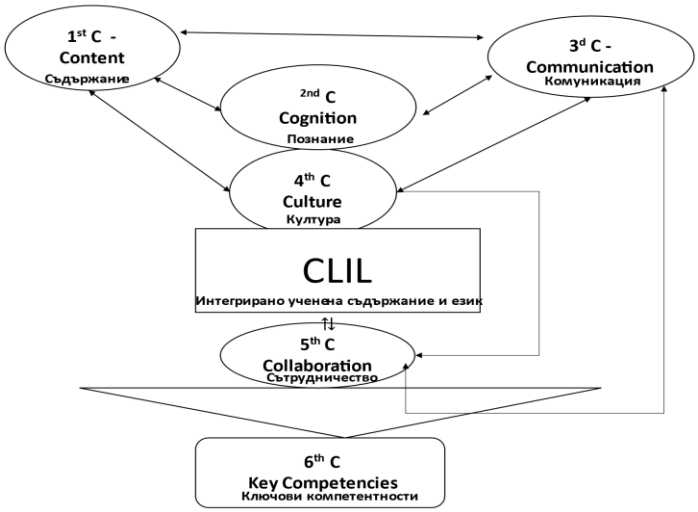

Figure III.2. 6C's model in teaching chemistry in English

In this part of the abstract, the individual components of the proposed model will be described, viewed through the prism of teaching Chemistry in English.

The **Content** is described as a system of specific educational objectives, and these should be achieved as final outcomes. The structuring of these aims is carried out along the main content lines of the subject, based on the modern taxonomy in three groups: basic knowledge (facts, concepts, laws, regularities, theories, methods of knowledge); typical cognitive and specific practical skills; relations (related to the protection of the environment, one's own health, the health of others, etc.). For each main content line, these three components of the learning content are defined and presented in a system - interconnected and parallel. This is also the approach facilitating the formation of key competences. This component is directly linked to the curriculum requirements. Here we pay special attention to the need to include the language (mother/native - L1 and English - L2) related to clarifying chemistry-specific terminology.

The relationship between content and **Cognition** is explicit. Skill formation takes place through relevant content. Cognitive abilities refer to developing thinking skills, which are classified in ascending order in Bloom's (1956) taxonomy. There are six main categories classified into two main blocks, Lower Order Thinking Skills (LOTS) - Reproduction, Comprehension, Application to Higher Order Thinking Skills (HOTS) - Analysis, Synthesis, Creativity. The updated taxonomy of Anderson & Krathwohl (2001) should also be mentioned. A new element in this version of the taxonomy is the connection of the separate categories of skills with the different dimensions and aspects of knowledge: factual, conceptual (notions, ideas, theories), procedural (actions) and metacognitive (use of different cognitive strategies and organization of one's own learning and self-knowledge, which includes self-observation, self-control, self-evaluation) (Anderson & Krathwohl, 2001).

In Chemistry education, these skills are developed by solving appropriate tasks by students, working with texts, graphs, tables, experiments, problem solving, information exchange, communication and others. We pay special attention to the formation of critical thinking skills, in order to increase the autonomy and responsibility of learners for their own learning. Of course, these are only some of the essential lifelong developed skills.

The next component of the model is **Communication.** The main goal of learning related to learning a foreign language or carried out in a foreign language is to form communicative competence, that is, to develop the ability and desire to carry out personal and cultural communication with others. Communicative competence is not a character trait or an innate quality. It is formed in the long process of communication. Therefore, the main task of the teacher is to create such a model of real communication that can trigger the internal motivation of students to interact with their classmates and with the teacher in authentic communication situations.

To implement this component of the framework, the teacher creates an atmosphere of acceptance and safety in which students feel free to express themselves without fear of making mistakes, encouraging them to take responsibility for their learning, empowering them to participate in goal setting, and the planning of activities. This is of particular importance for learning in a CLIL environment, where the focus is both on the acquisition of specific scientific terminology and the foreign language in which, it is taught. Therefore, the language used in lessons that follow this approach must be related to the learning context and through this language the learning takes place.

The objectives of CLIL, in this sense, are to enable learners to improve their competence in the target language and to develop oral communication skills in both foreign and native languages. For this to happen, the target language must be clear, accessible and relevant to the curricula for the relevant grade level. Another aspect related to the role of language in CLIL, which is also present in contexts based on language learning, are the major four skills that need to be developed, i.e.

- Oral comprehension (listening): comprehension of oral meaningful a input of information;
- Written comprehension (reading): comprehension of authentic texts adapted to the learners' levels;

• Oral production/expression (speaking): oral communication using correct structures and specific terminology;

• Written production/expression (writing): communicating in written form using appropriate specific vocabulary and structures.

In teaching and learning in a CLIL environment, this is done using the already mentioned language triptych of Coyle et al. (2010) (Fig. III.3), i.e.:

Language of learning is the language, which is used, when students are introduced to the content and the relevant terminology, as well as necessary skills related to the relevant lesson unit;

Language for learning is the language that is used in a CLIL environment. This is the language used in the classroom both in terms of content and in terms of interaction between participants in the educational process;

Language trough learning - this is the language that supports and improves the processes of thinking of the students while acquiring new knowledge. It is based on the principle that effective learning cannot take place without the active involvement of language and thinking (Coyle et al., 2010).

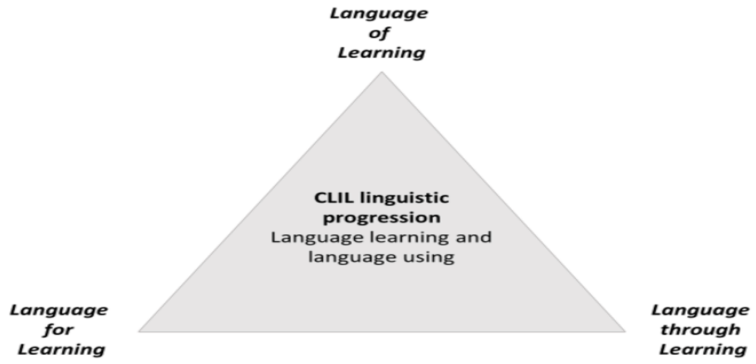

Figure III .3. Language Triptych (Coyle, Hood & Marsh, 2010)

In the preliminary research that was conducted, students clearly indicated that they prefer complex concepts and concepts covered in English chemistry classes to be explained first in their native language (L1) and then in the target language (L2). This, according to them, facilitates the acquisition of subject content in a CLIL environment.

Evidence for the potential benefits of moderate use of the mother tongue (L1) can be found in research by a number of authors (Gonzalez & Berbero 2013; Alegría de la Colina & García Mayo, 2009; Storch & Wigglesworth, 2003; Storch & Aldosari, 2010). Our research also confirmed that the moderate and structured use of the mother tongue, during the English-taught chemistry classes, leads to better comprehension of the subject's content.

Regarding the acquisition and teaching of target language as well as scientific terminology and vocabulary, Wellington & Osborne (2001) argue that the science teacher is essentially also a language teacher, and that a major problem in science learning is the acquisition of the relevant scientific language, which in its nature is equivalent, according to the authors, to learning a new language. Other authors, argue that the science curriculum can reinforce literacy activities such as speaking, reading, writing and doing, and teaching these skills is not only the responsibility of language teachers (Pearson, Moje & Greenleaf, 2010; Sanmartí 2007). Last but not least, it should be emphasized that the use of the foreign language, but also of the mother tongue, as well as of other languages by the learners, according to some authors, is "rather a resource than an obstacle, for the construction of knowledge' (Moore, Evnitskaya & Ramos-De Robles, 2018).

The formation of key competencies (Key Competencies) is the basis of modern education. The so-called key competences are knowledge, skills and attitudes that help learners achieve personal fulfilment in life.

They are enshrined in the main educational documents such as state educational standards and subject curricula and provide connectivity between the personal, social and professional expression of the modern person. This is also the reason why we consider them as one of the main components in our proposed model for the application of the CLIL methodology in the teaching of Chemistry in English in the Bulgarian secondary school.

The acquiring of specific key competences from students through Chemistry education can be considered in the following directions:

• knowledge of basic principles, laws, regularities and concepts in chemistry;

• readiness for scientific explanation of natural chemical processes and phenomena;

• ability to use information;

• skills for constructing apparatus and tools for conducting experiments;

• willingness to observe the rules for safe laboratory work;

• ability to perform observations, measurements and to register, analyze and present in a different form the results;

• ability to identify problems in the environment and to find solutions and prevent new problems;

• ability to research and select relevant information;

• digital competences - use of multimedia technologies in order to retrieve, evaluate, store, create, present and exchange information (Tzvetkov & Boiadjieva 2013).

It is extremely important, in our opinion, to pay attention to the active interaction between students in the process of acquiring knowledge and skills and forming relationships. That is why we also add the "collaboration" component to the framework we propose.

Collaborative learning, as a model of the cognitive social approach to teaching, aims to promote the overall development of the student both academically and in social and emotional aspects. In the classroom evolving towards inclusion, cooperative learning is seen as a method supporting learning that encourages interaction between students who differ in level of knowledge and skills formed, socio-ethnic and linguistic background, individual and special needs.

Research shows that educational experiences that are active, social, contextual, engaging, and student-driven lead to deeper learning. There are many examples of learning activities that ensure active and fruitful cooperation between students, in which emphasis is placed on the realization of social and communicative skills, as well as on mutual cooperation and the exchange of ideas.

For Chemistry education, we pay special attention to activities related to planning and organizing experiments, working in groups, discussing and presenting results; participation in projects - aimed at searching for sources, discovering and synthesizing useful information; sharing ideas and results in front of the class and class discussions.

The integration of content and language is seen as inseparable from cultural elements and cultural awareness (Culture) of students. CLIL aims to develop cultural understanding and awareness of the ideas that are embedded in the language of the studied content of a particular general education subject, which means "presenting alternative perspectives and shared understandings leading to a deeper awareness of otherness and self" (Coyle et al., 2010). In Chemistry classes, cultural awareness can be developed through:

• familiarizing students with the history of chemical discoveries, emergence and development of scientific theories, research methods and approaches used by prominent scientists;

• knowledge about the nature and ways of developing and enriching the chemical language;

• working in a group where everyone's ideas are approached with tolerance and respect, acceptance of different points of view during discussions and discussions;

• working in a safe environment in the chemical laboratory; responsibility for one's own health and the health of others;

• mutual evaluation of the knowledge and skills achieved in the training process, the so-called peer assessment and others.

The proposed 6C's model of CLIL and the balanced use of each "C" can contribute to building a comprehensive methodology, taking into account the content at both cognitive and linguistic levels. These components, considered in their unity, enriched the CLIL methodology with meaning.

