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Educating Science Teachers for All

ESTA

ESTA Speical Issue

Editorial #124

This issue is a special issue devoted to papers from the Erasmus+ project ESTA, Educating Science Teachers for All. Previous special issues have covered the SALiS project, the TEMI project and the DiSSI project. The focus of ESTA is the role of language in making science education accessible to all students and promoting inclusion.

The two pillars on which science and science education rest are language and mathematics. Without language proficiency there can be no teaching or learning, no thinking or communication. Language is not only the medium of instruction, but it is also the vehicle for conveying and using ideas and the foundation of thinking. Language proficiency in the language of instruction is now recognised as a major barrier to student learning.

As currently practised, a major obstacle to the learning of science is the failure to recognise the centrality of language activity to science and, as a corollary, the implications for its teaching.

Osborne, J., 2002, 'Science Without Literacy: a ship without a sail?' *Cambridge Journal of Education,* Vol. 32, No. 2, 203-218

Science has its own specialised vocabulary and in many ways it is seen by students as a foreign language. Although each language has its own specialised science vocabulary, there is also a common and universal language in the symbolic languages of chemistry and mathematics. The symbols, formulae and equations of chemistry and mathematics are universal.

As well as the inherent language difficulties in the sciences, almost every country now has the problem of greater numbers of non-nationals in their classrooms. They often have their own languages and the language of instruction is not their native tongue. They are thus trying to learn science, with all its difficulties, as well as learning a new spoken and written language.

This project is a small attempt to seek to address this issue in the partner countries. Solving the problem starts with recognising it and the project is based around teacher workshops, where teachers and trainee teachers become aware of the issues and become familiar with strategies to address it.

With an increasingly diverse student population in many countries, including Ireland, the ideas and practices described in these papers have relevance to anyone teaching science. Differences in languages can be divisive in the classroom but a common shared language can be a unifying factor, cutting across cultural boundaries.

I would like to thank the UL ESTA team who have also been involved in editing this issue: Dr. Catherine Martin, Dr. Ebru Eren and Dr. Sarah Hayes. The printing of this issue has been funded by the EU through the ESTA project.

Peter E. Childs

Peter E. Childs
Hon. Editor

In this issue #124

The major part of this issue is devoted to papers from the various partners on the work of the ESTA project. The focus is on the role of language for inclusivity in science education. This issue includes one paper each from Germany and Ireland; two papers from Georgia; 2 papers from the Philippines; and two papers from Bosnia and Herzegovina

The project leader, Professor Dr. Silvija Markic introduces the project (p.4). The German team then gives an overview of some of the important issues involved in teaching science relating to language, especially for non-native speakers (p.6).

The first paper from the Philippines describes their experience at the Philippine Normal University in working with pre-service science teachers, with useful proforma for planning lesson plans (p.11).

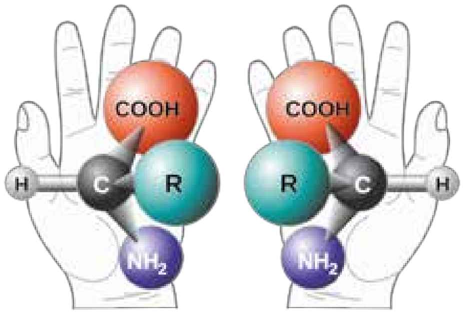
Next come two papers from Georgia, the first from Ilia State University (p. 22) and the second from Telavi State University (p. 26). Georgia has a unique spoken language and script, which presents extra difficulties for non-national students entering the Georgian education system.

A second paper from the Philippines from De la Salle University, Manila describes their journey with the ESTA project (p 31).

The paper from the Limerick team focuses on ways of teaching scientific vocabulary (p. 39). (An earlier paper on the project from UL appeared in *CinA!* #121, Spring 2023, pp. 36-42.)

The final two papers come from Bosnia-Herzogovina. The first (p.48), describes the materials they produced in several local languages for teacher's workshops. The second on p. 52 focuses specifically on bringing the ESTA ideas into chemistry laboratory teaching.

Finally, we have a short overview and reflection on the project from the EU evaluator, Dr. Rachel Mamlok-Naaman from Israel (p. 59).



Given the language theme of this issue I had to include a Chemlingo article, a series which looks at some of the quirkier aspects of scientific language. This one on 'Handy Chemistry' looks at the language of optical isomerism (p. 61).

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Reading. Reading maketh a full man; conference a ready man; and writing an exact man; and, therefore, if a man write little, he had need have a great memory; if he confer little, he had need have a present wit; and if he read little, he had need have much cunning, to seem to know that he doth not.

Francis Bacon (1561-1626)

Introduction

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Although the EU-report on science education for responsible citizenship and the Paris declaration recommend teaching all students for our better future, in Georgia, the Philippines, and Bosnia and Herzegovina, a large number of young people do not meet basic requirements in science. This has been shown in international assessments of science performance in which all three countries scored very low.

According to TIMSS 2007, in Georgia, 39 % of the students achieved only the lowest level of competence in science. The PISA 2015 results revealed an even more pressing need to improve the country's science education: 50.8 % of the students did not reach the lowest benchmark in science in grade 8. The Philippines only took part in one assessment, namely the TIMSS 2003 study. Here, the country's average achievement was 377 points far lower than the scale average of 474 points, which shows the students' very weak performance in science attainment. In Bosnia, 20 % of the students did not reach the lowest benchmark in the TIMSS 2007 study. The country's average score was with 466 points, far below the scale average. These results show the urgent need to improve science education at secondary school level in these countries.

Tne great challenge for science education in Georgia, Bosnia and Herzegovina, and the Philippines are the countries' plurality of languages and cultures. While the education system in Georgia and in Bosnia and Herzegovina, underwent major changes after the fall of the Soviet Union and the subsequent changes in power relations, colonialism has left its imprint on the Philippine educational system. Science education in all three countries takes place amidst political and ethnic divides that translate into linguistic heterogeneity and cultural diversity.

Thus, the Erasmus+ Project "Educating Science Teachers for All" (ESTA) seeks to work towards the sustainability goals put forward by the United Nations, which also play a central role in European Union sustainability policy. Our attempts can be subsumed under sustainability goal 4.1 to *"ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes"* (UN General Assembly, 2015, p. 17) with a special focus on the appreciation of cultural diversity (4a) and educating teachers to ensure an effective inclusive education system (4c). In a wider perspective, this contributes equally to goal 10.2, i.e. to *"empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status"* (UN General Assembly, 2015, p. 21). In particular, the European Commission's expert group for science education has conceptualized responsible science education as *"inclusive in terms of gender, social, economic and cultural diversity"* and therefore has adopted a broad definition of inclusive education.

Partners from two German universities (Ludwig-Maximilian University of Munich, Ludwigsburg University of Education), one Irish university (University of Limerick) supported partners from Georgia (Ilia State University in Tbilisi and Telavi State University), the Philippines (De La Sale University and Philippine Normal University) and Bosnia and Herzegovina (University of Sarajevo and University of

Mostar) on their way to developing their science teacher education towards inclusive teaching and learning. The project started in January 2020 and ended in January 2024. The external evaluator was Prof. Dr. Rachel Mamlok-Naaman from the Weissmann Institute, Israel.

ESTA aims to improve the level of competencies in HEI in the partner countries by the professionalization and development of university science teacher educators regarding diversity in science classes (with a focus on language and culture). The teacher educators, in turn, will share their knowledge and skills with in-service and pre-service science teachers, and thereby contribute to a more inclusive and higher quality science teaching in their countries.

In following papers, you can find the contributions of the ESTA partners, describing their work. We hope that our work will help you to reach all your students and your students to learn chemistry better.

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UN General Assembly, (2015), available at: https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf

Acknowledgments

The presented activities were part of the project "ESTA—Educating Science Teachers for All" which is co-funded by the Erasmus+ Programme of the European Union, under grant number 609719-EPP-1-2019-1-DE-EPPKA2- CBHE-JP. We would like to thank the European Union for its financial support. The European Commission's support for the production of this publication does not constitute an endorsement of the content, which reflects only the views of the authors, and the Commission cannot be held responsible for any use that may be made of the information contained therein.

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How to pay attention to scientific language in chemistry classes?

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Theoretical Background

The overarching goal of science education in general, and thus chemistry education in particular, is to promote scientific literacy and thus enable students to engage with science-related topics as reflective citizens (Bybee, 2015; OECD, 2017; Roberts & Bybee, 2014). Thus, literacy in scientific language is essential for students because *"it is impossible to build understanding of science without exploring how the multiple languages of science are used to construct meaning"* (Osborne, 2002, p. 206). In chemistry education, the scientific language – the *Chemish* – is important for teaching and learning chemistry (Markic & Childs, 2016). At the same time, learning the scientific language is one of the difficulties in science education (Wellington & Osborne, 2001).

Markic and Childs (2016) characterize Chemish's alphabet as consisting of the element symbols, chemical formulae to be the words of Chemish, and the rules of chemical combination as well as chemical equations as the syntax of the Chemish language. Furthermore, they identify six characteristics of Chemish (Markic & Childs, 2016, pp. 435–436):

- *technical words and terms* are mostly unfamiliar to students, complex, polysyllabic, and often difficult to spell, some are derived from Greek or Latin or only appear a few times, even symbolic language, as well as mathematical and graphical elements, equations, tables, etc., are included;
- *nontechnical words* are used in chemistry class that may have a different meaning from everyday usage and thus become technical terms in the context of chemistry;
- *logical connectives* are used to make sense over more sentences;
- *command words;*
- *argumentation and discourse patterns* are important to learn the scientific language and participate in science discourse;
- *readability of texts* is different to, e.g., novels, since there is a high density of information and technical terms in short and complex sentences which are often connected by logical connectives and written in a passive voice.

Furthermore, Chemish is used on *different representational levels* as there are (i) the macroscopic, (ii) (sub)microscopic, and (iii) representational or symbolic level (De Jong & Taber, 2007; Johnstone, 1993) and each of these levels requires specific use of language.

Teachers Knowledge on Teaching and Learning *Chemish*

Current research identifies a lack of pre- and in-service teachers' knowledge regarding scientific language and its teaching and learning. Regarding scientific language itself, teachers are found to lack knowledge about scientific vocabulary (Carrier & Grifenhagen, 2020; Colucci-Gray et al., 2013; Vladušić et al., 2016) or the characteristics of scientific language itself (Mayaba et al., 2013; Sagiannis & Dimopoulos, 2018; Walker, 2011). Moreover, pre-service science teachers are found not able to express the semantic structure of a concept (Yun & Park, 2018). Pre-service science teachers are even found to have only a narrow understanding of scientific language at the vocabulary level (Tang & Rappa, 2021) and identify only these as language demands within science classroom, without considering other characteristics of scientific language (Meier *et al.*, 2020). Additionally, pre-service science teachers are found to be unaware of their word choice (Carrier & Grifenhagen, 2020; Colucci-Gray et al., 2013), are not able to explain scientific concepts (Vladušić et al., 2016), struggle with the differentiation of term meanings regarding the everyday and science context (Gyllenpalm &

Wickman, 2011), or even misuse scientific terms and provide incomplete meanings (Carrier, 2013). Research shows as well that science teachers are found not to focus on scientific language and its characteristics when teaching (e.g., Mayaba *et al.*, 2013; Sagiannis & Dimopoulos, 2018; Walker, 2011; Yun & Park, 2018). They neither feel responsible regarding their task to teach scientific language in general (Markic, 2015) nor know how to identify and write lesson objectives focusing on scientific language (e.g., Mayaba *et al.*, 2013; Walker, 2011). Even if teachers are aware of the teacher's responsibility to teach scientific language, there is great uncertainty about how to support students in learning scientific language (Seah, 2016).

