CONTENT AND LANGUAGE INTEGRATED LEARNING APPLIED TO TEACHING CHEMISTRY: A CASE STUDY FROM EASTERN EUROPE

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Abstract. Adopting a Content and Language Integrated Learning (CLIL) approach implies a dual-focused education whereby a language other than one's native tongue is used to learn and teach the content of a given academic discipline in a foreign language. This research is based on using English to teach chemistry to Grade 9 students in one of the outstanding secondary language schools in Bulgaria. Correlation exists between the level of proficiency in this foreign language and the past exposure of the students to that language. Moreover, past and present attitudes towards studying chemistry have been studied. Participants were of the opinion that scientific concepts need to be explained in their native language and that more laboratory- based sessions need to be held, indicating the importance that students attribute to language integration through content learning, a crucial consideration in CLIL. Students are keen to experience alternative forms of classroom practice. Group work, involving the presentation in class of chemistry assignments in English, is not only perceived as an exercise in oral communication skills using a foreign language but also as a creative opportunity to deliver their collective effort in a scientific, innovative manner in a foreign language. This reinforces a consistent drive towards language learning and an urge for scientific literacy. This study supports the significance of a perspective which is less researched in CLIL, namely, language integration through content learning.

Keywords: content and language integrated learning; CLIL; chemical education research; English as a foreign language; secondary schools; Bulgaria

Introduction

The European Union (EU) considers language learning and knowledge as one of the key skills of future European citizens and thus it aims to promote language learning strategies such as the Content and Language Integrated Learning (CLIL) approach in schools throughout Europe. On the other hand, the demand for scientifically and technologically literate people sets the scene for the implementation of educational programs that focus on its promotion. Indeed, an early regulation of Council of the EU, dated 1995, addressed European collaboration in CLIL. It referred to the promotion of innovative methods and, in particular, to "the teaching of classes in a foreign language for disciplines other than languages, providing bilingual teaching" (CEU, 1995). This concept was included later on in the same year in the White Paper of the European Commission on Education and Training which focused on the effective practices that can help Europeans become multilingual and proficient in at least two European languages other than their native tongue:

In order to make for proficiency in three Community languages, it is desirable for foreign language learning to start at pre-school level. It seems essential for such teaching to be placed on a systematic footing in primary education, with the learning of a second Community foreign language starting in secondary school. It could even be argued that secondary school pupils should study certain subjects in the first foreign language learned, as is the case in the European schools. Upon completing initial training everyone should be proficient in two Community foreign languages.[1)]

A variety of benefits of the CLIL's multi-faceted approach, outlined in *The CLIL Guidebook*[2)] and graphically shown in Fig. 1, are listed by Apsel (2012).

Active learning and CLIL implementation in the classroom, where chemistry is taught in English, has recently been researched (Nikula, 2015; Recatalá, 2016). An early empirical study on the acquisition of content in a CLIL-based chemistry course attended by Polish students was undertaken some years earlier (Gregorczyk, 2012). This paper addresses another East European country, namely Bulgaria. Its aim, inspired by Akbarov et al (2018), is to evaluate the overall performance of the students studying chemistry through English, and their attitudes, opinions and responses towards the process of learning this subject in a CLIL environment in Bulgaria.

The following four research questions were addressed: (1) what is the level of effort which students, both individually and collectively in group work, put into studying chemistry taught in English through the implementation of the CLIL approach; (2) what is the level of satisfaction of students studying chemistry in English; (3) to what extent does chemistry taught in English improve the students' communication skills and knowledge of English; (4) from a student's perspective, how can the teaching of English-taught chemistry be improved.

Bulgaria as a case study

Since the establishment of the People's Republic of Bulgaria (1946-1991) the study of English grew rapidly and by the late 1950s it was a compulsory subject in several primary and secondary schools (Rankova, 1959). This momentum persisted but not at a consistent level. A decade after the 1989 reforms implemented rapidly in the Eastern Bloc, Bulgaria had attained an educational system reputed