III. 3. Specification of the theoretical model for the application of CLIL in the teaching of Chemistry in English in the Bulgarian secondary school when studying the unit "Practical aspects of chemistry in the field of materials" in the 10th grade

The concretization of the described 6C's model in the study of Chemistry and environmental protection is related to:

• selection of an **appropriate age group** of students where, in view of the psycho-physiological characteristics, such as the ability for in-depth processing of information, knowledge transfer, analysis, synthesis, creativity, etc., the CLIL methodology can be successfully applied;

• selection of an **appropriate educational content**, through which the requirements for achieving the double goal of the CLIL methodology -absorption of both the chemistry content in the unit and the foreign language will be realized at once;

• setting **the learning objectives** of the Chemistry curriculum (10th grade) for the unit "Practical aspects of chemistry in the field of materials" and on the other hand – to look for their intersection with the expected results of the English language curriculum for 10th grade.

• development of appropriate **methodological materials** for the study, in accordance with the requirements of the 6C's model;

• proposal of guidelines related to organization, management and fulfilment of the research, considering peculiarities of the 6C's model.

III.3.1. Selection of age group of students.

The present study was conducted with 10th grade students. They are at the end of the first stage of their secondary education and the development of their cognitive skills allows their inclusion in activities requiring the application of higher order thinking skills according to Bloom's taxonomy. With regard to the personal development of students of this age group, there is an increased desire for autonomy and independence, which implies the organizational skills developed to a greater extend. Moreover, they have abilities for more complex independent work with different sources of both the mother tongue and the target language. Those abilities have been mastered at a relatively good level at this age and allows the upgrading of specific vocabulary relating to different areas of human knowledge such as mathematics, natural and social sciences. Other essential features of this age are autonomy, self-assertion, self-management etc. (Silgijian, 1978).

These traits are associated with the students' desire to be seen as adults, with development of self-respect and increasing of their own dignity. Working in a team, providing an opportunity for self-management of the group and at the same time giving an opportunity for personal expression of the abilities, knowledge and skills of each of its members, contributes to their self-affirmation. Another benefit of working in a team is the formation of civic and cultural awareness, through mutual assistance and education in tolerance and respect for other people's opinion, culture and view-points. The leadership qualities of the team members, the ability to self-manage and delegate rights, presentation, searching for information from quality sources, debating and other socially significant skills can be demonstrated here.

III.3.2. Selection of learning content

For the purposes of the study, we focused on the section "Practical aspects of chemistry in the field of materials" of the curriculum of chemistry for 10^{th} grade. We believe that this is the content via which, a sufficiently good integration of the subject and the language can be achieved, according to the proposed model in all its components, through the selection of appropriate cognitive tasks, methods and means.

The reasons for the choice made are as follows:

• the subject content provides: upgrading of knowledge related to the structure and properties of substances widely used in practice; building scientific supports for revealing cause-and-effect relation; explaining natural phenomena at different levels; mastering methods and approaches for independent educational and cognitive activity for studying and researching objects and phenomena, for setting and solving tasks and problems, formulating and checking hypotheses, making analyses, conclusions, summaries and forecasts;

• the learning content implies: formation of abilities to apply relevant knowledge and skills to solve practical tasks and problems; for selection and transfer of knowledge in other related scientific fields; selection of strategies and organization for the implementation of decisions, analysis and evaluation of the achieved results, organizing and conducting discussions, argumentation; preparation for decision-making on global problems of our time.

• the educational content implies and directs the formation of a value system for chemical, ecological and, in principle, natural science knowledge, for its achievements and applications such as: formation of a critical attitude towards the role and importance of chemistry for building the modern natural science picture of the world, determining one's own view of alternatives, formation of attitudes towards certain views, assessments, opinions and ideas.

Another essential aspect of teaching Chemistry in English is the mastery of the necessary language elements and constructions through which students can express what they have learned about the subject. Here is the role of applying the CLIL methodology.

As already mentioned, the integration of a subject and a foreign language is not simply bringing the two subjects together, such as simply exposing the studied content to the foreign language, but finding interpenetrating connections between them.

Some of the possible levels of integration in the study of Chemistry in English are the following:

• work with chemical terms;

• composing simple and complex, as well as complex-compound sentences;

• composing a text with chemical content in a foreign language;

• a discussion on chemical content conducted in a foreign language;

• perception and processing of information in the foreign language through the auditory and visual analyzer (receiving oral instructions, reading texts, questions, instructions, watching video fragments, demonstrations accompanied by explanations in the target language, and others);

• implementation of project activity with intensive use of the foreign language;

• composing and solving tasks formulated in a foreign language.

The described levels of integration are widely represented in the lessons of the selected learning content with the application of the CLIL approach and are reflected in their planning.

Key competencies are also an important component in the proposed 6C's model. In addition to the already described competences related to natural science education, those provided for in the European Qualification Framework are also included here. In line with CLIL, we pay attention to the key competence of communicating in foreign languages.

III.3.3. Integrating content and language through the chemistry and environmental and English curricula.

Based on a detailed analysis of the Chemistry and environmental protection and English curricula for the 10th grade, intersections were found and, on this ground, the competencies were derived, in the form of outcomes at the curriculum level. Topics- "The world around me", "Health and a healthy lifestyle" and "Nature and ecology" in the English curriculum are the areas where we found a relation with the Chemistry and environmental protection curriculum for the section "Practical aspects of chemistry in the field of the materials" (appendix III.2 of the dissertation).

Viewed in the light of the 6C's model, the Chemistry and English curricula focus on improving students' skills in accordance with Bloom's taxonomy (Cognition) and creating conditions for teamwork and project work (Collaboration). . This gives each student the opportunity to assess their personal qualities and engage in a specific activity; to express and defend an opinion on an educational and scientific problem, while demonstrating openness and tolerance to the opinions of their classmates (Culture). In this regard, activities for research, analysis, systematization and presentation of information from various sources are foreseen. This allows not only the formation of knowledge transfer skills in other fields (biology, physics, geography, mathematics, information technology), but also communication skills in native and English, enriched with the relevant chemical terminology (Cognition, Communication).

All this contributes to the formation of the competences in natural sciences, foreign language and native language, as well as the skills for learning, cooperation, cultural awareness and the formation of skills for leading a healthy lifestyle (Key Competencies).

The described characteristics of our proposed 6C's model of CLIL, the peculiarities of the educational content and the attempt to integrate the expected results laid down in the curricula of Chemistry and environmental protection and English language, gave us the reason to propose a structure of the CLIL lesson.

III.4. Structure of the CLIL lesson

The structure of a CLIL lesson differs from the structure of an ordinary lesson. In CLIL lesson planning, apart from the content and language objectives, the set of activities to achieve the objectives, the balance between language and content, the assessment tools, the dual focus of CLIL and the developed 6C's conceptual framework, should be carefully considered.

A CLIL lesson, according to Darn (2009), has the following characteristics:

• integration of language and receptive (listening and reading) and productive (speaking and writing) skills;

•lessons are usually based on reading or listening to texts/excerpts;

• the language focus in the lesson does not imply a structural upgrade;

• the language is functional and is determined by the context of the subject;

• language is approached lexically rather than grammatically;

• the learning style of the learners is taken into account when structuring the types of tasks.

All four language skills as defined in the European Framework of Reference for Languages should be combined in the lesson as reflected in the Year 10th English curriculum.

In view of the extreme importance of the planning process, we offer a matrix for lesson planning, consistent with the features of the CLIL methodology and the presented 6C's model.

The basis of the matrix is proposed by Dr. Concha Julian-de-Vega University of Huelva/University Pablo de Olavide CLIL plan - a lesson that is adapted to the 6C's model we developed (Table III.1).As can be seen from the table, along with the main attributes of the curriculum such as topic, duration, class, materials used, taking into account the dual focus of the CLIL methodology, the framework aims to determine the language level of the students, the percentage of use of the native language L1 vs. use of the foreign language L2 in the particular lesson. Also, teacher can underline which of the language skills are represented - reading, listening, writing or speaking. Along with this, teacher have a space to formulate the objectives both in terms of chemistry content and purely linguistic ones for the particular lesson. The outcomes also serve as criteria for evaluating the achievements of the students in fulfilling the set goals. The language content is also described in details in the rubrics corresponding to the language triptych **-** ***language for learning, language of learning and language through learning.***

This part of the lesson plan corresponds to the **Content** and **Communication** components of the 6C's framework for planning CLIL lessons. The **Cognition** component is represented in the part where the main levels of Bloom's taxonomy are indicated and space is provided to relate the tasks used in the lesson to each of the cognitive levels in the scale. Columns are provided for determining the strategies for teamwork (**Cooperation**), as well as for indicating the key competencies (**Key Competencies),** which are set for improvement through the tasks and strategies used in the lesson. A separate column is provided for the component **Cultural awareness**, where the aspects in the lesson contributing to the development of students' intercultural awareness and the contribution of science to the development of human society are displayed.

In Methodology part is given a detailed description of the individual phases of the lesson - preparatory, actual and final with the relevant materials - worksheets, video fragments, teaching aids and those for experiments, means of control and evaluation of knowledge and skills. The Outcomes column is designed for reflection on the application of the detailed plan and identifying new strategies for its implementation if necessary.

Based on the therefore proposed matrix and the 6C's framework, detailed plans of different types of CLIL lessons - for new knowledge, a laboratory lesson and a lesson for revision from the section "Practical aspects of chemistry in the field of materials" have been developed. (Appendix III.3 of the dissertation).

Table III .1. Adapted matrix for CLIL lesson planning based on a 6C's model.