Since chemistry teachers have to act as linguistic guides for their students to help them acquire scientific language (Laszlo, 2013), they need a specific kind of teachers' knowledge. This is why, starting from PCL and Pedagogical Language Knowledge (PLK), which is defined as *"knowledge of language directly related to disciplinary teaching and learning and situated in the particular (and multiple) contexts in which teaching and learning take place"* (Bunch, 2013, 307), Markic (2017) adapts it to the notion of Pedagogical Scientific Language Knowledge (PSLK) as a chemistry or science teachers' *"knowledge of scientific language related to teaching and learning chemistry, focusing on different scientific topics and contexts"* (Markic, 2017, 181). PSLK nevertheless remains a rather theoretical construct and less is known about it.

The work of Mönch and Markic (2022; 2024) presents the knowledge that teachers need to have, when putting focus on scientific language (see Table 1).

Table 1: Facets of Pedagogical Scientific Language Knowledge (PSLK)

Knowledge of …	
… **Scientific Language Role Models**	Not only one as a chemistry teacher but also other students and instances outside school can serve as scientific language role models.
… **Specitfic Methods and Tools for Teaching and Learning Scientific Language**	Some methods are used often to teach scientific language, e.g., glossary, graphic organizer, concept map, scaffolds in forms of sentence patterns etc., gamification, digital resources.
… **Providing Scaffolds for Scientific Language Development**	The lower the grade level the more scaffolds, e.g., visual aids, text puzzles, sentence starters, are needed.
… **Communicating Expectations Clearly**	It's important to point out whether it's a learning or an evaluation situation for students to have the chance to use scientific language accordingly. Command words are reported to help.
… **Providing a Discursive Classroom**	Students must be given opportunities to practice, multiple dimensions of language must be incorporated, questions must be intentionally asked, and mistakes must be seen and used as learning opportunities.
… **Providing Multiple Resources and Representations**	Since especially the sub-microscopic level is very abstract to students, visualization, using mnemonic bridges, comics, models, etc., is crucial to foster students' understanding.
… **Making Scientific Terms and Language Explicit**	Intentionally drawing students attention to scientific terms and discussing its morphology, different scientific text types and discussing different meanings in everyday life and science.
… **The Development of the Concept Before the**	Slowly abstract from every day language on the level of the phenomena to a more abstract level and scientific language.

Development of the Scientific Language	
... **Motivation When Learning Scientific Language**	To not overwhelm students, scientific language has to be used very dosed in the beginning and accompanied by multiple resources and representations.
... **Lesson Preparation and Follow-Up**	Scientific language has to be part of the lesson objectives, students prior knowledge and potential problems have to be anticipated, scientific terms have to be selected and defined before teaching the lesson, material has to be checked for scientific language usage during preparation and afterwards the scientific language use has to be reflected.

Practical support in for teaching and learning scientific language in chemistry classes

Starting from the model of Pedagogical Scientific Language Knowledge the following tool – which can be uses as a reminder – is developed which should support chemistry teachers in more sensitive and explicit teaching and learning of scientific language in their chemistry classes.

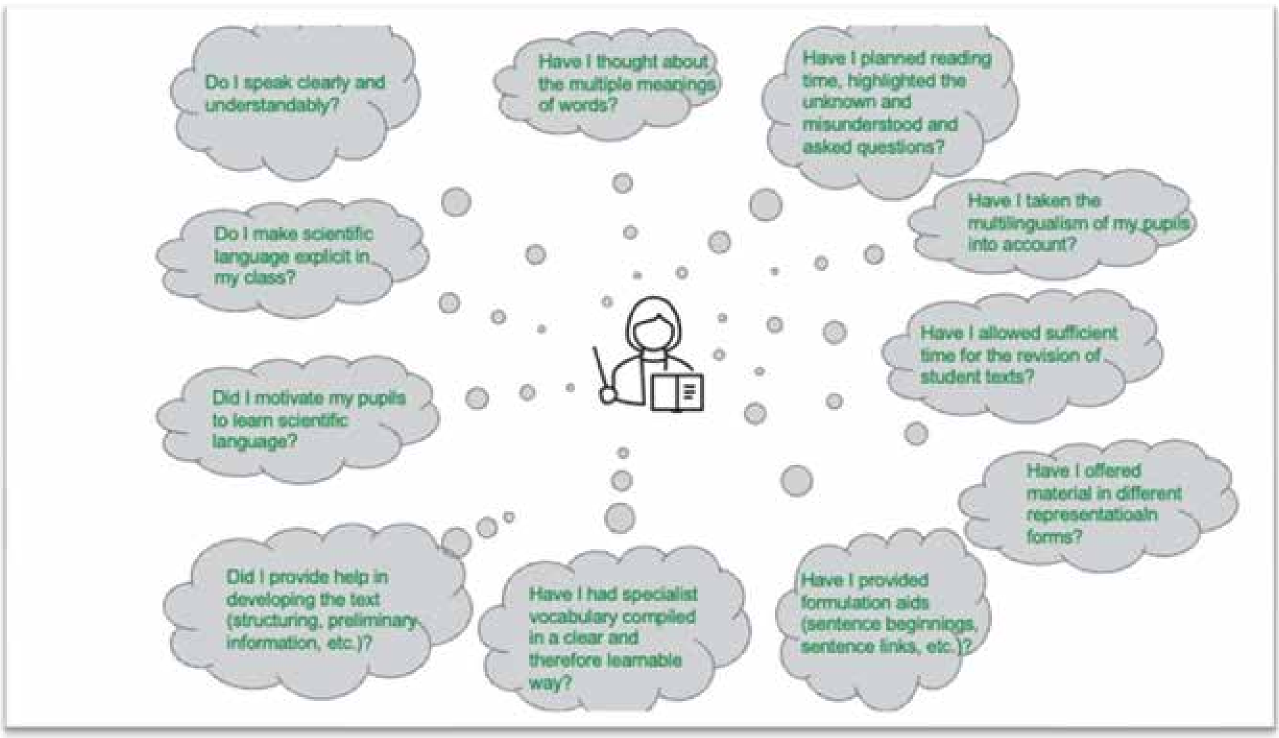

Figure 1: Checklist for teaching and learning *Chemish*

We suggest the picture in Figure 1 for teachers to use while preparing and planning their lesson, but also as a reflection tool after each lesson.

The tool was used in the German language in different teacher education programs. Teachers used it as a tool while planning their lessons in teams but also a "checklist" after the peer-observation of the lesson.

Acknowledgments

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Biographies

Professor Dr. Silvija Markic *is a professor of chemistry education at the Ludwig Maximilian University in Munich. Until April 2022 she was a professor for scientific learning at the Ludwigsburg University of Education. She studied chemistry and mathematics for grammar school and was senior researcher at the University of Bremen until March 2017. Current key areas of work include learning scientific language, teachers' knowledge of language, dealing with linguistic heterogeneity and cultural diversity in chemistry classes.*

Corinna Mönch *is a PhD student at the Ludwigsburg University of Education. Here she studied Mathematics, chemistry and ethics for the lower secondary school and is about to complete her internship. In her dissertation, she developed university teacher education program and researched with the focus on chemistry teachers` pedagogical scientific language knowledge.*

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Chronicles of Culture and Language Sensitization in Pre-Service Science Teacher Education for Inclusivity in Science Education

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Abstract
This article chronicles how pre-service science education students may be engaged to introduce inclusivity in science education. We sequenced the narration as the development of a framework for inclusive science education, designing training materials and training blueprints, and engaging the 325 pre-selected pre-service science students in a two-phase training. Results revealed that their developed products (Hook Videos and Lesson Exemplars) showcase the science capital dimensions and inclusivity attributes. Analysis of their evaluation responses and daily reflections confirm that they were able to enhance their perspectives and gain positive understanding and attitudes toward science teaching endeavors as indicated by the emerging themes: inclusivity in science education, goals and nature of science education, and science teachers' competence and pedagogies. These results proved the significance of pre-service science teachers' awareness and understanding of inclusive science education that will redirect and shape their instructional ideals, processes, materials, and practices. Envisioning more robust training can include in-person training, post-training monitoring, and expansion of the training field to include other culture- and language-rich localities in the country.

Introduction
The Filipinos grieve over the PISA 2022 results, which filled in the news in the Philippine Daily in December 2023. In the latest PISA data, the Philippines ranked 77th overall out of 81 participating countries and 3rd from the bottom for science, while 6th from the bottom rank for mathematics and reading (Chi, 2023). Hence, the Philippine Department of Education, responsible for the learning process of youth, has eyes towards strengthening curricular reforms, teacher training, pedagogical improvement, infrastructure enhancement, materials acquisition and development, and financial capabilities through increased budgetary provision (*MATATAG Curriculum | Department of Education*, no date). However, these reform activities in the Department of Education should be matched with comparable programs for teacher preparation at the pre-service level (Gouëdard *et al*., 2020). Deep training of science teachers begins at this level (pre-service), and recruitment of more entrants to preservice science education may be able to boost the country's ILSA (International Large-Scale Assessments) performance in science and improve the STEM pipeline for the country's economic growth.

Working on the domains of the country's new curricular reform known as the MATATAG curriculum, highlights, among others, the promotion of learner well-being, inclusive education, and a positive learning environment. Within this framework, the European-funded Educating Science Teachers for All (ESTA) program, involving five countries (Germany, Ireland, Georgia, Philippines, and Bosnia and Herzegovina), offered viable measures for pre-service science education students' training and pre-service teacher education programs. In particular, the Philippine Normal University (PNU) ESTA-Philippines group focused on developing frameworks, training, and tools for pre-service science education students to help achieve the country's goal of inclusive science education.

Science Education for Linguistic and Cultural Diversity in Philippine Public Higher Education (SELC-PhPHiEd)

The ESTA-PNU group utilized several research approaches and methodologies to develop and validate the ESTA-PNU framework, *Science Education for Linguistic and Cultural Diversity in Philippine Public Higher Education (SELC-PhPHiEd)*. Figure 1 visualizes three major components of the framework: the Filipino learners, the pedagogies and pedagogical frameworks, and the teachers' knowledge system in enacting the science curriculum. These general constructs of the framework outline how the blueprint may also influence the different teacher education processes that inform teachers' knowledge, training, research in pedagogies, and the development of products for teaching and learning, such as lesson exemplars, modules, and assessment within the bounds of linguistic and cultural inclusivity. SELC-PhPHiEd is PNU's vehicle to advocate concretely technology transfer and disseminate knowledge on linguistic and cultural inclusivity to other Teacher Education Institutions for higher-quality science education in the country.