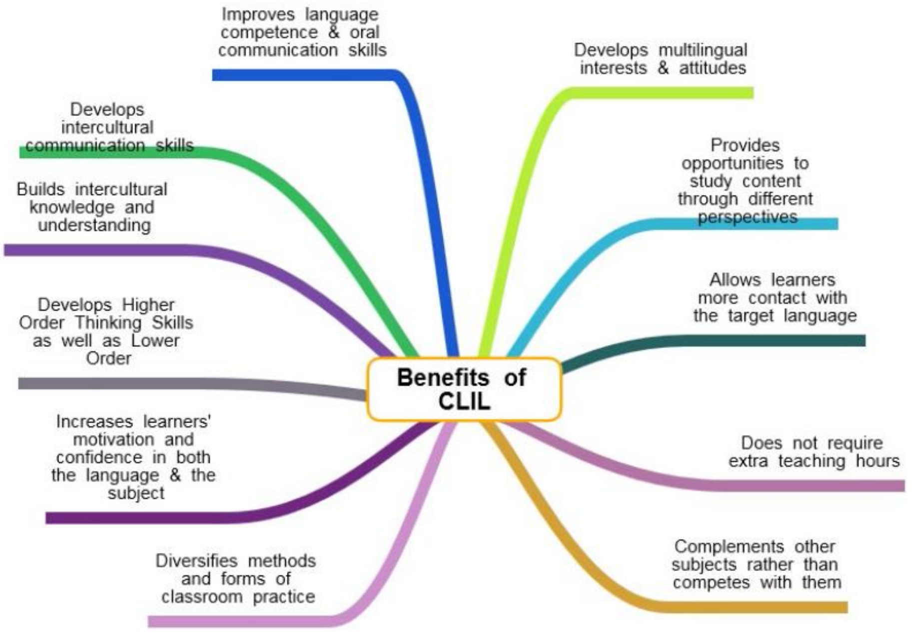


Figure 1. Benefits of CLIL[2)]

for producing a highly literate population (Garkov, 1999). The standard of higher education in chemistry in Bulgaria had been noted decades earlier by Wotiz (1973). Moreover, a study was conducted over a decade ago at the universities of Sofia, Plovdiv and Veliko Turnovo to assess the perceptions of tertiary level students following English studies in Bulgaria (Katsarska & Keskinova, 2011).

The structure of the education system in the Republic of Bulgaria after 1991 and the organisation of teaching foreign languages, particularly English, is outlined in Loboda (2018). The teaching process is directed by regulations regularly issued by the Ministry of Education and Science which cover a wide spectrum of aspects which fall under the remit of the Ministry. Two of these regulations are of particular significance to this study:

Ordinance No. 4 of November 30, 2015 on the Curriculum[3)]; and
Ordinance No. 11 of September 1, 2016 on the evaluation of the results of the students' education.[3)]

A study of the teachers of chemistry in English at Bulgarian high schools had identified the following considerations regarding high school chemistry education in English (Danailov & Tafrova-Grigorova, 2014): (1) a need for further pedagogical courses in bilingual teaching; (2) a lack of quality textbooks and supplementary books; and (3) a lack of suitable assessment tests.

Since teachers were keen on several contemporary scientific themes, they proposed an improvement in the curriculum to ensure the attainment of "more real-life knowledge, experimental work and key competencies and thus … enhance greater scientific literacy of students" (Tafrova-Grigorova et al., 2011).

Methodology

This study is based on one of the largest schools in Bulgaria where 95% of the students who complete their education proceed to further their studies at tertiary level. It caters for about 2,100 pupils from Grade 1 (average age: 7-8 years old) to Grade 12 (average age: 18-19 years). In this school, it is compulsory to study English from the First Grade. In the upper secondary school, that is Grade 9 and over, there are 650 students studying in 24 classes. At this grade, four subjects are taught in English, namely chemistry, biology, history and geography. The scoring system for exams is: 2 (poor), 3 (satisfactory), 4 (good), 5 (very good) and 6 (excellent).

A questionnaire was handed out at the start of scholastic year 2019/2020 to all the students in Grade 10 (average age 15 – 16 years) studying chemistry taught in English. This is their second year of studying chemistry in English. Pupils are introduced to study school subjects in a second language in Grade 9. For a more multi-faceted approach, a profile of the sample group was drawn up utilising a questionnaire which had three parts:

Questions Q01 to Q06: General information about the participant and her/his proficiency in English;

Questions Q07 to Q17: Feedback on attitudes towards studying and consequent performance with regard to chemistry taught in English exams during the previous scholastic year 2018/2019; and