<table>
<tr><td colspan="2">Teacher</td><td colspan="2">Institution</td></tr>
<tr><td>Subject: Chemistry
6 C's model of CLIL lesson</td><td>Year:</td><td>Students' age:</td><td>Timing/ number of sessions</td></tr>
<tr><td>Module:</td><td>Language level:</td><td colspan="2">L1 / L2 ratio: 30:70 □ 50:50 □</td></tr>
<tr><td>Topic:</td><td colspan="3">Resources and materials:
□ video fragments □ worksheet □ practical activities/lab equipment □ students' book
□ students' workbook □ dictionary □ other materials (specify)</td></tr>
<tr><td colspan="4">CONTENT</td></tr>
<tr><td>Teaching objectives</td><td colspan="3">Content objectives:
Based on the Chemistry curriculum for a specific grade and requirements for the topic discussed on the particular lesson</td></tr>
<tr><td colspan="4">COMMUNICATION</td></tr>
<tr><td colspan="4">Language objectives:

Based on the Language curriculum and requirements for the specific academic language needed for the topic discussed on that particular lesson.</td></tr>
<tr><td>Skills developed:</td><td colspan="3">□ Reading □ Writing □ Listening □ Speaking □ Interaction</td></tr>
<tr><td rowspan="3">Grammar and syntactic structures
Vocabulary
Pronunciation, intonation & fluency</td><td colspan="3">Language of learning
topic related terms (nouns, adjectives, verbs)</td></tr>
<tr><td>Language for learning
Grammar
The Present simple, The Present Continuous, The Present Perfect, The Future simple
The Zero conditional
The Passive voice
Comparatives and superlatives
Quantifiers – some, any, few, a few, little, a little
Language function
Compare and contrast
Identification
Classification
Analysing</td><td colspan="2">• language for following the teacher's classroom lectures on the subject content;
• language for discussing the subject contents;
• language for carrying out activities/ tasks relating to the subject content;
• language for questioning about the subject content;
• language for inquiring about activities / tasks relating to the subject content;
• language for questioning about or disagreeing on the correction of activities relating to the subject content;
• language for writing text on given topic
• language for creation and giving the oral presentation on topic discussed.</td></tr>
<tr><td colspan="3">Language through learning
• explaining processes: first, second, then, next, after that, finally, above, below, behind, beyond, across.
• expressing opinions: I think that, in my opinion, from my point of view,
I agree with you, I disagree with you, that's a good idea, you are right, you are wrong; It is suitable …
• giving instructions / feedback.</td></tr>
</table>

Learning outcomes/ Assessment criteria	Based on content and language objectives

COGNITION

Bloom's taxonomy							
Task N	**LOTS (Lower order thinking skills)**			**HOTS (Higher order thinking skills)**			
	knowledge	**comprehension**	**application**	**analysis**	**synthesis**	**evaluation**	**creativity**
	remembering	***understanding***	***applying***	***analysing***	***synthesizing***	***evaluate***	***creation***
1 **…**							

Scaffolding strategies

- Verbal scaffolding – use language to support students during instruction – prompts, questions, elaboration, paraphrasing, effective use of wait time, correct feedback techniques
- Procedural scaffolding – tools and resources to support students as they access learning
- Instructional scaffolding – graphic organizers, word walls, using visuals and imaginary, labeling visuals

Strategies for building collaboration. Teacher:

- Organize the students' activities;
- Set measurable goals distribute tasks ;
- Define and share team members goals;
- Keep groups an appropriate size;
- Model the behaviour and prize successful collaboration;
- Promote creativity and open communication;
- Share information and resources;

KEY COMPETENCIES

Communication in mother tongue
- Teacher explaining some difficult concepts or terms in L1

Communication in foreign languages
During the lesson students are:
-receiving and accepting teacher's instructions in L2,
-explaining the work done,
-working on tasks by looking for information in student's book, Internet, etc. via reading different texts; -writing to complete tasks watching video fragments listening teacher instructions and explanation or classmates' presentation in a foreign language;
-working in groups on some tasks;
-presenting or explaining results of work done;
-evaluating their own work or doing peer to peer assessment etc.

Mathematical and basic competencies in science and technology
Students develop those competencies via resolving tasks, given in their worksheets, discussing properties of copper and its compounds.

Digital competencies - searching for information in a digital bank.

Learning to learn
Students develop that competence by learning set of rules supporting the cognitive process; self-monitoring and exercising self-control when performing didactic tasks;

Social and civic competencies Collaboration via working on tasks; peer to peer assessment, presenting group tasks in front of classmates;			
CULTURAL AWARENESS			
Culture awareness and expression -Working in a group, studying content in a foreign language; learning about history and development of science, scientific discoveries etc.			
METHODOLOGY			
Lesson plan stages /activities		Materials	Time
1. Warming up	Brainstorming, Recap vocabulary and terminology	Tasks, Video, Graphs Tables, Schemas, Games etc.	5 min
2. Development	Detailed plan of the activities used in a lesson	Worksheet	60 min
3. Final and follow-up activities	Recapitulation of what have been learned/ acquired during the lesson	Tasks, games	5 min
4. Assessment	□ Formative assessment □ Summative assessment □ Self-assessment: What have I learned? □ Observation	Assessment rubrics Self-assessment grid Observation list	10 min
OUTCOMES			
Assumptions			
Anticipated problems and solutions			
Ideas /Improvements / Remarks			

The **selection of materials** that the teacher will use in the lesson should be in line with the CLIL characteristics already defined. The teacher must determine their purpose, review the content of the already studied material in Chemistry and choose methods, means and forms of organization of training adequate to the set goals, as well as predict the results of the overall activity. There is no doubt that the materials should be adapted to the actual level and interests of the students.

Where necessary, the teacher should plan the implementation of strategies to support students in the acquisition of both the content and the foreign language (scaffolding), by:

• the use of various visual supports – video fragments of educational films, demonstrations and simulations of chemical experiments and processes, intellectual maps, graphs, diagrams, tables, etc.;

• dividing the studied text into parts; keyword highlighting etc. with a view to ensuring accessibility of the studied content in a foreign language for the learners; use of dictionaries to the texts;

• activation of prior knowledge through guiding questions; guessing meaning from context through general content questions; choosing the correct alternative from several options;

• application of the information technologies where is appropriate;

• involving students in active communication in the foreign language in various communicative situations determined by the studied content, by providing models or frameworks - banks of words, sentences, etc. This is a way to help students complete tasks in the most efficient way and through this support ensure that their motivation increases and anxiety decreases.

The appropriate selection of activities is closely related to the characteristics of the students. And here two aspects must be taken into account:

• the communication skills of the trainees;

• their ability to perform tasks based on their cognitive abilities and learning context.

We base our choice of activities on the assumption that they have a higher average level of English proficiency as they are in the 10th grade of their compulsory secondary education, and linguistically this corresponds to level B1 in the European Framework of Reference (CEFR). Concerning their cognitive level, we have selected activities in line with the expected outcomes of the official curriculum for this stage of learning.

III.5. Assessment in learning in a CLIL environment

The assessment component is an integral part of lesson planning. A particular problem specific to CLIL is 'What to assess'? Evaluating content only or evaluating both language and content? There are different positions in this regard, and although no real assessment model has been proposed so far, the so-called "European" CLIL clearly states that the focus should be on content, and language is seen as a tool for the development of the latter (Coyle et al., 2010).

The priority over content does not mean that language errors should not be corrected, but it is considered that language accuracy should be ensured through comprehensible language support (scaffolding). According to Coyle et al. (2010) the teacher should spend time correcting errors rather than offering continuous corrective feedback that undermines confidence in the content.

Another issue that is addressed is which of the languages should be used to assess - the native/mother tongue (L1) or the foreign language (L2)? This must be reconciled with the requirements for teachers to fulfil the requirements of the relevant curricula, often cited as an obstacle to assessing the foreign language of instruction.

So-called assessment rubrics are considered as one of the most appropriate tools for evaluating integrated competencies. It is comprising rows where the characteristics of the performance to be evaluated are presented and columns with descriptors indicating the qualities of that performance and the corresponding results. They are a guide for students and teachers that is much clearer. It makes assessment more objective and meaningful, and also support learning by providing feedback to learners.

The assessment rubrics shows in practice how objectives, activities and assessment can be synchronized to create a learning environment in which students develop skills and acquire knowledge in both subject and language in accordance with set standards. Their potential is particularly useful in CLIL, where learning process needs to be supported in its various components and students are guided to realize the knowledge and skills they have acquired.

Table III.2. A rubric for evaluating progress in foreign language

Indicator					Evaluation
	1	2	3	4	
The student is able to: understands spoken messages/instructions/content questions formulated in L2 ***understands*** written content messages/instructions formulated in L2 ***asks*** questions about the L2 content studied extract, analyze and systematize L2 information about substances and processes from different sources - text, video, diagrams, diagrams, tables, etc. ***compose*** short oral presentations in L2 on the issues under consideration, giving reasons and making arguments ***expresses*** opinions and attitudes: I think I think, from my point of view, it's a good idea, you're right, you're wrong, I agree with... in L2. ***creates*** a logically connected and properly structured text on the studied subject areas of the L2, stating reasons and arguing ***creates*** a text based on anchor points, key words or illustrative material (graphic image, table, cartoon, comic) in accordance with the communicative task; make an outline of the content of a read or heard text plan and present the results of a chemistry experiment in L2 orally and in writing ***expresses*** himself grammatically correctly in oral and written form ***uses*** spelling and punctuation that do not hinder understanding and are in accordance with the norms of the language ***applies*** the scientific vocabulary intended for learning L2 accurately when performing tasks related to the studied content ***uses*** a variety of language devices, speech behaviour, communication register and compensatory strategies. communicates verbally both with the teacher and with his classmates when performing individual tasks and when working in a group					execution of oral and written instructions and tasks; participation in communicative situations role-playing games, discussions, dialogues; explanation and description of processes, phenomena, observed regularities; description of experiments performed, equipment used and techniques for solving specific cognitive situations; preparation and presentation of presentations on chemical, health and environmental topics; preparation of protocols for laboratory exercises; asking and answering questions; reading aloud; composing texts; solving tests; chemical dictations;

*Degree in which the language competences are formed: 1-not manifested; 2-appears partially; 3-manifests itself; 4 - is manifested in a high degree

III. 6. Informational and methodological materials in agreement with the requirements of the 6C's model

Adapting teaching materials, while using the CLIL approach in your practice, is proving to be a challenge. Science textbooks are known to be cognitively and linguistically challenging even for learners studying in their mother tongue (L1).

Mehisto (2012) identified ten criteria for the development/selection of quality CLIL materials that can be used by teachers. According to him, the materials should:

• make the learning process itself (in terms of language, content, learning skills) visible to students;

• promote systematic acquisition of the target language at the academic level;

• promote the development of learning skills and learner's autonomy;

• include independent, peer assessment and other types of formative assessment;

• help create a safe learning environment;

• contribute to the promotion of cooperative learning;

• imply the inclusion of authentic language and authentic use of the target language;

• encourage critical thinking;

• promote cognitive freedom by including techniques to support the acquisition of a) content, b) language, c) support the development of learning skills;

• help make learning meaningful for learners (Mehisto, 2012).