Figure 1: ESTA-PNU Science Education for Linguistic and Cultural Diversity in Philippine Public Higher Education (SELC-PhPHiEd) Framework

Key products stemming from the framework as tools for pre-service science education students included the Lesson Exemplar (LE) template, rubric assessment, peer review forms, and guide to Hook Videos. These tools and instruments facilitated the seamless training of pre-service science students to acquaint them with inclusive science education. Specifically, this article highlights the different sections of the Lesson Exemplar template that aided sensitization and appreciation of cultural and language diversities in Philippine classrooms.

The LE template has four key parts that mimic the ESTA-PNU framework. Table 1 presents the alignment of the key parts of the LE template to the ESTA-PNU framework and the different categories under each key part of the LE.

Table 1: Alignment of the key parts of the LE template to the ESTA-PNU framework and the different categories under each key part of the LE

ESTA-PNU Framework Constructs	LE Template Key Parts	Categories under each LE Key Part
The Filipino learners	The Filipino Learners	● Class/Learner's Demographic Profile ● Other forms of Heterogeneity (e.g., Technical Capability, economic status, race, disability, others with special needs) ● Misconception/Course Topic Impression

Pedagogies and pedagogical frameworks	Pedagogies	• Learning Standards
		  ○ Course Intended Learning Outcome(s) (CILO)/Most Essential Learning Competencies (MELCS)
		  ○ Alignment of objectives, content, and tasks
		• Addressed skills (cognitive, science process skills, future skills)
		• Scientific Attitudes and Filipino Values
		• Language Function
		• Mother tongue translation of difficult terms
		• Key Language
		• Teaching and Learning Process
		  ○ Use of STEAM approach
		  ○ Lesson Integration of culture, gender, language, and context
		  ○ Teaching strategies
		  ○ Learning activities for face-to-face and online setup using the 5E's approach

Teachers' knowledge system in enacting the science curriculum	Teachers' Knowledge	• Technology used by the teacher and the students • Assessment for Learning • Assessment of Learning • Teacher's competence • Readings/Materials/Tools • Reflection and Modification sections

Engaging the Pre-Service Science Education Students in Inclusive Science Education

The ESTA-PNU team designed training to engage the pre-service science education students of the country in inclusive science education. Using the ESTA framework (Figure 1) as the grounding model of the training design, pre-service science education students were recruited in a two-phase training workshop in the first term (September to December) of the school year 2023-2024.

Phase 1 of the training concentrated on inputs to participants on the science education landscape, culture, and language integration in enacting science lessons, hooks and interest science, language for sciences, science capital, technology integration, and flipped learning/classroom. Phase 2 of the training is a mentoring session for the pre-service science education student participants to develop their respective lesson exemplars and hook videos. We designed the mentoring session as a closely-monitored session of groups of five to seven students mentored by three to four ESTA-PNU core team members spanning one month. This mentoring session featured the following steps: 1) designing and developing the lesson exemplars and hook videos, 2) peer review of developed lesson exemplars and hook videos, 3) revision and finalization of the products, and 4) final presentation and critiquing.

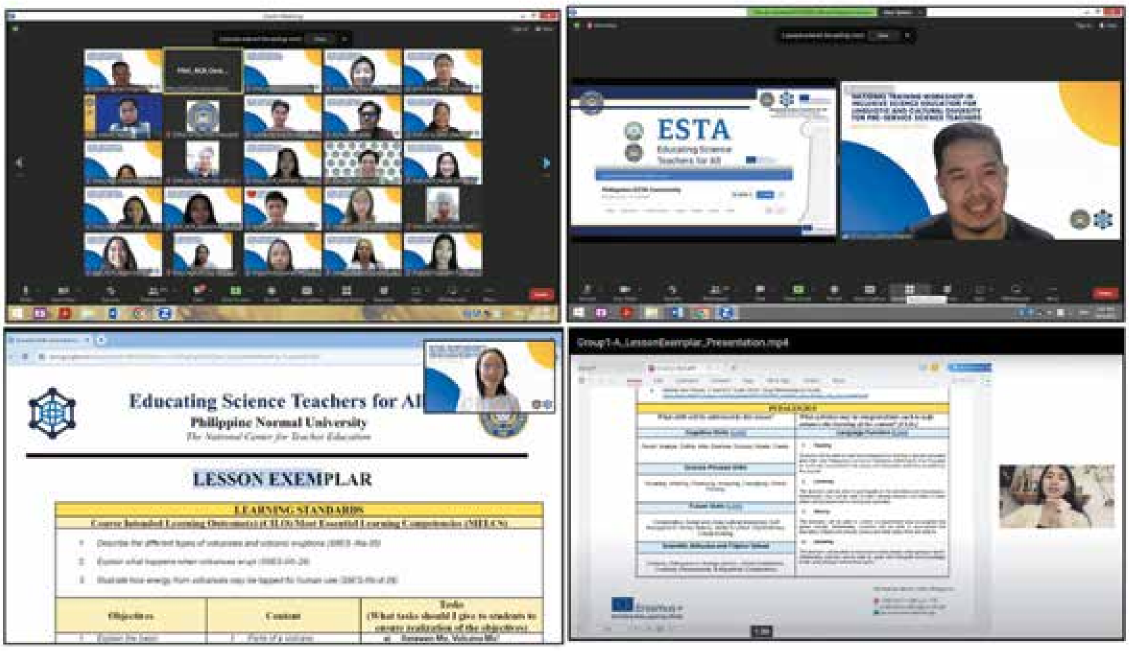


Figure 2: Plenary and Mentoring Sessions of the Training

The ESTA-PNU team recruited participants through official letters to accredited organizations such as the Philippine Network of Normal Schools (3NS) and the Philippine Associations of State Universities and Colleges (PASUC). We also extended the invitation to join the training to all the branches or campuses of the implementing institution. For phase 1 of the training, we have recruited 325 participants. For phase 2, purposive sampling using the following criteria identified 15 participants: attended and engaged in all phase 1 sessions, were endorsed by the university, and were willing to participate in an intensive mentoring session. Appendix 1 presents the participant profile.

(a) Training Implementation and Materials and Tools

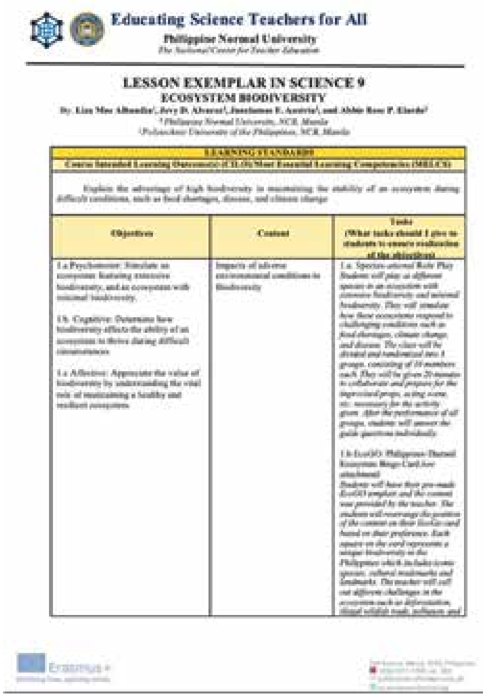
The training commenced on September 27, 2023, where we engaged the participants in initial assessments and evaluation using a profiler, pre-survey questionnaire, and pre-survey on science capital. All these tools were adapted and subjected to content validity by the core team members. Plenary sessions facilitated by the ESTA-PNU team started after the surveys were done. We also administered daily reflection questions to determine how the participants assimilated all inputs during the training days' inputs and re-administered the same assessment tools after phase 1 of the training. This article focuses on the initial results from our coding process for all the participant's daily reflections and open surveys.

Initial Findings

(a) Analysis of Developed LEs

The products developed by the pre-service science student participants showcase some dimensions of science capital and attributes of inclusivity in science education as presented in their developed lesson exemplars and hook videos. Table 2 showcases these attributes and dimensions.

Table 2: Science Inclusivity Attributes and Science Capital Dimensions Showcased by Pre-service Science Students Developed Lesson Exemplars and Hook Videos

Science Inclusivity Attributes and Science Capital Dimensions	Samples
● Scientific literacy ● Science-related attitudes, values, and dispositions ● Knowledge about the transferability of science skills ● Science media consumption ● Participation in out-of-school science learning contexts ● Family science skills, knowledge and qualifications ● Knowing people in science-related jobs ● Talking to others about science in everyday life	 Educating Science Teachers for All Philippine Normal University LESSON EXEMPLAR IN SCIENCE 9 ECOSYSTEM BIODIVERSITY LEARNING STANDARDS Objectives / Content / Tasks
● Teachers' Attitudes towards Valuing Students' Culture and Languages ● Teachers' Expectations of CLD Students' Academic Performance ● Positive Attitude towards Inclusion of CLD Students in Subject Area Classes ● Teachers' Beliefs about CLD Students Enrolled in their Subject Area Classes ● Teachers' Attitudes towards CLD Students' Needs	

<table>
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Class/Learner's Demographic Profile

Year Level: Grade 9   Course/Discipline: Life Science   Number of Students: 20 students

Ethnicity:
• All of the students do not belong to an indigenous group

Language(s):
• Most of the students are comfortable in speaking Filipino-English;
• Some students are more fluent in Filipino than English; and
• Few students are more fluent in English than Filipino.

Gender:
• Most of the students identify as heterosexual; 11 Female, 9 Male; while
• Some of students identify as part of LGBTQIA+

Other forms of Heterogeneity (e.g., Technical Capability, economic status, race, disability, others with special needs):

Technical Capability:
• All of the students have access to basic technologies such as cellphones and internet.

Economic status:
• Most of the students belong to the lower middle income class.
• Some of the students belong to the low income class.

Disability and special needs
• All of the students do not have disabilities and special needs.

Race
• All of the students belong to asian race, specifically Filipino nationality

Misconception/Course Topic Impression

1. "Fact or bluff: The more species in the area the better"


• Students' Misconception: Having more species in an ecosystem is good for biodiversity.
• Example: Water Hyacinth in Pasig River
• Explanation: Having a high number of species in an ecosystem may cause imbalance in the diversity, which leads to the destruction of the ecosystem. Water hyacinth is an invasive species. The rapid reproduction of the species causes decline in the diversity. Water hyacinth [illegible] the oxygen level of the water which kills other aquatic species. It also clogs off waterways which prevent fishing, and promote flooding.
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<td>
• Positive Attitude towards Inclusion of CLD Students in Subject Area Classes
• Teacher's knowledge and competence
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What skills will be addressed by this lesson? | What activities may be integrated into each to help enhance the learning of the content? [CLIL]

Cognitive Skills (Link)
• Identify the cause and effect of biodiversity loss
• Analyze species niche in an ecosystem
• Compare the conditions/response of high biodiversity and low biodiversity
• Relate lessons to personal life through eco-logging journal

Language Function (Link)
1. Reading
The students should be able to draw conclusions from the result of the simulation conducted. Specifically, it encompasses the role playing activity where students are able to see the difference between ecosystems with extensive biodiversity and minimal biodiversity.