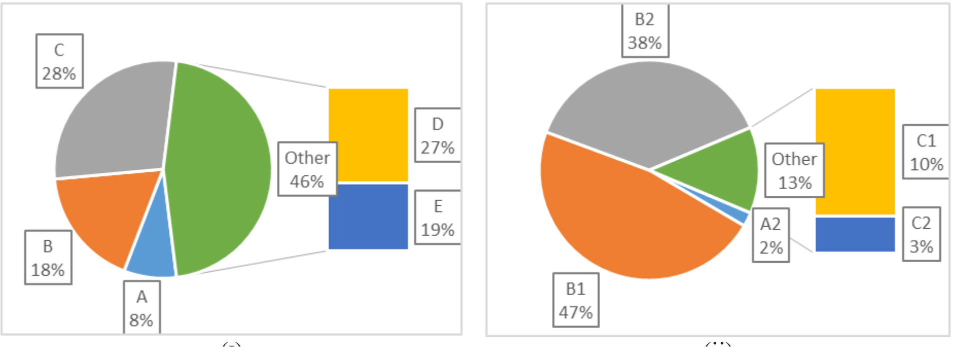
Questions Q18 to Q22: Attitudes and opinions about learning chemistry in English.

The questionnaire, designed to ensure anonymity and confidentiality regarding the participants, was handed out to all students and the responses were of those who voluntarily decided to participate. Afterwards, the responses were analysed collectively and not individually. The questionnaire is attached as an Appendix.

Results

The sample for this study was a census of all grade 10 students: 157 pupils in total (male: *N*=75, 47.8%; female: *N*=82, 52.2%). There were 142 valid submissions. The mean age of the participants was 15.9 years (Q1); there were more students who were 16 (*N*=124 or 87.3%) than 15 (*N*=18 or 12.7%) years of age. The percentage of males, females, others is 45.8% ($N = 65$), 52.1% ($N = 74$), 2.1% ($N = 3$) respectively (Q2). The data obtained from the questionnaire was analysed through *the Statistical Package for the Social Sciences* (SPSS) software (Clef, 2013; Kinner & Gray, 1999). The mean, standard deviation (SD), the minimum and maximum values of the responses for each variable in the questionnaire are given in Table 1.

In response to the question whether participants have relatives conversant in English (Q3), 81% responded in the affirmative (N=115). Most of the participants had been learning English for a minimum of 6 years (N=119, 84.5%). The general level of interest in studying school subjects in English (Q5) was graded into five categories: A (do not like at all studying school subjects in English), B (do not like so much), C (do not mind), D (like studying) and E (like studying school subjects in English very much). The respective frequencies and percentages are given in Table 2 and shown graphically in Fig. 2(i). The valid percentage was also calculated in order to account for missing responses.



(I) (II)

Figure 2. Level of interest in studying in English (I) and Proficiency in English (II)

Table 1. Mean, standard deviation (SD), minimum and maximum values of each variable

Question ref. no.	Valid responses	Missing responses	Mean	SD	Minimum	Maximum
Q01	142	0	15.87	0.334	15	16
Q02	142	0	01.56	0.539	1	3
Q03	142	0	00.81	0.394	0	1
Q04	142	0	08.92	2.628	2	14
Q05	141	1	03.32	1.197	1	5
Q06	142	0	03.64	0.802	2	6
Q07	142	0	04.12	0.829	2	6
Q08	141	1	04.16	0.807	2	6
Q09	139	3	02.96	1.265	1	5
Q10	139	3	1.232	1.633	0	15

Q11	141	1	02.87	1.330	1	5
Q12	140	2	1.936	1.894	0	12
Q13	140	2	02.86	1.317	1	5
Q14	136	6	00.49	0.584	0	4
Q15	136	6	02.92	1.283	1	5
Q16	65	77	03.72	1.038	1	5
Q17	65	77	04.83	0.486	2	5
Q18	132	10	02.08	0.772	1	4
Q19	133	9	03.00	1.267	1	5
Q20	113	29	03.53	1.648	1	5
Q21	128	14	03.12	1.098	1	5
Q22	128	14	02.96	1.153	1	5

With respect to the level of competence in English (Q6), the following six reference levels were used for evaluating the individual student's language proficiency on the basis of the Common European Framework of Reference for Languages: A1 (Beginner), A2 (Elementary), B1 (Intermediate), B2 (Upper-Intermediate), C1 (Advanced) and C2 (Proficient). The respective frequencies and percentages are shown in Table 3 and illustrated graphically in Fig. 2(ii).