For the purposes of the present study, a textbook on Chemistry and environmental protection for the 10th grade of Pedagog 6 publishing house (Pavlova, M., etc.) was used, translated into English by Irina Andonova (author of the present study). For each of the topics of the selected topic "Practical aspects of chemistry in the field of materials", in addition to the learning content, reflected in the curricula, a modified version of the worksheets in English for the 10th grade of the same publisher was used, expanded with additional English texts and tasks, the purpose of which is to improve the four language skills - reading, writing, listening and speaking. Part of the texts and language tasks to them are borrowed from the series of Cambridge University Press - Professional English in Use - Engineering: Technical English for Professionals, 2009 with author Mark Ibbotson. In the texts, these tasks are marked with (*) (appendix III. 7 of the dissertation).

The tasks are selected to follow the internal logic of the studied chemistry content and to develop the students' knowledge and skills not only in chemistry, but also in the foreign language, as well as in accordance with the criteria derived by Mehisto (2012). The selection of tasks in the examination of each lesson unit is subordinated to the dual purpose and the main principles of the CLIL approach, and in accordance with the 6C's model, namely through the content to develop along with the competences in the relevant general education subject, as well as those related to the foreign language. The teacher provides the necessary linguistic support (scaffolding) through oral explanations, schemes, diagrams, word banks, use of dictionaries, etc. (multimodal input). Options are being sought for students to work in groups (collaboration) and to be included in various communicative situations - dialogue with the teacher and classmates, explanation of performed activities, etc. (communication, cultural awareness). Tasks are selected with varying degrees of difficulty and can be modified to reduce or increase difficulty (for example - providing a word bank or having students guess which word is missing in the text with blanks to fill in). This is done in order to develop different thinking skills in accordance with Bloom's taxonomy (cognition) and certain key competencies (key competencies).

Chapter Three Summaries

• The results of the preliminary survey, designed to investigate the opinions of students studying Chemistry in English, served as a prerequisite and reference for developing a suitable model for integrated teaching of chemistry and English.

• Following an in-depth analysis of the existing models for applying CLIL in educational practice and considering the specifics of science education, in particular Chemistry education in English, an extended model of Do Coyle's 4C's framework is proposed - Content, Communication, Cognition, Culture. The inclusion in the 6C's model of the Collaboration and Key Competencies components allows to a large extent the full integration of content and language.

• Essential conditions for the concretization of the constructed model are the selection of an age group and appropriate educational content. In connection with the specific cognitive demands faced by students when learning the subject of Chemistry in a foreign language, its most successful application can be expected in students of adolescent age, which is related on the one hand to their cognitive-personal characteristics and on the other hand, with a relatively good command of the foreign language. The choice of learning content from the section "Practical aspects of chemistry in the field of materials" - 10th grade is related to its prospects to acquire through it a wide range of key competences laid down in the curricula of Chemistry and environmental protection and English language, by involving learners in a variety of activities.

• The selection of learning objectives is an important stage in the constructed model of integration of content and language. Areas of possible integration between the subject and the language have been sought through an analysis of the Chemistry curriculum for the section "Practical aspects of chemistry in the field of materials" and the English curriculum - 10th grade. This is an important condition for a clearer definition of the expected results and a prerequisite for the implementation of objective control, which is also a serious and incompletely resolved problem in CLIL education.

• Based on the proposed model and its concretization, a CLIL lesson planning matrix was developed, which would greatly assist teachers, in general, who teach Science in a foreign language.

• In terms of content, the specification of the 6C's model is provided through the development of informational and methodological materials to help teachers and students.

• The main conclusion we can draw based on the presentation is: If the application of the 6C's model of CLIL and the balanced use of each "C" in planning and teaching the specific learning content of the foreign language gives its results in terms of student achievement, knowledge acquisition and the formation of skills (competencies) at a higher level, we can expect that its implementation in the teaching of Chemistry in English can contribute to:

- ensuring systematicity in the learning process at all levels - defining goals, choosing learning content, appropriate methods and means to achieve them, implementing adequate control and, in general, building a comprehensive methodology, taking into account both the level of mastery of the content, embedded in the Chemistry curriculum, as well as at the required language level;

- raising the role of the student in the learning process and thus supporting the formation of much-needed personal qualities - activity, awareness, cultural, health and ecological awareness and creativity, to increase the motivation for learning, and hence the awareness of the need to acquire and mastering methods and tools for knowledge;

- application in the learning process of effective and creative learning practices, which to a large extent ensure full-fledged integral learning.

CHAPTER IV. EXPERIMENTAL STUDY OF THE 6C'S MODEL OF INTEGRATION OF CONTENT AND LANGUAGE IN CHEMISTRY PEDAGOGICAL PRACTICE (SECTION "PRACTICAL ASPECTS OF CHEMISTRY IN THE FIELD OF MATERIALS" – 10TH GRADE)

IV.1. General settings of empirical research

During the period 2019 - 2023, a pedagogical experiment was conducted to develop the 6C's model for applying the CLIL methodology in teaching Chemistry in English and test its effectiveness in real school settings.

The experimental verification of the constructed theoretical concept should prove experimentally the positive effect of the constructed 6C's model of CLIL on the achievements of students in accordance to its dual focus - content and language.

The main aim of the empirical study includes a complex of intermediate objectives:

1. Determining the variables that will be registered in the course of the experiment and which could be used to establish the impact of the theoretically grounded model on the achievements of students in Chemistry on the one hand, and the progress in learning the target language on the other hand in the process of training.

2. Development of didactic materials for the application of experimental technology in the teaching process of Chemistry in 10th grade.

3. Formation of a representative sample of students in the 10th grade for the individual stages of the pedagogical experiment.

4. Construction of a reliable research toolkit for the interpretation of the results of testing of the educational technology.

5. Planning, organizing and conducting the pedagogical experiment to test the enriching effect of the proposed educational technology.

6. Analysis of the practical effectiveness of the technology through mathematical-statistical processing of the data from the experiment.

The defined goals, outlining the trajectory of the overall empirical stage of our research activity, require the application of adequate empirical methods, through which it is possible to diagnose the desired changes in real school practice in Chemistry, namely:

- **Real Pedagogical Experiment** – the pedagogical experiment aims to trace the impact of the content and language integration model applied to a specific section of the Chemistry curriculum on student achievement in a real learning environment.
- **Didactic testing** –It is applied during the various stages of the pedagogical experiment with the aim of collecting sufficiently reliable information about the level of educational achievements (knowledge, skills, abilities, attitudes, etc.) or about the personal qualities of the student.

In accordance with the objectives of the research, we focused on developing two tests (Appendix IV.1 of the dissertation), as a means of measuring and evaluating the achievements of learners before studying the unit in question (Test 1) and after its completion (test 2). The aim is to obtain clear-cut information about the academic achievements in Chemistry of the students and to determine the absolute status of the group of tested persons - whether or not the relevant learning goals set in the curriculum have been achieved, on the other hand - to qualitatively assess learners' basic language skills such as vocabulary, reading comprehension, English text production and overall language acquisition progress.

- **Surveying** - the main goal that determines the use of this method is to establish the attitude of the students to the application of 6C's model in Chemistry education. We developed two questionnaires

that students completed at the beginning of the school year and after studying our chosen unit, coinciding with the end of the school year (Appendix IV.3 of the dissertation).

The purpose of the first survey is to find out students' attitudes towards studying the subject of Chemistry and environmental protection in English, their degree of satisfaction with studying subjects, and in particular Chemistry in the foreign language. This survey borrows some of the questions used in the pre-survey conducted in the 2019/2020 academic year with other students currently studying Chemistry in English in Year 10. The final survey aims to check the students' attitudes and degree of satisfaction with the study of the unit, through the application of the CLIL methodology, as well as the extent to which this has helped to improve the assimilation of knowledge and their productive and receptive skills in the target language.

- **Pedagogical (classroom) observation** - Observation is a method of direct and targeted perception of a certain pedagogical phenomenon by the researcher. The observation is carried out during a seminar for the presentation of projects prepared by the students on the topic " Practical Aspects of Chemistry in the Field of Materials".

- **Mathematical and statistical methods** - the empirical data obtained from the experiment via testing and pedagogical observation are processed using the SPSS computer program. Through this version, using parametric and non-parametric tests: T-test (Paired Samples Test), Wilcoxon's T-test (Wilcoxon Signed Ranks Test), Cronbach's Alpha (Cronbach's Alpha), correlation analysis, etc., the reliability of the constructed author's concept and the effectiveness of the organized experimental training in Chemistry.

IV.2. Results and discussion

IV.2. 1. Analysis of the results of a survey on students' attitudes towards studying Chemistry in English

At the beginning of the 2022/2023 academic year, 10th grade students were offered a questionnaire containing questions arranged into the following groups: general information about the participant and his English language proficiency; feedback on attitudes towards studying subjects, in particular Chemistry and environmental protection in English; degree of satisfaction with learning subjects in a foreign language and difficulties they encountered; students' opinions about ways to improve the teaching of the subject of Chemistry and environmental protection in English by using different methods and means (appendix IV.3 of the dissertation).

132 students from 10th grade took part in this study. The full results of the survey are described in the dissertation. Some of the results that we have identified as important for the upcoming research will be presented here.

One of the questions in the survey is related to students' attitudes towards learning school subjects in English (Question 6 of the survey) and is rated in five categories: A (I don't like it at all), B (I don't like it very much), C (I have nothing against), D (like) and E (like very much). The corresponding frequencies and percentages are shown in Table IV.1.

Table IV.1. Level of interest to studying school subjects in English

Level of interest to studying school subjects in English	A	B	C	D	E
F	12	13	45	42	20
%	9.09%	9.85%	34,1%	31.82%	15.14%

We recognize the presented results as important, since almost 2/3 of the students express a positive attitude towards learning school subjects in English.

Another important indicator is the level of English language proficiency of the students interrogated, according to the six reference assessment levels of the Common European Framework of Reference for Languages CEFR: A1 (Beginner), A2 (Elementary), B1 (Intermediate), B2 (Upper intermediate), C1 (Advanced) and C2 (Proficient). The corresponding levels, number of students and percentages are indicated in Table IV.2. A good level of language proficiency by students is an important prerequisite for fulfilling the set goals.