2. Listening
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<td>
• Teachers' Attitudes towards Valuing Students' Culture and Languages
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Filipino Values
• Environmentalism/ Nature Stewardship/ Makakalikasan

What are the action words and vocabulary for this lesson? Please provide Mother Tongue translation for each identified vocabulary [MTB-MLE]

• Philippine Tarsier = Mamag
• Mindoro Dwarf Buffalo = Tamaraw
• Arabian Jasmine = Sampaguita
• Palawan Peacock-Pheasant = Tandikan
• Whale Shark = Butanding
• Philippine Pangolin = Balintong
• Sander's Vanda = Waling-Waling
• Philippine Eagle = Agila
• Philippine Crocodile = Buwaya
• Carabao = Kalabaw
• Coconut Palm = Buko
• Sea Cows = Dugong
• Green Sea Turtles = Pawikan
• Round Leaf Fountain Palm = Anahaw
• Visayan Hornbill = Tariktik
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<td>
• Teacher's knowledge and competence in technology
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TEACHER KNOWLEDGE

Technology Being Used by Students
What technology will my students use in this lesson?
• DIY EcoGO
• Plickers Photo Quiz
• Eco-logging Journal

What were your reasons for choosing the technology for the students to use?
• DIY EcoGO - to let the learners make their own Philippines-themed Ecosystem Bingo Card using recyclable materials to showcase their own creativity. This will help them to analyze and navigate their own EcoGO cards. Printed EcoGO is not

Technology Being Used by Teacher
What technology will I use in this lesson?
• Laptop
• Smart TV/Projector
• Canva Presentation
• Printed Sample EcoGO
• Printer
• Plickers App - Cellphone
• Plickers Website

What were your reasons for choosing the technology for the teacher to use?
• Laptop - to make the canva presentation and other activities.
• Smart TV/Projector - to display the canva presentation.
• Canva Presentation - to facilitate the discussion and instruction through
</td>
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<td>
• Scientific literacy
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- Science-related attitudes, values and dispositions
- Knowledge about the transferability of science skills
- Science media consumption
- Participation in out of school science learning contexts
- Family science skills, knowledge and qualifications
- Knowing people in science-related jobs
- Talking to others about science in everyday life
- Teachers' Attitudes towards Valuing Students' Culture and Languages
- Teachers' Expectations of CLD Students' Academic Performance
- Positive Attitude towards Inclusion of CLD Students in Subject Area Classes
- Teachers' Beliefs about CLD Students Enrolled in their Subject Area Classes
- Teachers' Attitudes towards CLD Students' Needs
- Teacher's knowledge and competence in technology and assessment

5. What instructional flow would capture all these plans? 7Es

The entire lesson will be divided into 2 sessions. The first one will be from Elicit to Explain and the other will from Elaborate to Evaluate. The Extend is a take home activity in which students will log one species each day for five days (weekends excluded). Eco-logging Journal will be submitted after a week and will be recognized as a performance task.

Lesson Phase	Essential Question/s	Activity (specify the modalities)	Expected Output/Learning
Elicit	What are the components of an environment?	**Hook Video:** Mangrove and Wave Surges [illegible] Learners will watch the hook video that shows how mangroves safeguards coastal areas from big wave surges. Learners will predict the outcomes of the phenomenon, explain their reasoning, before observing the real outcome. ***Guide Questions:***	Learners must be able to describe the ecosystem depicted in
Engage	How can environmental conditions impact biodiversity?	**EcoGO: Philippines-Themed Ecosystem Bingo Card** Students will have their pre-made EcoGO and the content was provided by the teacher. Each square on the card represents a unique biodiversity in the Philippines which includes iconic species, cultural trademarks and landmarks.	Learners must be able to understand that species have a niche, or role in the ecosystem. Learners must be able to identify what species will be affected by the environmental conflicts.

Appendix B

Sample design for EcoGO:

[illegible]

(Journal Details)

SPECIES OF THE DAY

(INSERT PICTURE OF THE PLANT/ANIMAL)

COMMON/LOCAL NAME	PLACE WHERE IT CAN BE FOUND/AVAILABLE	ADDITIONAL INFORMATION/ TRIVIA FACTS	CURRENT SITUATION OF THE SPECIES

	Species options for students • Plants ○ Pepper elder ○ Artillery plant ○ Croton plant ○ Asthma plant ○ Heart of Jesus • Animals ○ Tukmo bird ○ Hantik ○ Long-flange millipede

As gleaned from the analysis in Table 2, the products developed by the pre-service science students (Lesson Exemplar and Hook Videos) showcase all the eight science capital dimensions and principles of inclusivity, which includes sensitization and valuing the student attitudes, culture, and language. These connections to the science capital dimensions and inclusivity attributes are evident in unpacking competencies, identifying the learning/lesson objectives, determining the corresponding content, and designing the learning tasks that will formatively achieve the lesson objectives. The target skills were intricately identified. Specific inclusions of translations in the students' mother tongue or first language and the use of contextualized examples highlight this inclusivity attribute (e.g., Aikenhead, 1995; Archer *et al*., 2015; Mujtaba *et al*., 2018; Thompson *et al*., 2016), which may affect how students perceive themselves concerning science. Furthermore, their developed products cohere with the ESTA framework, underscoring the three key elements (pedagogies, teachers' knowledge, and Filipino learners) to achieve inclusive science education. Their LEs show extensive diagnosis and analysis to include gender, language, culture, race, technical capability, economic status, disability, special needs, and misconceptions on the intended topic(s) for discussion to determine the diversity of their classes. Their LEs also feature their competencies in technology, assessment, and teaching strategies and provide means of improving them if insufficient. Preparatory activities related to Language for Sciences are also embedded in the Lesson Exemplars.

Finally, their developed LEs feature programmed learning activities and assessments presented using the 5E's, highlight several teaching and learning approaches and strategies (e.g., STEAM Approach, constructivism), and provide a sense of success in developing science capital dimensions and inclusivity attributes. Hence, intentions to build the science capital are coherently observed in all parts of the Lesson Exemplar, which may lead to the development of science capital dimensions of their future students (Christidou *et al*., 2021; Thompson & Jensen-Ryan, 2018). These contentions match the emerging themes from the thematization and abstraction process in Table 3, presented in the next section.

(b) Pre-Service Science Students' Reflections

We have derived three key themes representing the participants' reflections, key takeaways, and intentions to implement what they have learned in their respective future science classes, as shown in Table 3.

Table 3: Coding and Abstraction of Participants Key Takeaways, Reflections, and Intentions to Implement Inclusive Science Education

Sample responses	Codes	Themes
My reflection for today's workshop, is how *being culturally aware and inclusive plays* a major role in our society. As pre-service teachers, we can implement these things and apply them to our teaching methods.	Intentions, Practices, and Principles of Inclusivity	Inclusivity in Science Education
It is important *to understand your student's behavior is important.* The most important that I learned today is *how teachers affect student motivation and learning acquisition*. It is important to have better training experiences for both teachers and pre-service teachers.	Sensitization and Sensitivity	
It is important *to know and understand our students' cultural backgrounds as teachers for us to create a safe space for learning and for them to engage in our class truly.*	Culture-based approach:	
I encountered a student who cannot understand Ilocano… I felt validated by the lecture because *when the student mispronounced an Ilocano word, making an effort to contribute to their brainstorming for a project, I told him, "This is the more proper way of saying it."* I am glad I did so because I know now how bad the effect could have been if the first words that came out of my mouth were laughs.	Language-based approach	
I have learned that *inclusive education is an advocacy that supports every student regardless of age, race, ethnicity, gender, disabilities, etc.,* and that they all have the right to quality education.	Aims/Objectives of Science Teaching	Goals and Nature of Science
We have learned *how important science instructions are in our daily integration of the lessons.* Also, *I have widened my knowledge of the TPACK model,* which was introduced to us by our teacher. With the help of this webinar, I learned more and discovered more about the things I must integrate as soon as I become an educator.	Underpinnings of Science Instruction	
Engaging in practical exercises honed my ability to adapt knowledge to specific situations, enhancing problem-solving skills… Contextualization, to me, *empowers individuals to navigate complexities with confidence and sensitivity.*	Skills/ Attributes developed through Science Teaching/ Learning	
As teachers, to make the teaching and learning process, it is best to integrate technology, as *this would motivate our students more and make it easier for us to deliver our lessons.*	Teachers Knowledge of Instructional Resources and Technology	Science Teachers' Competence and Pedagogies
As a future teacher, I realized that *successful learning could happen if we can connect the lessons that are relevant to the students…*	Teachers' Instructional Competence (Lesson Planning, Implementation, and Assessment)	
It is essential to set up your classroom *to teach science and trigger their curiosity about science is essential.* As a future teacher, part of *my vocation and mission is to make students fall in love with science.* It means that they will find this subject interesting and fun to learn. One of my jobs is to ensure that I will be able to teach my learners how vital science is in their daily lives.	Teachers' Attitudes/ Orientation/ Beliefs in Science Teaching	
I think we should also be *technologically literate as Science Education majors.* Since *science and technology go hand in hand, and both will continue to evolve throughout the years,* we must ensure	Teachers' Scientific,	

that we can keep up with their development as they are *crucial tools for teaching in our generation.*	Soft, and Future Skills	
I've learned that in science, *we need communication to drive knowledge about the transferability of science…*	Teachers' Communication Attributes	

Our analysis in Table 3 shows three key learnings that the pre-service students assimilated during the training, that they explicitly want to implement in their future science classes. One of the themes emphasizes their competence and pedagogies as science teachers underscored in all the teaching and learning processes that include how they plan their lessons, their knowledge of instructional resources and technology, their skill sets, and communication competence to invoke quality and inclusive science education (Darling-Hammond *et al*., 2019; Guerriero, n.d.). This theme has to be paired with their strong desire to achieve the goals and nature of science, which may be included in their lesson designs and instructional underpinnings and the processes they implement to achieve inclusivity in science education, that highlights culture and language-based approaches and sensitization (Kim *et al*., 2019; *Reimagining the role of technology in education: 2017 national education technology plan update*, 2017).

Conclusion and Recommendations

We documented in this article how pre-service science education students may be engaged to introduce inclusivity in science education. We sequenced the narration as the development of a framework for inclusive science education, designing training materials and training blueprints, and engaging the pre-service science students in a two-phase training. Results of this sequence of processes reveal that the pre-service science students were able to enhance their perspectives and gained positive understanding and attitudes toward science teaching endeavors as indicated by the emerging themes: *inclusivity in science education, goals and nature of science education, and science teachers' competence and pedagogies*. Furthermore, their developed products (Hook Videos and Lesson Exemplars) showcase the science capital dimensions and inclusivity attributes. These results proved the significance of pre-service science teachers' awareness and understanding of inclusive science education that will redirect and shape their instructional ideals, processes, materials, and practices. The provision of this kind of training and related training will equip teachers to address challenges encountered in highly diverse science classrooms.