Table 2. Level of interest in studying school subjects in English (Q5)

Level	Frequency	%	Valid %	Cumulative %
A	11	07.7	07.8	07.8
B	25	17.6	17.7	25.5
C	40	28.2	28.4	53.9
D	38	26.8	27.0	80.9
E	27	19.0	19.1	100.0
Missing responses	*01*	*00.7*		
N	142	100.0	100.0	

Table 3. Level of proficiency in English based on the Common European Framework of Reference for Languages (Q6)

Level	Frequency	%	Valid %	Cumulative %
A1	00	00.0	00.0	00.0
A2	03	02.1	02.1	02.1
B1	67	47.2	47.2	49.3
B2	54	38.0	38.0	87.3
C1	14	09.9	09.9	97.2
C2	04	02.8	02.8	100.0
Missing responses	*0*	*00.0*		
N	142	100.00	100.00	

The correlation of variables with the level of competence in English (Q6) is listed in Table 4. To check for consistency both Spearman and Pearson correlation coefficients are also tabulated.

In the previous scholastic year 97.9% of the participants (*N* = 139) scored 3 to 5 in the final test of chemistry taught in English (Q7): 23.9% (*N* = 34), 36.6% (*N* = 52) and 37.3% (*N* = 53) was the respective score for 3, 4 and 5. This is reflected in the final mark for the subject at the end of the year (Q8): 18.4% (*N* = 26), 41.1% (*N* = 58) and 37.6 (*N* = 53) for score 3, 4 and 5 respectively.

The extent of how much time the participants devoted to learning chemistry lessons in English (Q9) is calculated on the basis of the number of hours they had utilised to complete their homework (Q11). Nearly a third disliked such lessons (*N* = 53 or 32.3%) in contrast with 38.1% (*N* = 53) who liked them and 29.5% who did not mind having them (*N* = 41). More than 2 out of 5 participants (44%, *N* = 62) put limited effort into their homework whilst 22.7 % (*N* = 32) and 33.3% (*N* = 47) put moderate and significant efforts respectively. These results mirror the weekly hours spent to complete their homework (Q10): 40.3% (*N* = 56) spent less than half an hour whilst 48.9% (*N* = 68) spent between one and two hours and 5.1% (*N* = 7) over three hour hours per week. With respect to studying and preparing for the annual examination (Q12), 22.9% (*N* = 32) spent less than half an hour whilst 50.7% (*N* = 71) spent between one and two hours and 9.3% (*N* = 18) over three hours per week. Yet, the amount of effort involved (Q13) is minimal as in Q11: 44% (*N* = 62) put in limited efforts whilst 17.6 % (*N* = 25) and 37.8% (*N* = 53) put in moderate and significant efforts respectively. The amount of effort to participate in class (Q15) is substantial: 15.4% (*N* = 21) and 42% (*N* = 57) put in moderate and significant efforts respectively whilst 42.6% (*N* = 53) put in little or no effort. Under half of the students (46.3%, *N*= 63) participated in a group project in chemistry taught in English (Q14). Most participants were either moderately (15.4%, *N*= 10) or greatly satisfied (67.7%, *N*= 44) (Q16). The maximum score for this group project was 5, a level attained by 86.2% (*N*= 56) of the total number of participants; 12.3% (N = 8) scored 4 (Q17). The valid percentage efforts with respect to completing homework (Q11), studying and preparing for the examination/tests (Q13) and participation in class (Q15) are plotted in Fig. 3.

Table 4. Correlation of variables with the level of competence in English (Q6)

Question Ref. no.	*N*	Spearman's rho correlation	Significance (2-tailed)	Pearson c orrelation	Significance (2-tailed)
Q01	142	-0.044	0.601	-0.012	0.884
Q02	142	-0.189*	0.024	-0.152	0.071
Q03	142	-0.033	0.695	-0.061	0.474
Q04	142	0.218**	0.009	0.226**	0.007
Q05	141	0.460**	0.000	0.484**	0.000
Q07	142	0.119	0.158	0.097	0.250
Q08	141	0.112	0.188	0.079	0.353
Q09	139	0.226**	0.008	0.253**	0.003

Q10	139	0.008	0.928	-0.070	0.416
Q11	141	0.069	0.414	0.080	0.348
Q12	136	-0.070	0.414	-0.075	0.381
Q13	135	0.036	0.675	0.056	0.511
Q14	136	0.079	0.358	0.122	0.159
Q15	135	0.109	0.206	0.117	0.173
Q16	65	0.103	0.415	0.101	0.423
Q17	65	-0.006	0.961	-0.034	0.789
Q18	132	-0.020	0.818	-0.053	0.545
Q19	133	0.180*	0.038	0.201*	0.021
Q20	113	0.045	0.635	0.096	0.313
Q21	128	-0.175*	0.048	-0.154	0.082
Q22	128	0.047	0.599	0.072	0.422