Table IV.2. Level of English language proficiency of the students according to the Common European Framework of Languages

Level / CEFR	F	%
A1 (Beginner)	-	-
A2 (Elementary)	-	-
B1 (Intermediate)	74	56.06%
B2 (Upper intermediate)	42	31.82%
C1 (Advanced)	11	8.33%
C2 (Proficiency)	5	3.79%

Approximately one third of the participants enjoy or very like studying Chemistry in English (N = 58 or 43.94 %) in contrast to 7.58% (N = 10) who do not like at all, 16.7 % (N = 22) who do not like much and 31.82 % (N = 42) who do not mind having such lessons (N = 33). The results are presented in Table IV.3

Table IV.3. Learner's preferences for studying the subjects of Chemistry in English

Learner's preferences for studying the subjects of Chemistry in English	do not like at all	do not like much	do not mind	like it	like it very much
Честота F	10	22	42	38	20
%	7.58	16.7	31.82	28.79	15.15

Regarding students' preferences to study Chemistry in English, in Bulgarian or in both languages (Question 9 of the survey), the majority of students (53.79 %, N = 71) do not mind either language to teach Chemistry, while (28.79%, N = 38) prefer the teaching to be in Bulgarian and only 17.42% (N = 23) want it to happen in English. The results are presented in Table IV.4.

Table IV.4. Language preferred by students for studying Chemistry

Language preferred by students for studying Chemistry	F	%
English	23	17.42%
Bulgarian	38	28.79%
No preferences – either English or Bulgarian	71	53.79%

In this study, we are also interested in answers of the question "How often did students encounter difficulties in learning chemistry concepts in English?" Over two-thirds of students sometimes (16.67 %, N = 22) or rarely (25%, N = 33) had difficulty learning chemistry concepts in English, only 18.94% (N = 25) and 10.61% (N = 18) have "often" and "always" difficulties, respectively, while nearly a third of the respondents (28.79%, N = 38) have never encountered difficulties (Table IV.6).

To a large extent, it can be said that the difficulties are due to the lower level of proficiency not only in the foreign language, but also in the academic language.

Table IV.6. Frequency of encountered difficulties by students in their preparation, when learning Chemistry in English

Frequency of encountered difficulties	never	rare	sometimes	often	almost always
F	38	33	22	25	14
%	28.79	25	16.67	18.94	10.61

In response to how Chemistry taught in English changed the participants' attitude towards studying Science in English (Question 12), almost a quarter of the respondents (18.94%, N = 25) claimed that their attitude had changed to very positive, and at 26.52%, to positive. More than a quarter of the respondents (27.26%), however, state that their attitude has changed in a negative way (table IV.7.). This is also the group of students who require special attention, both in terms of mastering the learning content and in terms of finding ways to present scientific terminology in an accessible and easier to understand way, by visualizing, explaining in the native language and others.

Table IV.7. Extent to which learning Chemistry in English changes students' attitudes towards learning other subjects in English

Students 'attitudes	very negative	negative	slightly positive	positive	very positive
F	15	21	36	35	25
%	11.36	15.9	27.27	26.52	18.94

When asked to what extent Chemistry taught in English helped them to improve their knowledge and communication skills in English (Question 13), over a third of the students (37.88 %, N = 50) answered that, in their opinion, their knowledge and communication skills in English improved to a large and very large extent, as a result of studying Chemistry in English, for 27.27% this happened to a moderate extent, and for nearly a quarter of the respondents there was a little or very little improvement (table IV.8).

Table IV.8. Extent of improvement in English knowledge and skills, according to students, as a result of studying Chemistry in English

	very little extent	a little extent	moderate extent	large extent	very large extent
F	21	25	36	28	22
%	15.9	18.94	27.27	21.21	16.67

When asked what type of communication they prefer when studyed Chemistry in English, almost a third of the participants (36.4%, N = 48) prefer the teacher to explain the main concepts in the English lesson in the traditional way. Almost the same number of respondents (39.4%, N = 52) gave a preference to group work on tasks in the lesson, and teacher only facilitate their activities, while 24.2% (N = 32) stated that they had no preference to the way of communication. The results are shown in Table IV.9.

Table IV.9. Preferences of students about type of lesson deliverance

	types of lesson deliverance	F	%
A	Teacher explains the basic concepts in English in a traditional way.	48	36.4
B	Group work on tasks. Teacher act as facilitator.	52	39.4
C	I have no preferences	32	24.2

At the end of the survey, no more than 29.54% (N = 39) of the participants expressed an opinion and/or suggestion on how to improve the teaching of Chemistry in English (Question 15), namely: they insisted for classes with teaching in Bulgarian, especially when complex scientific concepts and terms should be explained; running more experiments in school; observing simulations and incorporating video materials; preparation of intellectual maps and diagrams for a better understanding of the material; conducting lessons (in and outside the school premises) with interesting games; participation in more interactive group projects with interesting topics.

Insights from the survey

The results obtained from the survey were evaluated in order to understand the dynamics of teaching and learning Chemistry in English and thus to improve the teaching of this subject in a foreign language. Students' English language proficiency was related to: the number of years the participant had been exposed to the language; whether he/she likes studying a subject in English; the extent to which a participant positively perceives Chemistry lessons taught in English. The level of satisfaction in Chemistry classes taught in English and the difficulty experienced in understanding chemistry concepts taught in a foreign language are also related to students' level of language proficiency. An important finding from the survey is the willingness of students to have more complex terminology explained in class in their native language before translating it into English. In addition, alternative and innovative forms of classroom practice are interpreted by learners as opportunities to enhance their ability to learn the foreign language via general educational subject.

This is a trend seen across all students, both those interrogated in the 2019/2020 school year and those we interrogated in the 2022/2023 school year.

The results obtained were an important guide in the overall preparation of both the didactic materials used and the assessment tools.

IV.3. Analysis of tests results

As already mentioned, two tests were developed for the purpose of the study. Each of the tests is accompanied by a table that contains a description of the included tasks in terms of their compliance with the outcomes of the curriculum and Bloom's taxonomy (presented in Appendix IV.2 of the dissertation).

The specific application of the selected statistical procedures is carried out in the following chronology:

1. Formulation of statistical hypotheses (null and alternative) that relate to the distribution of the random variables X and Y and must be tested using statistical criteria.

2. Defining the level of credibility (significance).

3. Selection of a verification quantity.

4. Outline the critical area, i.e. the area of the theoretical value with which the empirically obtained value of the test quantity is compared.

5. Calculation of the value of the quantity tested.

6. Agreeing on acceptance or rejection of the null hypothesis

The first test, called for brevity T1 (with a length of 17 tasks) was used in the input measurement. It is oriented towards measuring the knowledge and skills required to study "The Practical Aspects of Chemistry in a Field of Materials" unit.

The second test, called for brevity T2 (with a length of 20 problems), used in the final testing, was developed on the learning content of the unit "The Practical Aspects of Chemistry in a Field of Materials". (Table IV. 11).

Table IV.11. Results of the descriptive statistics of Test 1 and Test 2

	N	Statistical quantities							
		X	Me	Mo	R	SD	V	Min	Max
Test 1	133	25,1742	26,0000	26,00	36,00	10,01487	100,298	8,00	44,00
Test 2	126	29,0159	30,0000	36,00	35,00	9,30719	86,624	9,00	44,00

Note. Abbreviations used in table …: *N – sample volume; X – arithmetic mean; Me – median; Mo – fashion; R – span; SD – standard deviation; V – coefficient of variation; Min – minimum value of the test score; Max – maximum value of the test score.*

Index of difficulty of test items

The difficulty of a task is determined by the percentage of students who solved it correctly. The higher percentage they solved a given task correctly, the easier it is, and vice versa – the higher percentage they solved a given task incorrectly, the harder it is. Quantitatively, the difficulty of a task is calculated using the so-called index of difficulty (P) (Stoyanova, 1996; Tafrova-Grigorova, 2008) (Table IV. 12).

Table IV. 12. Index of difficulty of T1 and T2 tasks

	Index of difficulty (P) of test items T1			**Index of difficulty (P) of test items T2**
Task 1.	73,61%		**Task 1.**	94,12%
Task 2.	73,61%		**Task 2.**	79,41%
Task 3.	63,88%		**Task 3.**	82,35%
Task 4.	56,94%		**Task 4.**	80,88%
Task 5.	51,39%		**Task 5.**	82,35%
Task 6.	48,61%		**Task 6.**	80,88%
Task 7.	51,39%		**Task 7.**	85,29%
Task 8.	54,17%		**Task 8.**	77,94%
Task 9.	58,33%		**Task 9.**	79,94%
Task 10.	50,00%		**Task 10.**	85,29%
Task 11.	54,17%		**Task 11.**	80,88%
Task 12.	44,44%		**Task 12.**	86,76%
Task 13.	47,22%		**Task 13.**	76,47%
Task 14.	51,39%		**Task 14.**	76,47%
Task 15.	61,11%		**Task 15.**	73,53%
Task 16.	69,44%		**Task 16.**	75,00%
Task 17.	38,88%		**Task 17.**	70,59%
The difficulty index of the tasks for T1 is within the limits: 38.88% - 73.61% Average difficulty for T1 overall: 55.97%			**Task 18.**	64,71%
			Task 19.	64,71%
			Task 20.	60,29%
			The difficulty index of T2 tasks is within the limits: 60.29% - 94.12% Average difficulty for T2 overall: 77.89%	

In general, the second test T2 can be defined as easy (average difficulty above 70%). This result is justifiable from the point of view of the desired change as a result of the applied new methodology. Both tests are constructed in accordance with the expected results in the curriculum and aim to verify the effectiveness of the studied methodology and are not loaded with other functions.

Reliability of the tests (Test 1 and Test 2)

The next aspect of statistical analysis is determining the reliability of the developed and verified tests. The reliability of a test is an illustration of its accuracy and reliability of measurement. Like any measuring tool, tests are always subject to measurement error. There is the following dependence - the smaller the measurement error, the higher its reliability.

The reliability of the constructed tests was measured in terms of the internal consistency between the items (tasks), which were provisionally differentiated into two equal subgroups ("split-half reliability"). For T1, the first subgroup includes 8 tasks, and the second - 9. While for T2, each subgroup includes 10 tasks. As an indicator of reliability, the Cronbach's coefficient α was chosen, through which it is tracked for the presence/absence of consistency between the total scores of the two halves forming the separate tests. (Table IV. 13)

Table IV.13. Reliability of the developed tests at the initial and final measurement (T1 and T2)

Reliability factor	Test 1	Test 2
Split – half – reliability (two equal subgroups) Cronbach's α	0,9870 p = 0,000 p < 0,05	0,9153 p = 0,000 p < 0,05
Kuder-Richardson (KR21)	0,9350 p = 0,000 p < 0,05	0,8110 p = 0,000 p < 0,05

The results show that the empirically obtained values of Cronbach's α are of the order of 0.9870 for Test 1 and 0.9153 for Test 2, and of Kuder-Richardson (KR_{21}) for Test 1 - 0.9350 and Test 2 - 0.8110, p = 0.000 , p < 0.05, at significance level α = 0.05. The results of the applied statistical procedures are sufficient reason to claim that the developed tests have high reliability for measuring student achievement.