We also encountered several challenges in implementing this study and provided several suggestions. It may be good to conduct a series of in-person training programs on inclusive science education for linguistic and cultural diversity among in-service and pre-service science teachers. Particularly in academic communities with high levels/ density of cultural and linguistic diversity (e.g. CAR and BARMM regions). For continuity and sustainability of the study, it may also be good to conduct follow-up interviews or Focus Group Discussions with selected participants to verify the veracity of the initial results (qualitative and quantitative measures). From these processes, we might be able to determine other factors or variables that influence science teachers' understanding and practices of inclusive science education and design other means towards inclusivity and quality science education.

Acknowledgments

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□

Appendices: Appendix 1: Participant Profile

Profile	Frequency	Percentage
Age		
Above 30	1	0.31%
25-30	2	0.62%
20-25	217	66.77%
15-20	105	32.31%
Sex		
Male	104	32.00%
Female	221	68.00%
Gender identity		
Male	97	29.85%
Female	220	67.69%
Non-binary	8	2.46%
Mother tongue		
Filipino	210	64.62%
English	3	0.92%
Other dialects	112	34.46%
Language spoken at home		
Filipino	210	64.62%
Dialect	112	34.46%
English	3	0.92%
Geography (Regions)		
I	36	11.08%
IV-A	23	7.08%
IV-B	16	4.92%
VII	34	10.46%
VIII	25	7.69%
X	12	3.69%
NCR	117	36.00%
Year Level		
Fourth Year	103	31.69%
Third Year	114	35.07%
Second Year	69	21.23%
First Year	1	0.30%
Graduate	2	0.62%
No Training	222	68.31%
With training attended	103	31.69%
Cultural Heterogeneity		
covered in a lecture/seminar	120	36.92%
module on topic	86	26.46%
covered over multiple lectures/seminars	119	36.62%
Linguistic Diversity		
covered in a lecture/seminar	130	40.00%
module on topic	151	46.46%
covered over multiple lectures/seminars	44	13.54%
Special Needs		
covered in a lecture/seminar	112	34.46%
module on topic	105	32.31%
covered over multiple lectures/seminars	108	33.33%

Implementation of ESTA project - Experience from Ilia State University, Georgia

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Introduction

ESTA teachers and trainers in the SALiS laboratory at ISU

The main aim of the ESTA project is to improve the level of competences in HEIs of participant countries by professionalization and development of university science teacher educators regarding diversity in science classes, with the focus on language and culture.

The ESTA project and its implementation plays a significant role for teacher education in Georgia, as 16.2% of the total population of Georgia consist of national minorities (FN 1) who are either dispersed widely across Georgia or live in compact settlements. (FN 2) For the purpose of their civil integration, knowledge of the state (Georgian) language is of particular importance, which is still one of the biggest challenges for the integration of ethnic minorities (Analysis of the BTCC Research Group 2008; Tabatadze 2016, 2019), especially in Kvemo Kartli and Javakheti, the regions with dense settlements of ethnic minorities. The reason for this is, first of all, that in contrast to dispersely- populated ethnic groups, the population in dense settlements of ethnic minorities is isolated from Georgian-speaking society and lead socially closed life, forming as a result parallel societies instead of one whole civic society.

Therefore, mastering the Georgian language and raising the general level of education is extremely important for ethnic minority groups in achieving social, practical and academic goals. The Georgian government recognizes the critical role that knowledge of the Georgian language plays in enabling ethnic minorities to communicate with broader society and receive a complete education. Responding to these issues are priority goals of the Georgian state.

The state ensures that all citizens receive education in the State language (see Constitutional Law No. 1324 of October 13, 2017 on the state language of Georgia). The majority of ethnic minority groups live isolated from the Georgian linguistic majority and have no contact with Georgian language. Thus the minority children have their first contact with the state language (Georgian) when they enter the primary school. Therefore its' acquisition and the acquisition of various subject knowledge in this language is associated with many difficulties. That is why not only mastering the Georgian language, but introducing it as a language of instruction for other subjects, is a necessary condition and a priority of the state and non-governmental organizations.

In accordance with the existing unified policy towards the education of national minorities, the Ministry of Education and Science of Georgia aims to achieve the civic integration of representatives of national minorities through the introduction of multilingual education. One of the modern tools of which is the Content and Language Integrated Learning (CLIL) method, which was developed in Finland in the late 1980s as a methodology for integrating language and different subject content simultaneously (Marsh, *et al.,* 2001).

Unlike traditional lessons, during which only a single language or a subject is taught, CLIL expands the language competence of the language learner based on the content of a subject/subjects, and the teacher helps the student to improve their language skills while teaching a subject/subjects. At the same time, the language of teaching is not only a means, but also a goal. Along with the acquisition of subject competence, the student also acquires new language competences, which are related to subject content.

In order to help ethnic groups in this direction by the state or non-governmental organizations, many projects have been implemented in the country in recent decades and are currently being implemented at the school or university level. The projects in ethnic minority schools, first of all, promote teaching of the state language and the formation of various subject competences among students, providing them with a good education. One such project is the Erasmus Plus project ESTA (Educating Science Teachers for All) funded by the European Union, in which representatives from 8 universities participated from Germany, Ireland, Georgia, the Philippines and Bosnia-Herzegovina.

Implementing the ESTA project

Georgian teachers working in the SALiS laboratory at ISU

Ilia State University (ISU), as a partner in the ESTA project, prepared, developed and implemented materials for in-service and pre-service science teachers. Prior to organizing in-service teacher training, the ESTA team from Ilia State University organized a meeting with experts from the Ministry of Education and Science in Georgia. The main topic of discussions was the current situation in the country where, in some schools, there are up to 80% of students from national minorities. Teachers have trouble conducting lessons in classes like this. They are not equipped with the relevant teaching materials, especially at the primary school level.

The ESTA team at Ilia State University decided to invite primary level science teachers for training. Thirteen teachers from different regions of Georgia attended the training at the SALiS laboratory at Ilia State University. The main aim of these workshops was to give invited in-service teachers a general overview and basic knowledge of teaching science in ethnic minority classes, where the students mostly are not able to speak Georgian language, which is the state language in the country, but not the mother tongue of those students.

Academic staff from ISU prepared and offered a blended course to Georgian science teachers. Some meetings were conducted online and some meetings face-to-face. All materials were prepared based on the online workshops from the ESTA European team, or experiences of study tours in Ireland and Germany respectively. The first meeting was organized in May 2022 and the final meeting – in June 2023.

Lilu's House - Teaching materials developed by Science on Stage teachers from seven countries was selected for this workshop. (https://www.science-on-stage.eu/material/lilus-house)

These teachers developed practical advice on how to support the scientific knowledge of the students at primary level while also practising and developing their skills in speaking, reading and writing. This book tells the story about Lilu and Alina, who are discovering scientific phenomena in the bathroom, living room and kitchen. They solve problems, conduct different experiments and have fun with science. The experimental units are given with methodological recommendations and texts with diverse levels of difficulty. All these materials support science teachers to prepare and conduct inclusive lessons.

Cover of Lilu's House, Georgian edition

Lilu's House was translated and adapted for Georgian students by the project teams from Ilia State University and Telavi State University. Some of the experiments were conducted by the in-service teachers during the workshops and prepared for delivery to their classes.

Over the period of one year, several meetings were organized in the SALiS laboratory at Ilia State University with ESTA in-service science teachers. During the workshops their experiences were discussed and analyzed and recommendations were given by their colleagues and academic staff from ISU. The workshop sessions were analyzed by the ISU ESTA team. Teachers stressed the importance of the sessions at the laboratory and some of their impressions following the ESTA workshops are presented below:

Teacher A: *Training session was very productive for me, I'll definitely use all materials in my classroom*

Teacher B: *I like friendly and comfortable environment, I am very much satisfied with the training*

Teacher C: *I like to conduct experiments and share experiences with the colleagues*

Based on the experience of in-service teacher ESTA workshops, the ISU team developed and conducted an elective course on *CLIL (Content and Language Integrated Learning) in Science* for primary teacher education pre-service program students in the spring term 2023. The course was conducted by two lecturers in tandem: Ekaterine Slovinsky from the science teaching department and Tinatin Kiguradze from the language didactics department. Twelve Students participated actively in this course. All of them were female: ten ethnic Georgians and two Azerbaijani ethnic minority students.

The pre-course knowledge of the students was obtained from previous courses on the pre-service teacher education program - science didactics on primary education level. The aim of this course was to give students additional knowledge of teaching science in ethnic minority classes, where some or all pupils have insufficient knowledge of Georgian, which is the state language but not the mother tongue of those students. During the course, the students gained knowledge about: the problems associated with teaching science in diverse classroom; bilingual education and language separation theory (one-language-one-person/source); CLIL models in science teaching; language as a tool for acquiring knowledge in science; Standards for Georgian Language Levels ("Can-Do's" on different levels A1-C2).

An ESTA class in school in Georgia

Within the framework of the ESTA Project, the *"Lilu's House"* science teaching materials were translated into Georgian, adapted to minority students' needs and included intercultural topics such as "Georgian Bread". These materials were presented, analyzed and discussed during the "CLIL in Science" course. The students worked on their weekly homework tasks related to the materials. During the course, the students developed their own, linguistically-modified teaching materials based on science experiments from different topics based on *Lilu's House*. Experiments were developed and conducted in Tridems (mostly 3 students in each group). The materials included student's worksheets and instructions for teachers, which were discussed between group members and lecturers. After discussing and improving the teaching materials, they were piloted in an ethnic minority private school "Momavali" in Marneuli - a main city on Kvemo Kartli, with the densest settlements of ethnic Azerbaijani people in Georgia.

The outcomes of the pilot lessons at the school were discussed in the seminars. By the end of the course, each student had written their own reflection of both a lesson and materials with an improved version of the teaching material (student's worksheet and teacher's manual), based on the experience gained through the pilot lessons. For course materials and homework, a digital LMS (Moodle) platform of the Ilia State University was used: www.elearning.iliauni.edu.ge . On May 30th 2023 some students attended the conference in Telavi State University organized by the ESTA team, where they presented their material.

At the end of the course pre- and post-questionnaires (filled anonymously in Google Forms by course participants) were analyzed. The most important outcome was that the participants' attitudes towards linguistic/cultural diversity were slightly changed at the end of the course. Another important issue was that their sceptical attitude about the possibility of gaining knowledge through another language by ethnic minority students also changed, after they conducted lessons with their own materials and analyzed the lessons and results.

Conclusion

After the piloting, the ESTA Course is now part of the Science teacher preparation program at Ilia State university and will be offered every year to pre-service science teachers. Overall, the implementation of the ESTA project contributed to more inclusive and higher quality science teaching and gave interesting and productive results for Georgian in-service and pre-service science teachers.