* correlation is significant at the 0.05 level (2-tailed).
* * correlation is significant at the 0.01

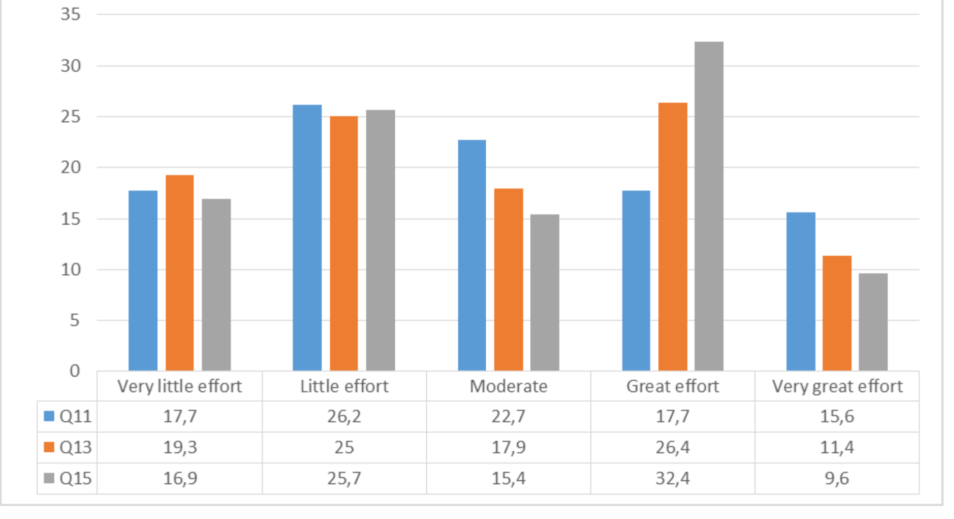
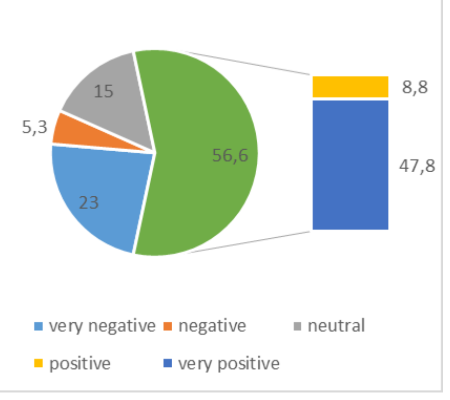
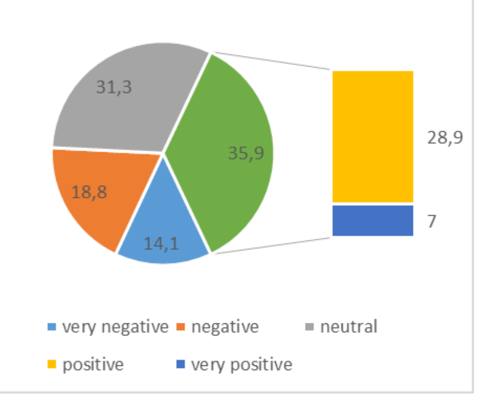


Figure 3. The valid percentage effort with respect to questions Q11, Q13 and Q15

With respect to students' preference to study chemistry in English, Bulgarian or in both languages (Q18), there was a slight preference for studying chemistry in the native language as opposed to English or both languages (□^{2} = 6.2, df = 2, p = 0.045). Over a third of the participants (37.6%, N = 50) were little satisfied; the percentage of students who are moderately and greatly satisfied is 21.8% (N = 29) and 40.6% (N = 54) respectively (Q19). Responses regarding how chemistry taught in English changed the participants' attitude to studying a science subject in English (Q20), nearly half of the respondents (47.85, N = 54) claimed that their attitude was



(I)



(II)