The empirical material and the analysis of the results of the statistical study of the test data are focused on solving the following question:

→ Is there a difference between the distributions of the random variables X and Y that numerically characterize the students' achievements at the initial and final measurements?

The resolution of this question is related to the empirical verification of the following statistical hypotheses formulated on the basis of the hypothesis of pedagogical research:

Null hypothesis (H0): The distribution of the random variable X at the input measurement is not significantly different from the distribution of the random variable Y at the output measurement.

Alternative hypothesis (H1): The distributions of the random variables X and Y at the initial and final finding differ significantly.

The comparison of the arithmetic mean values ( ) describing the students' achievements in the two measurements (T1 and T2) was carried out using a parametric (Paired Samples Test) and non-parametric (Wilcoxon Signed Ranks Test) test for dependent samples. (Table IV. 14).

Table IV. 14. Summary presentation of the results of the statistical examination of the data from the input and output testing

Parametric test for dependent samples (T-test - Paired Samples Test) - T1/T2			**Non-parametric test for dependent samples (Wilcoxon Signed Ranks Test) - T1/T2**	
Paired Samples Test **H_0: $\mu_1^2 = \mu_2^2$** **H_1: $\mu_1^2 \neq \mu_2^2$**	t = (-19,813) df- 122 p=0,000 p < 0,05 **H_0- is rejected**		**Wilcoxon test** **H_0: /u/<u_α** **H_1: /u/≥u_α**	Wilcoxon (W)= 6315, 000 Z= (-9,231) p=0, 000 p < 0,05 **H_0- is rejected**

The verification of the statistical hypotheses is based on the empirically obtained data reflecting the total score of the students in both measurements. The data from the descriptive statistics and from the applied tests (Paired Samples Test and Wilcoxon Test) for comparing the students' achievements (T1 and T2) indicate that the mean values characterizing the studied indicator differ significantly in the two measurements (t = (-19.813); Wilcoxon (W) = 6315.000, Z = (-9.231)), p = 0.000, p < 0.05, at significance level α = 0.05. The obtained empirical values from the applied tests are grounds for accepting the alternative hypothesis - (H1): The distribution of the random variables X and Y in the initial and final diagnostics differ significantly.

It can be reasonably argued that the proposed model, the developed and applied methods, and teaching tools have a positive effect on student achievement.

IV.2. 3. Pedagogical monitoring In the second chapter of the dissertation, attention is focused on one of the main theories, which fully corresponds to the ideas of CLIL -the constructivism and one of its manifestations – the Project-Based Learning. Focused diagnostic observation to students takes place during the presentation of group projects. The organization of the project activity is discussed in detail in chapter IV.5. 1. of the dissertation work. In table IV.16. the correlation between the model developed for the application of the CLIL approach and the components observed and evaluated in the development and presentation of the students' projects is disclosed.

In the course of the empirical research, it became clear that Project-Based Learning, in our opinion, is the form through which the dual objectives of CLIL can be most fully realized. With this type of activity, the proposed 6C's model can be fully deployed in the teaching of Chemistry in English in the Bulgarian secondary school.

In the research, observation was used as an additional diagnostic method.

The units of observation in relation to the components of the 6C's model are:

1. Content - the content chosen by the students, thematically and factually corresponds to the task given. A bibliography of the sources has been prepared.

2. Communication/Language - students' presentation skills, expressed in a clear way; accurate demonstration of facts, contact with the audience, intonation, tone, pauses, pronunciation, etc.; students express themselves grammatically correctly in accordance with the expected level of the European Language Framework B1; They use scientific concepts and terms correctly. A glossary of terms has been compiled, with a definition in English.

3. Cognition – Students developed skills for selecting proper sources and extracting and processing information through mental activities - understanding, application, analysis, synthesis and evaluation.

4. Collaboration – Student developed social and civic skills, expressed via effective communication, ethical attitude and tolerance between team participants, ability to delegate social roles in the team, for planning and precise timing for preparing the product, etc.

5. Culture - Manifestation of originality and creativity in the design and layout of the product, forming a position on environmental issues and those related to the health of the individual, as well as related to the production and use of the materials considered in the projects.

For each measured unit, there can be only one meaning from the following four: a – high degree of manifestation; b – manifests itself; c – partially manifested; d - does not occur.

The monitoring results are systematized in a monitoring protocol specially developed for the purpose. It includes 5 surveillance units with four levels to each.

Table IV.16. Relation between the 6C's model and the components assessed in project development

6C's model	Content	Communication	Cognition	Collaboration	Culture	Key Competencies
P R O J E C T	**Content compatibility to topic given/** **Accuracy of facts/ Images, graphics, pictures are included Gathering information/** **Ability to work with proper sources of information – books, scientific articles, encyclopedias, journals with impact factor etc Bibliography /Sources included in a proper style**	**Specific vocabulary/ Correct grammar/ Coherence and cohesion of the text/** ***Кохерентност и кохезия на текста*** **Glossary of specific terms included** **Oral presentation of text related to level B1 of CEFR/ Intonation and pauses, pitch, pronunciation**	**Planning / LOTS/ Knowledge** **Comprehension** **Application** **HOTS/** **Analysis** **Synthesis** **Evaluation**	**Group dynamics: -social roles -collaboration -communication -time management - contribution to each part of the process of making a product**	**Originality/ Creativity** **Organization and disposition** **Body language: facial expression, contact with the public, gestures** **Design of the project** **Originality**	***Science and mathematics Digital competences Foreign language skills Study skills*** **by learning rules supporting the cognitive process; self-monitoring and exercising self-control when performing tasks;** ***Skills to support sustainable development and for a healthy lifestyle and sport*** **by assessing problems related to the impact of substances and processes on human health and the environment;** ***Cultural awareness and creative expression skills*** **• making models, models and posters;** **• study and presentation in an appropriate way of the development of chemical science, achievements of famous scientists and some more important technological processes;** **• preparing an essay on a specific topic and expressing positions on environmental and socio-societal problems;** **• presentation of independent studies and projects.**

The main goal of this method is to diagnose the degree to which a set of skills and attitudes have been mastered, contributing to the formation of key competences in the field of natural sciences, foreign language, social and civic competence, cultural awareness and skills of expression through creativity,

learning ability, as well as the formation of ecological, health and consumer culture when studying the section.

The reliability of the instrument applied to pedagogical observation was examined using Cronbach's coefficient alpha α, which judges the presence/absence of correlation between the answers to test units, as well as the strength of this correlation. (Table IV. 17).

Table IV. 17. Summary results of the statistical evaluation of the pedagogical monitoring protocol

Statistical measures of reliability and validity	**Evaluation methods and coefficients**	**Empirically derived values**
The empirical value of Cronbach's coefficient alpha α	Cronbach's coefficient alpha α	Cronbach's Alpha – 0,7921 p=0,000 p < 0,01

The empirical value of Cronbach's coefficient alpha α for the instrument as a whole is of the order of 0.7921 (p=0.000; p < 0.01). Considering the relatively small number of items, these values indicate good reliability.

IV.2. 4. Correlation analysis

Correlation analysis is used to establish the existence of a relation between variables, measuring its strength (degree) and direction.

Statistical processing is based on data from the sample, which implies testing the hypothesis to what extent the dependence observed in the sample is the result of the influence of a particular factor. For this purpose, the statistical significance of the correlation coefficients is checked. The absolute value of the calculated coefficient (remp) is compared with the critical value (rα), with degrees of freedom k = n – 2. The decision is made as follows:

• If **r** emp < rα – it is assumed that the dependence found in the sample is random and is not the result of the impact of the specific factor;

• If **r** emp ≥ rα – it is assumed that the dependence found in the sample is statistically significant and is the result of the impact of the specific factor.

A research question. Does it exist and what is the strength of the correlation dependence between the students' achievements on the T2 test and the results of the pedagogical observation, in the conditions of a purposefully organized learning process?

The resolution of this question is related to the empirical verification of the following statistical hypotheses:

Null hypothesis H_0: There is no significant positive correlation between the variables X and Y, which characterize the studied variables with numerical values.

Alternative hypothesis H_1: There is a significant positive correlation between the variables X and Y, which characterize the studied variables with numerical values.

Since the variables are not rank-scaled and it is not known what the distribution is - normal or non-normal - the Pearson Correlation r is applied.

Table IV. 18. Degree of correlation between students' achievements on the final test - T2 and pedagogical observation

Correlation coefficient	Correlation between T2 and pedagogical observation
Pearson Correlation (r)	Corrélation Coefficient = (0,912**) p = 0,000 p < 0,01 N= 126 K = 124 H_{0-} is declined

The empirical values of the Pearson Correlation (r) describe a very large dependence between the average values, describing with numerical values the achievements of the students at T2 and the pedagogical observation. They are sufficient reason to accept the alternative hypothesis: H_1: There is a significant positive correlation between the variables X and Y, which characterize the investigated variables with numerical values.

IV.7. Presentation and analysis of the results of a survey regarding the students' opinion on the study of chemistry in English with the application of the CLIL methodology through the developed 6C's model

When the unit "Practical Aspects in Chemistry in the Field of Materials" has been completed to the students of the 10th grade, in the academic year 2022/2023, a questionnaire was proposed. It was developed under The Lifelong Learning program of the European Union and adapted to the needs of the study.

This survey aims to establish the opinion of the students regarding their participation in learning the unit specified of the Chemistry curriculum in English, through the developed 6C's model for the application of the CLIL methodology, as well as the extent to which this has helped to improve the acquiring of knowledge and their productive and receptive language skills (Appendix IV.3 of the dissertation). The responses were then analyzed collectively rather than individually, applying descriptive statistics to analyze the results.

The questionnaire was completed by 127 students who participated in the overall study from the 10th grade. The results of the entire survey are described in detail in Chapter IV of the dissertation. Here we will present only some of the results.

When asked "How do you rate your learning experience in a CLIL environment?", three quarters of students rate it as important (30.71%) and very important (61.42%). 5.51% of the respondents accept this experience as moderately important, and only 2.36% consider it not important (fig. IV.10).