Acknowledgments

The presented activities were part of the project "ESTA—Educating Science Teachers for All" which is co-funded by the Erasmus+ Programme of the European Union, under grant number 609719-EPP-1-2019-1-DE-EPPKA2- CBHE-JP. We would like to thank the European Union for its financial support. The European Commission's support for the production of this publication does not constitute an endorsement of the content, which reflects only the views of the authors, and the Commission cannot be held responsible for any use that may be made of the information contained therein.

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Footnotes

1. Georgians represent the majority of the population (86.8%), and from the remaining 26 ethnic groups, 6.2% are Azerbaijanis, 4.5% Armenians, 0.7% Russians, 0.4% Ossetians, 0.3% Yezidis, 0.2% Ukrainian, 0.2% Kist, 0.1% Greek, 0.1% Assyrian and 1.51% other ethnic group such as Jewish or Chinese (see Office for National Statistics 2014, 8).
2. There are compact settlements of national minorities in Kvemo Kartli, Javakheti, Kakheti, Shida Kartli.

Biographies

Prof. Dr. Marika Kapanadze *is a professor of Science Education at Ilia State University, Georgia and head of Science Education Research Centre SALiS. Together with the pedagogical activities she coordinates implementation of international projects in Science Education in Georgia. She is a member of Editorial Board of several scientific peer-reviewed journals and joint founding editor of international peer-reviewed journal ARISE. She cooperates with European and American universities and conducts joint studies. Her research interests are: Inquiry Based Science Education, Modern Approaches for Teaching and Learning Science, Students Motivation for Science Learning, Development of Science Teachers Attitudes and Action Research in Science Education.*

Prof. Dr. Ekaterine Shaverdashvili *is a professor of Educational Sciences at Ilia State University (Georgia) with a focus on second / foreign language teaching; She is a head of the Innovative Educational Research Center. Her research interests are didactics of foreign and second language; language policy; values education; In recent years she has been interested in the CLIL method and would like to work on the integration of science subjects and foreign or foreign languages with CLIL.*

Assist. Prof. Dr. Tinatin Kiguradze *is working in the field of teacher education for Georgian as a Second/Foreign Language and German as a foreign Language at Ilia State University. Her main research interest are CLIL in education of ethnic minorities in Georgia: Teaching/learning languages with a particular aim (e.g. learning and teaching chemistry and Georgian as a second language or history and Georgian).*

□

Bridging Language Gaps in Science Education

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Abstract

This paper explores the implementation of the Content and Language Integrated Learning (CLIL) approach, specifically within the context of science education in Georgia. The ERASMUS + project ESTA (Educating Science Teachers for All), launched in 2020, aimed to enhance science teacher proficiency by developing a specialized academic course for primary teacher education. The course focused on language-centered natural science lessons, addressing the unique needs of students for whom Georgian is a Second Language. Through comprehensive training and the use of innovative modules, the project successfully blended science subjects with the Georgian language, facilitating a holistic learning experience. The paper presents practical examples of the CLIL approach, emphasizing its impact on students' language proficiency and the practical application of the strategies developed under the project.

Introduction

In today's globalized world, where national borders are easily traversed through relatively straightforward legal and administrative processes, students often find themselves studying in environments and languages that differ from their mother tongue. Furthermore, numerous countries have been home to ethnic minorities for centuries, contributing to a rich cultural heritage. For instance, Georgia stands as a vivid example of a multi-ethnic nation, deriving its charm from this diversity.

Fostering integration becomes pivotal in the promotion of education. Consequently, it becomes imperative to employ educational methodologies that enhance language competencies. This not only facilitates integration into society but also aids students in comprehending educational content, thereby enabling them to attain the long-term goals outlined by the national curriculum. Recognizing the significance of this, countries globally are striving to implement flexible educational approaches tailored to their unique perspectives in this domain.

In 2020, the ERASMUS + project ESTA (Educating Science Teachers for All), was launched in Georgia with funding from the EU. Led by two Georgian universities, Ilia State University and Iakob Gogebashvili Telavi State University, the project aimed to enhance the proficiency of primary science teachers. A specialized training course was developed for the Primary Teacher Education Bachelor-Master integrated program, focusing on equipping educators with the skills necessary for planning language-centered natural science lessons. This approach specifically addressed the needs of students for whom Georgian serves as their Second Language.

Within the project's scope, teachers underwent comprehensive retraining. The curriculum included an innovative integrated module that employed the CLIL (Content and Language Integrated Learning) method (Coyle *et al.*, 2010). This module, implemented at primary level in schools participating in the project across Tbilisi and various municipalities with significant minority populations, blended science subjects with the Georgian language, fostering a holistic learning experience. As a tangible outcome, the project facilitated the translation and adaptation of the manual *"Lilu's House: Language skills through experiments"* (www.science-on-stage.eu) for primary school teachers. This adaptation ensured relevance and applicability within the local context, reinforcing the project's commitment to bridging language gaps and promoting effective science education.

Figure 1: A page from the Georgian version of Lilu's House

The paper discusses the efficacy of the CLIL approach within natural science education, highlighting its impact on students' language proficiency. Given the research-oriented nature of natural science teaching, language competency becomes a crucial aspect of the learning process. Particularly at the primary education level, where students engage in guided research activities based on pre-prepared instructions, challenges arise in tasks involving listening, reading, and comprehending instructions. To address these challenges, the paper explores practical situations and activities designed for natural science lessons. These strategies are specifically tailored to the students for whom Georgian is a Second Language. Developed at the Faculty of Education Sciences of Telavi State University, within the international project ESTA, the material has undergone piloting. It involved pre-service teachers of Primary Teacher Education Program and schoolchildren from Duisi Public School in Akhmet Municipality. The practical application highlights the real-world relevance and effectiveness of the proposed approaches in diverse educational settings.

Figure 2: Conference of ESTA teachers in Telavi

Practical Assistance in Magnet Study

The chosen focus on exploring the properties of magnets aligns seamlessly with the mandatory subject outlined in the Natural Science Standard—the Earth (National Curriculum, 2022). The proposed tasks not only meet the Educational standard but also contribute substantially to fulfilling the broader, long-term goal defined in the standard—the human body. Engaging in simple experiments, students will gain the ability to articulate the magnetic properties of substances and grasp the fundamental concept of magnetism. Publications of the following authors serve as the theoretical framework for the project's practical part: Colburn & Clought, 1997; Coyle *et al.,* 2010; Edwards, 1997; Hebrank, 2000; Llewellyn, 2005; Kapanadze *et al.,* 2016. Through hands-on activities developed based on the works of the aforementioned authors and the application of elementary research skills, students actively compared the properties of magnets with those of other objects. This process aims to identify and analyse both similarities and differences between magnets and other bodies. It is of paramount importance that the investigation into magnetic properties unfolds with the active participation of students, fostering a spirit of research and encouraging the excitement of discovery. This approach not only enhances the learning experience but also underscores the significance of hands-on exploration in comprehending scientific principles.

Let's consider some examples:

When offering the various resources needed for research, it is important to provide students with an image along with the list of materials or tools on the worksheet (Figure 3) to make it easier for them to understand (Example 1), or to provide explanations if necessary (Example 2).

Example 1:

1. Cardboard roll
2. I-shaped magnet
3. Magnet rings

Figure 3: The image along with the list of materials or tools on the worksheet (Cardboard roll, I-shaped magnet, Magnet rings)

Example 2.
1. A set of magnets - magnets of different shapes and sizes.
2. Cardboard box - a box made of thick and dense paper.

In inquiry-based learning, it is important to formulate a research question. However, it is not easy to formulate it at the initial level in such a way that the influence and role of the independent variable can be distinguished. Therefore, the teacher usually suggests the research question on the worksheet or helps the students to formulate it (example 3, 4).

Example 3. How does the thickness of the cardboard affect the action of the magnet towards the bodies placed in the box?

Example 4. To what extent does the volume of water affect the action of a magnet on bodies immersed in water?

The understanding of the research question is followed by the expression of opinions and the formulation of hypotheses by the students, in which the teacher encourages and helps by offering different linguistic constructions on the worksheet (examples 5, 6).

Example 5. Express your opinion, what will happen if we bring magnets closer to each other?

Use one of the phrases in the box to express your opinion
I think that... in my opinion... If I had to guess, I would say I suppose that... My hypothesis is that...

Example 6.
Which of the items in the container do you think will be attracted to the magnet attached to the "hook"?
Record the opinions in the table with an X

Body *(In the second column, write down all the resources available to the students)*	**Magnet attracts**	**Magnet does not attract**

Expressing opinions is undoubtedly valuable, yet the significance of validating those opinions cannot be overstated. In the foundational stages of education, a teacher plays a pivotal role by guiding students through the process of conducting experiments, as illustrated in Examples 7 and 8. Following the provided instructions, students meticulously execute the steps, keenly observe, record data, perform a thorough analysis (as demonstrated in Example 9), draw informed conclusions (as showcased in Example 10), and test the initially posited opinions. This structured approach not only fosters critical thinking but also instills a habit of substantiating one's viewpoints through empirical evidence, enriching the learning experience.

Example 7. Instruction
• Take a cardboard roll;
• Put the magnet rings on the top and bottom;

• Approach the created cart with an I-shaped magnet from different (S and N) sides (pole);
• Observe the events and analyse them.

Example 8. Instruction
• Make a "hook" - attach a thread to a stick, and attach a magnet to the thread;
• Place bodies of different materials in a container filled with water;
• With the help of "hook" remove one body at a time;
• Check the data you marked in the table and analyse it.

The data analysis part is particularly important, in which the teacher helps by asking questions (Example 9).

Example 9:
What kind of objects are attracted by a magnet?
What material is attracted by a magnet?
What happened when you acted on the magnets from different (S and N) sides (poles)?
which poles caused the balls to attract?
which poles caused the balls to repel?
What happens if we increase the thickness of the surface?
Which unknown property of magnet did you discover?

Example 10:
What did you find?
What conclusion did you draw after the observation?

The teacher offers different language support to the students. For example, definition of question words (example 11), agreement of adjectives with nouns, definition of terms used in the research process (example 12), sentence construction (example 13) and others.

Example 11:
How many? – We get information about number.
Which? – we choose.
What kind? – we describe characteristics of a thing.

Example 12:

Research	To study a matter in detail, to make a discovery
Resource	Materials needed for research
Hypothesis	An assumption we make before conducting research
Instruction	a set of directions /steps to guide in performing a specific task

Example 13:
Follow the example and make 3 sentences:
The magnet attracted the nail.
1. ______________________________
____
2. ______________________________
____

In parallel with research, it is possible to work not only on lexical units, but also to process grammatical material. Let us consider one of the stages of the instruction:

- Take a cardboard box and place the drawing paper in it;
- Apply paint on the surface of the magnet and place it in the box so that the painted surface touches the drawing sheet;
- Place the box on the desk;
- Take another relatively large magnet and place the desired figure (flower, ball, square) on the lower side of the desk in the place where the painted magnetic box is placed;
- Now open the box and carefully remove the magnet and drawing paper

Conjugate verbs (Changing person and number)

Singular form მე ავიღე, შენ აიღე, მან აიღო (I took, You took, He/she/it took) **Plural form** ჩვენ ავიღეთ, თქვენ აიღეთ, მათ აიღეს (We took, You took, They took)
Singular form მე დავხატე, შენ დახატე, მან დახატა; (I drew, You drew, He/She/It drew) **Plural form** ჩვენ დავხატეთ, თქვენ დახატეთ, მათ დახატეს (We drew, You drew, They drew)

Singular form
მე შევღებე, შენ შეღებე, მან შეღება; (I painted, You painted, He/She/It painted)
Plural form
ჩვენ შევღებეთ, თქვენ შეღებეთ, მათ შეღებეს (We painted, You painted, They painted)

Follow the instructions and write the actions you performed in the first person, plural according to the example: *We took a cardboard box.*

1. ______________________________
   ____
2. ______________________________
   ____

Such activities/assignments are useful for developing language competence and writing a science research report.