Figure 4. Attitudes of Bulgarian students (%) towards studying chemistry in English on the basis of the chemistry course taught in English (I) and the extent to which that course helped them to improve their knowledge and communication skills in English (II)

very positive (Table 5). The findings were plotted in Fig. 4(i). Over two-thirds of the students (67.2%, N = 86) sometimes (37.5%, *N* = 48), rarely (24.2%, *N* = 31) or never (5.5%, *N* = 7) encountered difficulties in studying chemistry concepts in English (Q21); only 18.8% (*N* = 24) and 14.1% (*N* = 18) have respectively 'often' and 'always' difficulties. Similar congruent values were obtained when the participants were requested to state to what extent chemistry taught in English helped them to improve their knowledge and communication skills in English (Q22). Over two-thirds of the students (67.2%, *N* = 86) responded that their command of English improved moderately to a great extent (Table 6). The results were plotted in Fig. 4(ii).

Table 5. Attitude towards studying science in English (Q20)

Attitude	Frequency	%	Valid %	Cumulative %
very negative	26	18.3	23.0	23.0
negative	6	04.2	05.3	28.3
neutral	17	12.0	15.0	43.4
positive	10	07.0	08.8	52.2
very positive	54	38.0	47.8	100.0
Missing responses	29	20.5		
N	142	100.00	100.0	

Table 6. Extent to which chemistry taught in English improves one's knowledge of English and communication skills (Q22)

Extent	Frequency	%	Valid %	Cumulative %
very little	18	12.7	14.1	14.1
little	24	16.9	18.8	32.8
moderate	40	28.2	31.3	64.1
great	37	26.1	28.9	93.0
very great	9	06.3	07.0	100.0
Missing responses	14	09.8		
N	142	100.0	100.0	

Discussion

No appreciable variations exist between the nonparametric and parametric correlations of variables with the level of competence in English. Students competent in English like to study school subjects taught in English. This applies also for participants who had studied English for a number of years. A less pronounced positive correlation exists between the level of competence in English and the extent to which a student likes to study chemistry in this foreign language. This finding indicates a consistent drive towards language learning coupled with an urge for scientific literacy.

CLIL provides an opportunity to study chemistry through varying perspectives. Participants highlighted that the students' urge for scientific literacy could be encouraged if complex scientific concepts are explained in their native language and more practical laboratory sessions are provided. These are clear indicators of the students' inclination to study chemistry in English. These rectifications can increase the students' motivation and proficiency in both the foreign language and the pedagogical subject matter. This provides an insight regarding the importance of language integration through content learning, a perspective which unfortunately is less researched (Llinares et al., 2012). The language used for learning and the content to be learnt are both crucial considerations in CLIL.

Coyle (1999 had proposed a curriculum for a given subject taught in a foreign language based on the 4Cs, the four dimensions of CLIL, namely (i) content, (ii) cognition, (iii) communication and (iv) culture. In CLIL, the cultural context is, along with cognition, content and communication, the foundation that provides the setting for an engaging learning environment with specific language learning and subject area goals. Coyle and al. (2010) emphasize the importance of the cognitive engagement of students for effective learning. Students are interested in alternative teaching methods and forms of classroom sessions, with some calling for the utilization of diverse forms of teaching methods ranging from games to interactive classroom practices, therefore underlining the cognitive process. Solving problems and formulating questions, while working in groups, are important ways for pupils to master the process of "constructing knowledge which is built on their interaction with the world" (Coyle et al. 2010). Students were eager to undertake the group project written in English about a chemistry topic wherein they were requested to work in groups and utilise this opportunity to demonstrate their creativity, their ability to communicate chemistry concepts in English and to exercise this ability by presenting the information to their peers through a foreign language. These actions serve to improve their oral communication skills in English thereby improving their competence in a language of the European Union whilst developing scientific literacy through such an international transcultural tongue.

In Bulgaria there exists a positive attitude towards the bilingual programme in chemistry, promoting the learning of a science subject in a foreign language. Compared to the north-western Spanish region of Asturias, which is the subject of recent academic research (Linares-Cardoso, 2016), Content and (English) Language Integrated Learning applied to teach chemistry in Bulgaria achieves the vision of the EU by providing the necessary grounding for enabling future citizens skilled in using the language of another EU Member State.

Conclusions

The results obtained in the research, undertaken on Grade 10 students, were evaluated in order to understand the dynamics of teaching and learning chemistry in English in Bulgaria and thereby improve the teaching of this subject in a second language. No gender influences were noted in this study.