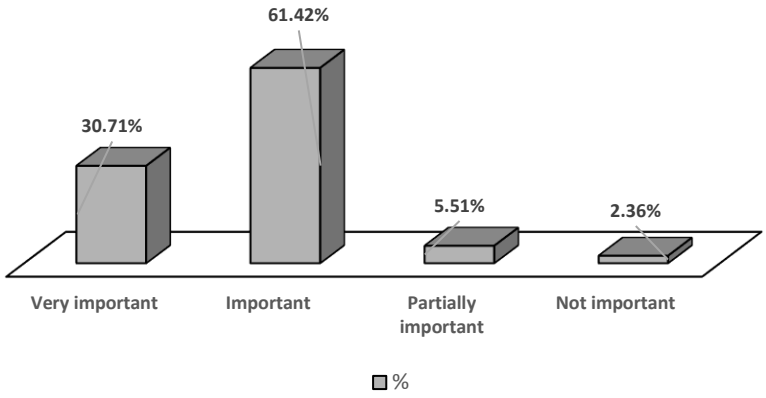

Figure IV.10. Evaluation of learning experiences in a CLIL environment

Regarding the question (Question 2) in which of the following situations do you use the foreign language and how often, more than half of the students indicated giving an oral presentation in front of the class, communicating with classmates in group work, answering set questions and communicating with the teacher as situations in which most often they use the foreign language (Fig. IV.11)

Figure IV.11. Use of the foreign language in certain communicative situations (in percentages)

The degree of comfort experienced by students in different communicative situations is reflected in figure IV.12. It can be seen that, to the greatest extent, students feel good when communicating with their classmates and with the teacher. Group work and participation in discussions are the other communicative situations in which a large number of students feel comfortable. Oral presentation in front of the class as well as answering questions (interview) make students feel uncomfortable to varying degrees.

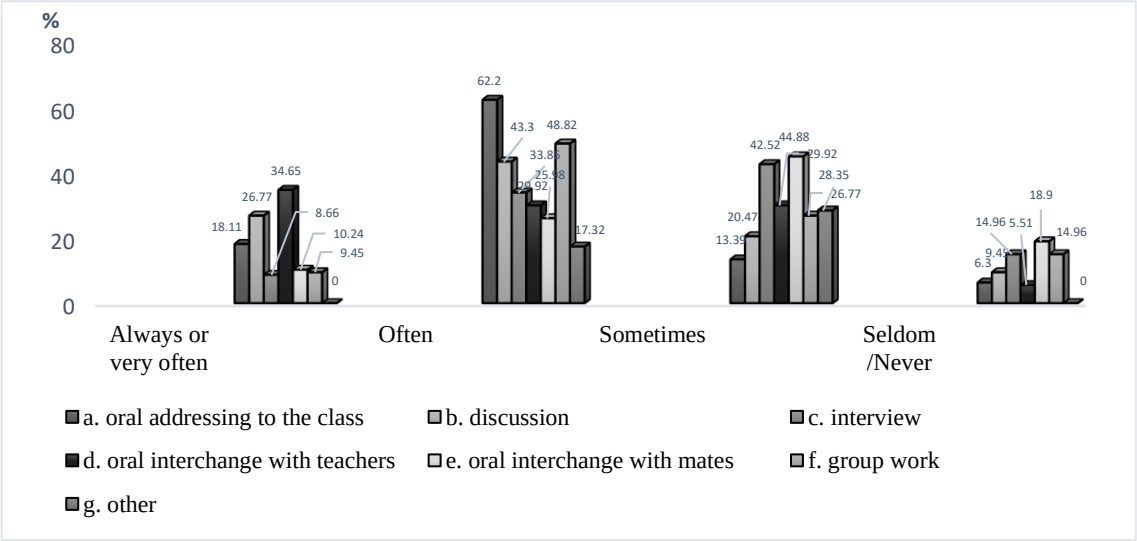

Figure IV.12. Students' level of comfort in using the foreign language in different communicative situations

To the question: "Which strategies do you find most useful when completing the tasks?", students indicate listening to the teacher's explanations as a useful strategy (62.2%), and 37.8% of them define it as relatively useful. It is important to note that no students indicated that this strategy was not helpful. This

shows the important role of the teacher as a facilitator. Regarding answering questions asked by the teacher or classmates, three-quarters of the students considered this a relatively useful strategy, and between 8-10% rated it as not very useful and not at all useful. For more than half of the students, it is also useful to use the examples given by the teacher, repeat aloud what was heard, read or written in some earlier stage of the training, as well as attempts to convey the learned knowledge in their own words. The use of images, tables, graphs, diagrams, etc. is indicated by most students as a useful and relatively useful strategy for solving the tasks set for consideration. Only 11.82% find it not particularly useful (fig. IV.13).

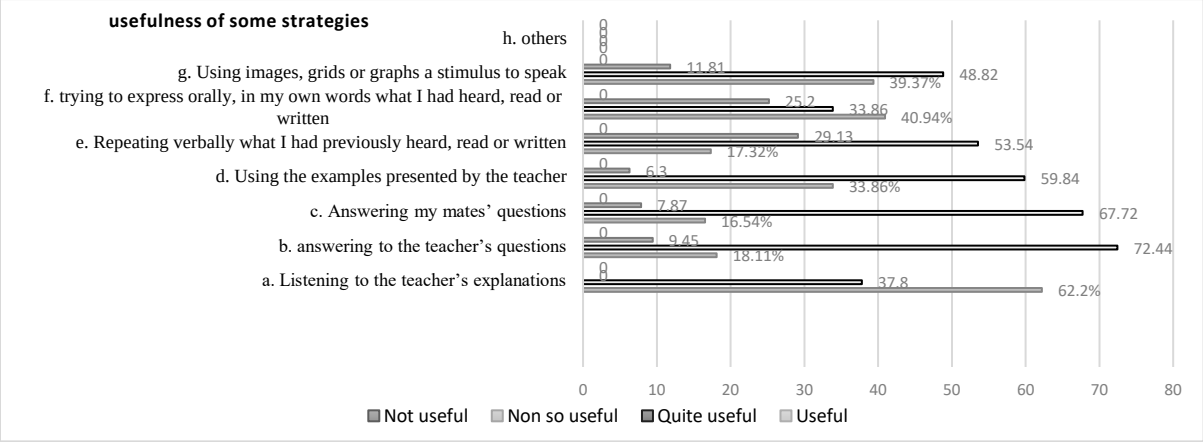

Figure IV.13. Useful strategies, according to the students, for solving the tasks

When asked: "Do you think this CLIL learning experience is useful for you?" 62.65% rated it as very useful, nearly 26% as useful, 8.66% considered it moderately useful and only 4.02% said not is useful. (Fig. IV.19). To the question: "Why?" (Question 10), the answers ranged from "I learned a lot of new things.", "It was fun.", "I improved my English by enriching my vocabulary," "I had the opportunity to speak a lot in the foreign language and work on a project with my classmates."

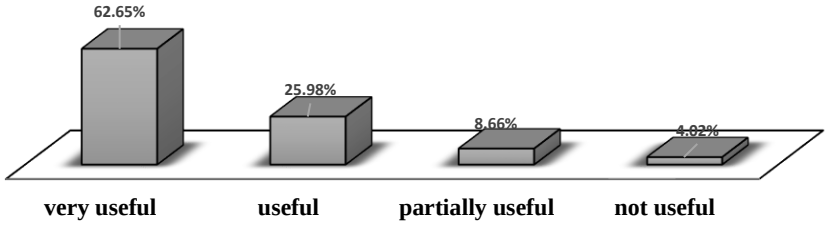

Figure IV.19. Extent to which learners find learning experience using CLIL methodology useful

Regarding whether the interrogated students liked learning in a CLIL environment (Question 11), 91.56% answered YES and only 10.44% NO. As reasons for this, they point out that it was interesting to them and that the teacher made the presentation interesting (fig. IV.20).

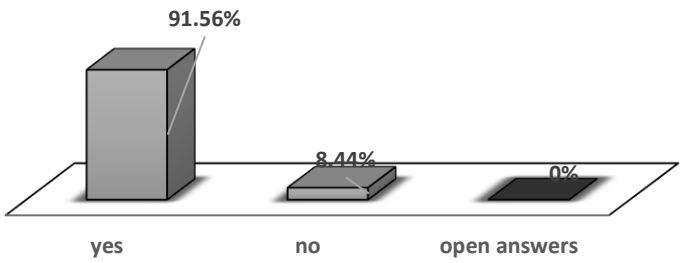

Fig. IV.20. Students' attitudes towards learning in CLIL environment

To question 12: "If you had the opportunity to choose between learning in a CLIL environment and in a traditional environment, which would you choose?". 83.53% of students answered that they would prefer learning in a CLIL environment. As a reason, they indicate that for them it is something new, interesting, useful and they think that it is easier to learn in this way. 18.11% of the respondents, however, prefer the traditional way of education (fig. IV.21).

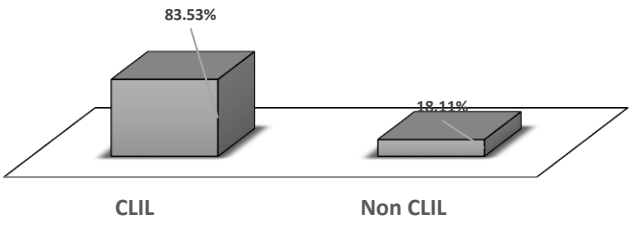

Figure IV.21. Students' preferences for learning in a CLIL environment versus learning in their usual environment

In the course of the study, all students participated in a group project, and in this regard, the next question (Question 14) asks students to rate their level of satisfaction with their participation in the group project. As can be seen from the results, 35.6% of the students experienced very high satisfaction, 58.33%, high satisfaction, and 6.06% were satisfied to a lesser extent. The results are presented in Figure IV.23.

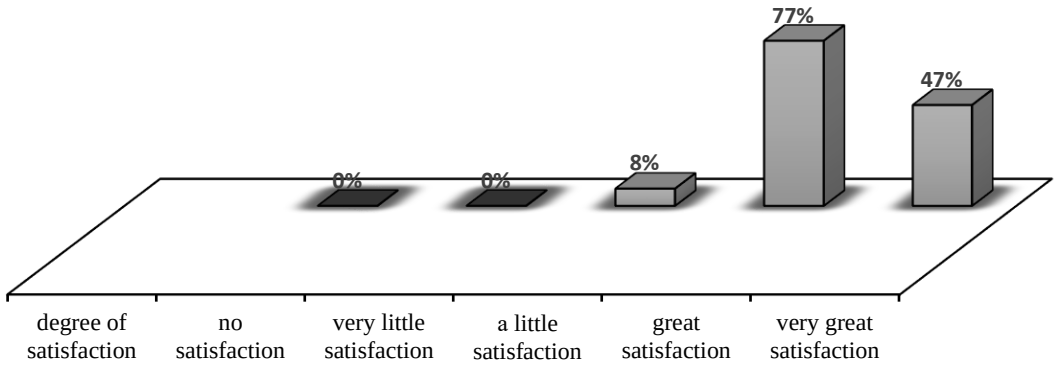

Figure IV.23. Level of student satisfaction with participating in a group project

The analysis of the results of survey 2 showed that students positively perceive the application of the CLIL methodology when learning the subject of chemistry in English. They evaluate this kind of

experience as new, interesting, fun, giving them the opportunity to work more with the foreign language, which, according to them, has improved their language skills. For a majority of them, learning in a CLIL environment is a useful experience and they enjoy being taught in this way. The students experienced particular satisfaction when participating in the group project. As strategies supporting learning content in a foreign language, respondents indicate the teacher's use of video fragments, word banks, illustrative material - schemes, tables, diagrams, appropriate authentic texts and others. Regarding the components important for the development of the foreign language, and specifically speaking skills, correct pronunciation, clarity and grammatical correctness are important for students. The communicative situations indicated by the respondents as those in which the foreign language is used to the greatest extent are during an oral presentation in front of the class, communication with the teacher and when communicating with their classmates when working in a group.