Conclusions

The paper underscores the critical role of language competency in natural science education, especially for students engaged in research-oriented activities. The practical application of CLIL in exploring magnetic properties provides tangible evidence of its effectiveness, fostering hands-on exploration and enhancing students' understanding of scientific principles. Furthermore, the paper emphasized the importance of language support, exemplified by various language assistance strategies, ensuring effective communication and comprehension during the scientific inquiry process.

Acknowledgments

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Biographies

Nino Modebadze *- a Professor at the Faculty of Educational Sciences, Telavi State University since 2003, has extensive experience in scientific and administrative roles. She has authored and co-authored various vocational, bachelor, master, and doctoral programs. Engaged in international projects, she participated in ERASMUS+ initiatives, undertook staff exchanges, and managed projects funded by the European Union, USAID, and UNICEF.*

Natela Bagatrishvili *- an Associate Professor at Telavi State University's Faculty of Education Sciences. Her research focuses on enhancing the methodology of teaching natural science subjects through active learning, fostering students as explorers of new ideas. As a mentor teacher, she*

creates electronic and material resources to make the learning process engaging and motivates students. She actively shares her expertise through international collaborations, workshops, webinars, and seminars.
Tamar Mikeladze *– an Associate Professor, serves as the head of the Department of Educational Sciences at Telavi State University. Her expertise lies in innovative teaching, adult education, adult language learning, and English teaching. Tamar has supervised doctoral students since 2014, conducted research in European universities, and received scholarships for studies in Greece, Finland, Latvia and Netherlands.*

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ESTA: Our Lasallian Journey

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Introduction

The Philippines is an archipelago that consists of more than 7,000 islands, with more than 110 indigenous groups and more than 170 languages being spoken as native languages. A reflection of these diverse cultures is linguistic heterogeneity, which has become a central issue in the educational setting. Being part of the ESTA consortium has given our team the opportunity to help improve the current situation in our science classrooms, that is, to raise the level of literacy of our students in both science and language, through the capacity-building of teachers.

Our Preparations

Our preparations for this capacity-building-of-teachers initiative consisted of internal meetings discussing the underlying concepts of diversity and inclusivity, Content and Language Integrated Learning (CLIL) and innovative approaches to teaching science, particularly using technology. We received support from the ESTA coordinators through online and onsite trainings and consultation. The starting materials were made available for us on our ESTA website.

Because none of us was accustomed to CLIL, we immersed ourselves in reading books and journal articles to gain a comprehensive and nuanced understanding of the practical aspects and outcomes of CLIL in educational environments. Through our group discussions during our internal meetings, we were able to enrich our knowledge base and gained valuable insights for the development of our training materials for our capacity-building activities. The result of this endeavor included a crafted CLIL slides presentation, a compilation of selected CLIL videos, an adapted CLIL lesson plan template and exemplars. (These can be found in our ESTA webpage at our DLSU website: https://www.dlsu.edu.ph/esta/.) The integration of these resources aims to provide our participants with a comprehensive and tangible understanding of CLIL's application in their real-life teaching scenarios. By utilizing multimedia elements such as videos and incorporating practical lesson plans, our goal is to enhance the learning experience for participants and empower them with the knowledge and tools needed to seamlessly integrate CLIL principles into their teaching practices.

Our Trainings

The initial phase of our training were conducted during the classes of our own graduate students who were science and mathematics teachers. We had the privilege of immersing ourselves in their teaching practices. It became evident that many of them were instinctively incorporating CLIL techniques into their instruction, even without explicitly recognizing it. This unintentional integration underscores the organic and impactful nature of CLIL in our educational context, highlighting the potential for its seamless incorporation into various subject areas.

In the next phase of our trainings, a similar scenario unfolded during our collaborative online webinars (ARAL International Conference 2023 and Action Research Workshop for La Salle Iligan) and in-person workshop (CLIL Workshop for DLSU-IS). Beyond the customary lecture elucidating the principles of CLIL and its positive influence on the proficient learning of both language and content subjects, we took an interactive approach. Participants were actively engaged in applying CLIL concepts to develop lesson plans tailored to their respective subject areas.

After the CLIL lesson plan construction, our team led in providing feedback regarding their outputs. During the subsequent critiquing, it was apparent that our teacher-participants demonstrated a remarkable ability to seamlessly integrate the teaching of the target language, which in our case is the English language, with the substantive content of their specific subjects. This practical application not only underscored the adaptability of CLIL but also highlighted its potential to enhance language acquisition, while fostering a deeper understanding of subject matter, thus contributing to effective and comprehensive learning experiences for both educators and students alike.

The CLIL Lesson Plan

Figure 1: Condensed CLIL lesson plan form
Appendix A.docx - Google Docs

The CLIL Lesson Plan

Our team would like to share one of the materials we used in our trainings, the CLIL lesson plan, as found in the Appendix A. It drew inspiration from the Erasmus Plus Training Courses for Teachers. This template, widely adopted and applied by educators globally, has been adapted to suit diverse teaching contexts and has proven to be a valuable resource for teachers worldwide. This is shown condensed in Figure 1.

Our team would like to share one of the materials we used in our trainings, the CLIL lesson plan, as found in the Appendix A. It drew inspiration from the Erasmus Plus Training Courses for Teachers. This template, widely adopted and applied by educators globally, has been adapted to suit diverse teaching contexts and has proven to be a valuable resource for teachers worldwide. This is shown condensed in Figure 1.

In filling out the template, the teacher will initiate the CLIL Pathway session by pinpointing the subject area where the CLIL approach can be effectively applied, encapsulating this information within the designated CLIL Pathway box. In our trainings, English teachers worked with subject teachers on this. Subsequently, they will determine the grade level corresponding to the selected subject, specifying the module title, and identifying the particular subject topic.

In alignment with the original lesson plan, the teacher will enumerate the teaching objectives for the subject. Additionally, they will incorporate the materials earmarked for use during the instruction of the subject. A distinctive characteristic of the CLIL lesson plan lies in its integration of the 4 C's of CLIL - Content, Cognition, Culture, and Communication (Eren and Martin, 2023).

Within this framework, the teacher will delineate the teaching objectives that harmonize with the overarching goals of the course concerning Content. This involves outlining how the course will shape students' Cognitive understanding of the subject matter, fostering an appreciation for Culture in connection to the course content, and elucidating how language through Communication will facilitate the realization of these educational aims.

The complete lesson will be detailed within the "Activities" section, providing a comprehensive step-by-step delineation of the entire instructional process. Subsequently, a thorough evaluation and assessment of the students' performance will be conducted to gauge their understanding and mastery of the lesson content. A sample of a completed CLIL lesson plan is found in Appendix A.

CLIL Learning Objectives

Here is an example of a learning objective in general physics: "*Explain Newton's laws of motion.*" We see that the statement lacks how this objective is to be achieved. This can be improved to "*Explain Newton's laws of motion by producing descriptions and interpretations of applicable scenarios.*" Here a procedural content has been added. CLIL approach offers a third component, the linguistic content: "*Explain Newton's laws of motion by producing descriptions and interpretations of applicable scenarios using comparative phrases and discourse markers.*" The comparative phrases and discourse markers are the specific language contents that the students should learn as they learn the topic on Newton's laws of motion.

In writing learning objectives using the CLIL approach, we simply add the linguistic content to the conceptual and procedural contents. Here is another example: "*Determine the forces acting on an object by identifying the objects interacting with it, using prepositions for locations such as to, from, on, and by.*" The breakdown to the 3 components of CLIL (Ball *et al.,* 2019) is shown in Figure 2.

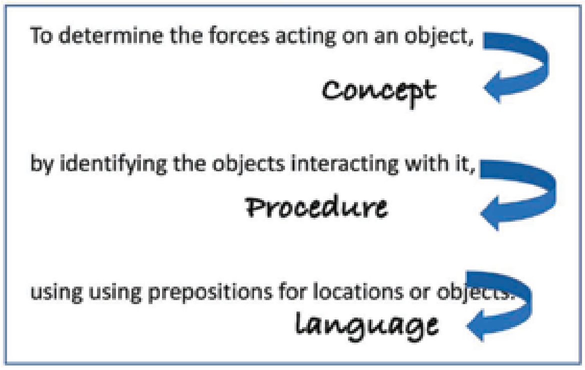

Figure 2: The 3 components of CLIL: Conceptual content, Procedural content and Linguistic content

Next, we use some common Directed Activities Related to Texts (DARTs) that our team first learned from one of the workshops conducted by the programme universities of ESTA. These can be part of the Activities or Evaluation sections of the CLIL lesson plan. The gap-fill or "cloze" is an activity where students fill in the missing word or phrase. The deleted words or phrases can be provided for the students to select from. If not, the deleted word should be carefully chosen to avoid multiple possible answers. This activity helps students develop not only their vocabulary skills but also sort out their ideas to provide correct meaning to the texts. This is shown in Figure 3.

Newton's Third Law of Motion

Choose from the prepositions: ***by, on***

Imagine a book (weight, 5N) rests on a desk. An upward force of 5N is exerted ____ the book ____ the desk . A downward force of 5N is exerted ____ the desk ____ the book. An upward force of 5N is exerted ___ the book ____ the earth. A downward force of 5N is exerted ____ the earth ____ the book.

Figure 3: Gap-fill or "cloze" activity

The Matching activity can be in the form of matching terms and definitions, matching beginnings and endings of sentences, or matching headings (or titles) and paragraphs or visuals. This activity is a step further in building a good grasp of the vocabulary as the students familiarize themselves with how the language is being used in learning a particular topic.

There are also the completion activities in the form of table completion or diagram completion. The table completion activity is where students read a text and complete the cells of a table. This is a good activity in helping students identify and organize key ideas from their reading. The diagram completion activity is where students provide the necessary information to complete the diagram, either by labeling or by describing the process. The students work on these activities from reading materials provided by the teacher.

Making notes is also an activity that prepares the students to transition from identifying to organizing key ideas to help them find patterns that lead to the big ideas of the texts. There are also activities that help students analyze the materials, such as concept mapping, flow diagrams, illustrations, and summary. These are excellently described in the book of Ball *et al.*, (2019).