There exists a nonparametric correlation with the level of competence in English. Students' proficiency in English is related to: (i) the number of years that a participant had been exposed to the language; (ii) whether s/he enjoyed studying a school subject in English; and (iii) the extent to which a given participant enjoyed the chemistry taught in English lessons.

The level of satisfaction in classes of chemistry taught in English and the difficulties experienced in comprehending chemistry concepts taught in a foreign language are also related to the extent to which s/he were proficient or otherwise in English.

To ensure accurate scientific literacy, chemistry concepts should be explained in class in the native language prior to translating them into English. Furthermore, alternative and innovative forms of classroom practice are interpreted by the students as opportunities to increase their aptitude to study the subject in a foreign language. Group work is a medium which stimulates active communication regarding pertinent scientific concepts, ideas and practices between peers such that the receivers understand the message of the transmitters. Thus group work can sustain the acquisition of scientific literacy through a foreign language, a case of language integration through content learning.

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Appendix

Questionnaire: CLIL in Chemistry Secondary Education (Based on Akbarov et. al, 2018)

Q1: Age: ______ years

Q2: Gender: Male / Female / Other

Q3: Do any of your parents and/or grandparents and/or siblings speak English: Yes / No

Q4: For how many years have you been learning English?

Q5: Do you like studying school subjects in English? (*Select A to E*: A-not at all, B-not so much, C-do not mind, D-like studying, E-like studying very much):

A B C D E

Q6: The Common European Framework of Reference for Languages standard for evaluation of proficiency in a given language makes use of the following six reference levels for grading an individual's language proficiency:

A1 (Beginner)
A2 (Elementary)
B1 (Intermediate)
B2 (Upper-Intermediate)
C1 (Advanced)
C2 (Proficient)

What is your level of English proficiency? (*Mark with circle one from the above levels which best represent your proficiency in English*).

Q7: What was your mark at the final chemistry test in Grade 9?

3 4 5 6

Q8: What was your final mark for Chemistry taught in English in Grade 9?

3 4 5 6

Q9: To what extent do you like your chemistry classes taught in English (*Select A to E*: A-not at all, B-not so much, C-do not mind, D-like it, E-like it very much):

A B C D E

Q10: How many hours per week do you spend to complete your homework of the chemistry classes taught in English? _____hours

Q11: How much effort do you put to complete your homework of the chemistry classes taught in English? (*Select A to E*: A-very little effort, B-little effort, C-moderate, D-great effort, E-very great effort):

A B C D E

Q12: What was the number of hours per week that you spend studying and preparing for your examination/ tests of chemistry taught in English? _____ hours

Q13: How much effort do you put to study and prepare for your examination of chemistry taught in English? (*Select A to E*: A-very little effort, B-little effort, C-moderate, D-great effort, E-very great effort):

A B C D E

Q14: Did you participate in the group project written in English and covering the important topics from the field of chemistry? Yes / No

Q15: How do you rate your participation in chemistry classes taught in English? (*Select A to E*: A-very little effort, B-little effort, C-moderate, D-great effort, E-very great effort):

A B C D E

Q16: If your answer to Question 14 is YES, what was your overall personal satisfaction of work undertaken (*Select A to E*: A-very little satisfaction, B-little satisfaction, C-moderate, D-great satisfaction, E-very great satisfaction):

A B C D E

Q17: If your answer to Question 14 is YES, what was the final mark of the group project for chemistry taught in English? ______

Q18: In which language do you prefer to study chemistry? *Select one of the following:*

in English,

in Bulgarian

I do not mind whether it is taught in English or Bulgarian

Q19: What is your level of satisfaction with chemistry classes taught in English? (*Select A to E*: A-very little satisfaction, B-little satisfaction, C-moderate, D-great satisfaction, E-very great satisfaction):

A B C D E

Q20: In which way did English-taught chemistry content change your attitude towards studying science in English? (1 – to become very negative, 5 – to become very positive):

Q21: Do you have difficulties with understanding chemistry concepts taught in English? (*Select A to E*: A-never, B-rarely, C-sometimes, D-often, E-almost always):

A B C D E

Q22: To what extent did chemistry taught in English improve your English knowledge and communication skills? (*Select A to E*: A-very little; B-little, C-it did improve it, D-great extent, E-very great extent):

A B C D E

NOTES

1. https://europa.eu/documents/comm/white_papers/pdf/com95_590_en.pdf
2. https://www.languages.dk/archive/clil4u/book/CLIL%20Book%20En.pdf
3. https://www.mon.bg/bg/59

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