Chapter Four Summary

Based on the results of the statistical study of the data obtained from the testing, survey and pedagogical observation, the following generalizations can be made:

• The testing carried out during the pedagogical experiment showed that the used methodology of content and language integration has a positive impact on the students' achievements, according to the outcomes in the chemistry curriculum, regardless of the fact that the teaching is carried out in English.

• The pedagogical experiment proves that providing learning conditions in a CLIL environment can have a beneficial effect not only on the acquisition of knowledge and skills in chemistry and English, but also on the formation of important personal qualities - self-esteem and motivation to learn, expressing striving for higher results, hence higher student activity in the learning process. Teamwork contributes to the improvement of important social and civic skills such as cultural, health and environmental awareness, mutual assistance and cooperation. We ascertained some of these manifestations through the answers of the students in the conducted survey, and others were most strongly manifested during the preparation and presentation of the group project.

• The work on group projects proved to be not only satisfactory in an emotional and motivational aspect for the learners, but also as a means of successfully forming a wide range of the main key competences in them. In this type of activity, the application of the 6C model proposed by us can be deployed to the fullest extent.

• In the future, the research could develop in the direction of a detailed study of the extent to which students' language competences are improved when studying chemistry in a foreign language, through precisely designed assessment tools in a team with specialist philologists.

CONCLUSION

Teaching a general education subject in a foreign language is a long-standing practice in Bulgarian secondary schools with extended foreign language study. Nevertheless, the present study highlighted a number of unresolved issues, such as the need to create a theory and methodology for teaching a subject in a foreign language; the lack of appropriate didactic materials corresponding to the current curricula; the lack of integrated state educational standards for teaching a general education subject in a foreign language and, last but not least, the problem related to assessment in the conditions of studying a general education subject in a foreign language. The CLIL approach has the potential to solve these problems. This is also the reason to look for opportunities for their solution by developing a model of integration of subject content and a foreign language, applied and studied on the example of specific educational content in Chemistry and environmental protection.

Completion of the objectives formulated in Chapter I leads to answers of the previously posed research questions as follows:

1. What are the existing practices for integrated content and language learning in our country and in other European countries?

As a multilingual area, the European Union actively encourages its citizens to learn at least two European languages, other than mother tongue, with a view to successful mobility and integration within the Union. The CLIL methodology is perceived as a strategic decision in the field of education, implemented in the educational systems of the member countries, in order to meet the requirements of the European Council. Within CLIL, language is used as a medium for learning non-linguistic content, and content in turn is used as a resource for language learning. As an educational approach, CLIL is used in almost all countries in Europe. However, there are still no unified provisions on CLIL in the European Union, therefore each country can implement it in accordance with its local educational policies. This also explains the wide variety of "CLIL-practices" in European countries, each with its own particularities arising from its own linguistic history, educational policy, social context, needs and goals.

The practice of CLIL application in Bulgaria is not well researched. Despite over a hundred years of history of bilingual education, the CLIL approach has been introduced in educational institutions only in the last ten to fifteen years, mostly as a "good practice". Similar practices can occasionally be found in primary and secondary education and less often in higher education. CLIL is always implemented taking local conditions into account, so there is no universal CLIL model that can be used equally successfully everywhere. Such an orientation towards achieving practical results in a specific context leads to the problem related to the insufficiently developed theoretical and methodological foundations of CLIL in general.

2. What are the main theories that underlie learning in a CLIL environment?

The theoretical analysis carried out showed that research in the field of CLIL is mainly focused on identifying and disseminating best practices in its implementation and this further leads to its popularization. Unlike other educational approaches, the development of CLIL goes not from theory to practice, but rather from practice through the analysis of concrete experiences to theoretical generalizations. The dual nature of CLIL implies building a theoretical foundation based on language-related theories (Second Language Acquisition Theories (SLA), Vygotsky's sociocultural theory, which considers communication, reflection and learning as linked processes in the construction of language knowledge and development. On the other hand, CLIL methodology requires the active construction of one's own knowledge and personal meanings for the learner, and this strongly links it to constructivist ideas. Last but not least is CLIL's association with postmodernism, as grounds for this are its characteristics of 'inclusive' and 'flexible' - it encompasses a variety of teaching models and curricula and can be adapted to the age, abilities, needs and interests of learners. This variety of theories and principles found in CLIL, determined lead to difficulty in building a unified theory and is a serious challenge facing its researchers.

In this doctoral thesis, an attempt has been made to present the various viewpoints, but the focus is on applying primarily theories related to language and constructivist ideas.

3. What components should the CLIL model include according to the specifics of teaching natural sciences and chemistry in particular?

Coyle's 4C's model (Coyle, 1999, 2005), consisted of the components Content, Communication, Knowledge and Culture. Two new components have been added to the listed four i.e. Collaboration and Key Competencies. Thus, the 4C's model was extended to 6C's. With the additions made, it is possible not only to cover various aspects of teaching Chemistry in English, but also to realize a full-fledged integral teaching, which is the aim of CLIL. The practice in our country shows that the moderate and structured use of the native language (L1) as a means of language support, in chemistry classes taught in English, leads to a better assimilation of the learning content in chemistry.

The construction of the model is the result not only of the theoretical analysis, but also of the long-term practice of the author of the present dissertation, as a Chemistry teacher in English.

4. How can the CLIL model be applied to a specific chemistry curriculum?

The proposed 6C's model of CLIL and the balanced use of each "C" can contribute to building a comprehensive methodology, taking into account the content at both cognitive and linguistic levels. The 6C's model is based on some of the theories mentioned above, and its practical application was explored integrating competencies derived from the Chemistry and environmental protection and English language curricula for 10th grade. This is an important step that led to the selection of appropriate educational content, the selection of methods and means to achieve the expected results, the development of appropriate didactic materials and assessment tools. As a final result, a CLIL lesson planning model is presented.

5. What is the students' attitude towards the created CLIL-environment of learning chemistry in English?

The analysis of the results of the survey conducted with the students at the end of the school year showed that the students perceive very well the applied methodology when studying the subject of Chemistry in English. They evaluate this kind of experience as new, interesting, useful, giving them the opportunity to work more with the foreign language, which has improved, according to them, their language skills. The results of the conducted tests are also important for us, which show a good achievement of the expected results laid down in the chemistry curriculum. Students demonstrate knowledge of chemical terminology, handle it well, can compose short scientific texts, as well as reflect on them. The learners experienced particular satisfaction when participating in the group project presented in the third chapter of the thesis. Group work is a means that stimulates active communication of scientific concepts, ideas and practices among peers so that receivers understand the message of the transmitters.

Existing limitations are taken into account in the research process. First of all, we can point to the fact that the present study was conducted among the students of only one school and by only one teacher teaching Chemistry in English. In the future, this research can be extended to students and teachers of a larger number of schools, as well as applying the 6C's model to the study of other subjects besides Chemistry. The conduct of the research also coincided with the so-called COVID-19 pandemic, which limited the possibilities of expanding the scope of the studied students.

The main contributions of the dissertation work can be outlined in the following directions:

1. Based on the analysis of documents, philosophical, pedagogical and methodological literature on the CLIL method, a theoretical framework for integrated learning of content and a foreign language (CLIL) in the process of teaching Chemistry in English is substantiated, which in the largest degree to reflect the dual nature of CLIL and the peculiarities of the Bulgarian education system. A toolkit was developed to study the applicability of the model in pedagogical practice.

2. In accordance with the model, a complete methodology of teaching Chemistry in English in the CLIL environment is presented, including the choice of learning content; integrating curricula and clear definition of the expected results in terms of both the learning content and the foreign language; development of didactic materials and assessment tools.

3. The productivity of the developed model has been experimentally proven and the integration of chemical and language knowledge and skills of the students in the studied group has actually been achieved, as well as the formation of a positive attitude towards the study of the subject of Chemistry in English.

4. Based on the research, we consider the idea of a wider applicability of the model not only in the teaching of Chemistry, but also in other natural science disciplines to be defensible, which is, however, subject to further research and verification.

Scope of future work

In order to outline the direction of future research, it is necessary to mention the difficulties we encountered while developing the present work. First of all, they are found in the analysis of the literary sources related to the essence of CLIL. The positions of the researchers are divergent in nature and there is no unanimity on the matter. The theories underlying it are also very diverse and extremely difficult to unify. All this stems from its multi-layered nature.

Secondly, the abundance of practices through which CLIL is implemented could hardly be systematized. There are also difficulties with assessment tools and the answer to the question "What are we assessing?" – content or language or both. This is a question that also confronts researchers.

Overcoming the mentioned difficulties could hardly be realized in a dissertation work, but it is a challenge for future ones. The limited application of the CLIL approach in school practice in our country is due to the outlined problems related to the lack of:

1. methodology for teaching a subject in a foreign language, which is legally guaranteed,

2. curricula and appropriate didactic materials for integrated subject and language teaching,

3. a sufficient number of teachers prepared to teach in CLIL environment.

This opens up a wide field for discussion and further research by experts both in foreign language learning and in individual general education subjects taught in a language. The creation of integrated curricula, assessment guidelines and preparation of teaching materials in a CLIL environment is imperative.

The lack of regulations for teaching in a CLIL environment deprives teachers willing to apply the methodology in their practice from the opportunity to plan their activities legally, which is a demotivating factor for its implementation. Therefore, to remedy the current situation, it is necessary to develop assessment tools that include both content-related criteria and language-focused criteria that help students receive due recognition for the knowledge and skills they demonstrate. This problem remains open for further examination at the level of experts and persons responsible for educational policies in the state.

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Co-author of textbook and workbook

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