Other than CLIL workshops, our team also conducted activities and workshops on diversity in the classroom, differentiated learning, action research and inclusive education through culturally- responsive teaching, all of which form part of the ESTA project initiated by DLSU.

Figure 4: Teacher training at La Salle Academy (note the teachers attending remotely or from the school library)

Final reflections

Being part of the ESTA Project has changed us. The Project has taught us not only to be more sensitive to how diverse our students are but also to take a more proactive role in capitalizing this diversity to enhance our students' academic performance. The trainings conducted by the ESTA program institutions equipped us about how CLIL and other innovative approaches can be used to promote inclusive education. And as a partner institution, we become ambassadors of this ESTA advocacy in upskilling (not only science) teachers for all kinds of students.

This realization prompts us to further contemplate the role of language in the challenges faced by the Philippines, particularly evident in the recent 2022 PISA tests where our performance in Math, Science, and Reading fell short. While acknowledging the multifaceted factors contributing to the underperformance of our 15-year-old students, it becomes apparent that our proficiency in the English language plays a pivotal role. The correlation between poor English proficiency and academic performance suggests that addressing language barriers could be a key strategy in improving overall educational outcomes in these critical subjects.

Moreover, our experiences in developing the ESTA project provided us with a deeper and more meaningful view of the diversity of students in the classroom. CLIL clearly contributes to inclusive education as this approach promotes equity and inclusivity by allowing all students, regardless of their language proficiency, to participate in the same educational experiences in the classroom. We realized in the process that diversity enhances learning and capacitates teachers to be more creative in their teaching approaches. Given this the advocacy of the ESTA project will be integrated in our process of developing an institutional policy on inclusive education.

De La Salle University has recently established structures that provide support, develops policies and programs on diversity, inclusion and well-being. The Lasallian Center for Inclusion

Diversity and Well-being (LCIDWell) is a unit in the University that collaborates with the ESTA Team in its goal of developing a framework and policy on inclusive education. This will hopefully expand its efforts in equipping teachers to be more inclusive in their teaching methods. The ESTA Project of teaching diversity in the classroom will be institutional in DLSU as it will form part of its program to promote diversity in academics and engagement activities.

The ESTA Project has made a great impact not just on the teachers we train but also to us as members of the project team. The recognition and appreciation of inclusivity and diversity allowed us to become more creative, accepting, understanding and stronger in our resolve to making teachers as "educators" for all.

Acknowledgments

The presented activities were part of the project "ESTA—Educating Science Teachers for All" which is co-funded by the Erasmus+ Programme of the European Union, under grant number 609719-EPP-1-2019-1-DE-EPPKA2- CBHE-JP. We would like to thank the European Union for its financial support. The European Commission's support for the production of this publication does not constitute an endorsement of the content, which reflects only the views of the authors, and the Commission cannot be held responsible for any use that may be made of the information contained therein.

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□

Appendix A: Example of a completed lesson plan

CLIL LESSON PLAN	
CLIL PATHWAY: SCIENCE	**LEVEL: PRIMARY EDUCATION (4TH GRADE)**
CLIL MODULE: ***The Excretory System***	**CLIL TOPIC:** ***The Human Body***
TEACHING AIMS	**MATERIALS**
_To identify and name the different organs of the excretory system: kidneys, ureters, urethra, bladder, urine, sweat glands, skin and lungs. _To understand and learn the different functions of each organ in the excretory system. _To develop awareness about the importance of hydration: importance of water for the body and the relationship with urine. _To understand why it is important to eliminate waste in our body and how we do it. _To be able to talk and build short sentences in English (about excretory system and their functions). _To establish relations between life style and body function and to be conscious of the importance of healthy/unhealthy habits and their consequences. _To do an oral presentation about the final product (creating an Excretory System...) _To give coherent answers using grammatically correct sentences in the planned activities. _To understand wh-questions correctly. _To work autonomously and proactively, developing collaborative group strategies (in pairs or small groups)	_Worksheet 1 – Theory related to the Excretory System _Activity 1: To match each organ with their functions (in groups) _Activity 2: To match each organ with their functions in their notebooks individually.
LEARNING OUTCOMES – 4Cs	
CONTENT	**COGNITION**
_To name and to identify the different organs of the excretory system: kidneys, ureters, urethra, bladder, urine, sweat glands, skin and lungs. _ To understand and learn the different functions of each organ in the excretory system. _ To develop awareness about the importance of hydration: importance of water for the body and the relationship with urine. _ To understand why is important to eliminate waste in our body and how we do it.	_ **Name** and **identify** the different organs of the excretory system. _ **Understanding** and **learning** the different functions of each organ in the excretory system. _ **Developing** awareness about the importance of hydration: importance of water for the body and the relationship with urine. _ **Understanding** why is important to eliminate waste in our body and how we do it. _ **Connection** between the digestive system and

_ To connect the digestive system with the excretory system. _ Develop awareness about the importance of hydration for the body.	the excretory system. - **Select** and **organise** specific information. - **Analyse** it and **report** it back to the class.
CULTURE	**COMMUNICATION**
- Develop awareness about the importance of hydration for the body and especially for the excretory system. - Recognise the importance to drink more water when we are practising sports. - Establish relations between life style and body function and be conscious of the importance of healthy/unhealthy habits and their consequences. - Importance of the Mediterranean diet to keep our body healthy.	**Language Function:** Talking about the excretory system. Organs, functions and hydration. Connection between the digestive system and the excretory system. Why and how the body eliminates waste. Importance of healthy food to be healthy (especially the Mediterranean diet). Drink water and not other fizzy drinks for the body. **Vocabulary:** - Excretory system: kidneys, ureters, urethra, bladder, urine, sweat glands, skin and lungs. - Eliminate waste: pee... -Hydration, illness, healthy habits. - Review digestive system organs. **Verb:** _ Verb to be: is, isn't , are / aren't , isn't and am not _ Present Simple: sentences and questions. _ Can / can't. **Wh- questions:** What / Where / When / Who / how / how many... **Language structure:** Are the kidneys in the urinary system ? Yes they are/ No, they aren´t.... Is the water important for the body ? Yes, it is... No, it isn't.....
ACTIVITIES	
Lesson 1: **Step 1 – To tune pupils into English** - Teacher /pupils greet each other in English. - Pupils open the lesson /write the date on their Science notebooks in English. - Pupils are set into groups of cooperative work in English and each student has a different role and responsibility in their table groups.	

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_ To connect the digestive system with the excretory system. _ Develop awareness about the importance of hydration for the body.	the excretory system. - **Select** and **organise** specific information. - **Analyse** it and **report** it back to the class.
CULTURE	**COMMUNICATION**
- Develop awareness about the importance of hydration for the body and especially for the excretory system. - Recognise the importance to drink more water when we are practising sports. - Establish relations between life style and body function and be conscious of the importance of healthy/unhealthy habits and their consequences. - Importance of the Mediterranean diet to keep our body healthy.	**Language Function:** Talking about the excretory system. Organs, functions and hydration. Connection between the digestive system and the excretory system. Why and how the body eliminates waste. Importance of healthy food to be healthy (especially the Mediterranean diet). Drink water and not other fizzy drinks for the body. **Vocabulary:** - Excretory system: kidneys, ureters, urethra, bladder, urine, sweat glands, skin and lungs. - Eliminate waste: pee... -Hydration, illness, healthy habits. - Review digestive system organs. **Verb:** _ Verb to be: is, isn't , are / aren't , isn't and am not _ Present Simple: sentences and questions. _ Can / can't. **Wh- questions:** What / Where / When / Who / how / how many... **Language structure:** Are the kidneys in the urinary system ? Yes they are/ No, they aren't.... Is the water important for the body ? Yes, it is... No, it isn't.....

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Teaching scientific vocabulary in multilingual classrooms

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Abstract
Today's science classrooms in Ireland exhibit a rich diversity of languages and cultures, presenting a pressing need for pedagogical approaches that can effectively address this diversity. With a significant proportion of the population identifying as non-Irish, teachers must adapt their methods to ensure equitable scientific literacy for all students. This paper explores the principles of language and culture responsive teaching, focusing on two key approaches—Content and Language-Integrated Learning (CLIL) and Translanguaging—within the context of science education. Drawing on research in applied linguistics and language pedagogy, we provide practical strategies for science teachers to implement these approaches effectively.

Introduction
In the contemporary educational landscape in Ireland, classrooms are characterised by a rich tapestry of linguistic and cultural diversity, with students originating from diverse language backgrounds. Recent data from the Irish Central Statistics Office (CSO) shows that 12% of the Irish population described themselves as 'non-Irish' in origin (CSO 2022). This data does not include the additional multicultural diversity in Ireland due to the continued net influx of Ukrainian refugees. Consequently, teachers need to develop language and culture responsive teaching approaches to develop the scientific literacy and knowledge of all students in their multicultural and multilingual classrooms. In fact, language and culture responsive teaching can be seen as an inclusive pedagogical approach that endeavours to consider the varying needs and abilities of learners in linguistic and culturally diverse classrooms in order to better support teaching across the curriculum. A number of frameworks with guiding principles for teachers in developing language and culture responsive pedagogies have been proposed. These principles include: development of teachers' language awareness; development of teachers' openness to the use of home languages in the classroom; the use of multi-modality for greater accessibility with subject content and language; the use of scaffolding strategies; fostering inter-cultural awareness; and availing of suitable assistive technologies (Farrell et al. 2023; Yoon, 2023).

As science teachers teach in increasingly linguistically and culturally diverse classrooms, it is important that they are supported in developing language and culture sensitive pedagogical approaches. In this paper, the UL ESTA team report on work we have engaged in to investigate approaches that science teachers can adopt to meet the challenge of teaching scientific language and concepts to students whose first language is not English or Irish. Drawing on research from applied linguistics, language pedagogy and pedagogy in bilingual/multilingual contexts, we examine two prominent approaches: Content and Language-Integrated Learning (CLIL) and Translanguaging. We have examined how science teachers can begin to implement these approaches in their classrooms to create inclusive learning environments that foster both language development and scientific understanding whilst also valuing diverse cultural perspectives.

Teaching scientific vocabulary in multilingual and multicultural classrooms
Scientific vocabulary is crucial for students to engage meaningfully with science subject content. However, in multilingual classrooms, traditional teaching methods may fall short. For example, Laszlo (2013) investigated the linguistic demands of teaching chemistry in multilingual and multicultural classrooms and advocated for more language-focused

pedagogical approaches that consider the development of chemistry literacy as language development. Furthermore, students' development of scientific knowledge and language is dependent on the extent of science teachers' knowledge of scientific language and their ability to support the teaching and learning of it (Bunch 2013; Mönch & Markic 2023). In taking a more linguistic responsive approach, Lucas & Villegas (2013) point to the need for teachers to develop knowledge of their students' language backgrounds and leverage this in the classroom in addition to identifying the specific linguistic demands of classroom tasks and the use of multiple ways to scaffold the learning of content-specific language. In catering for the needs of multilingual and multicultural learners, teaching methods should be adapted to ensure that scientific vocabulary is effectively communicated and comprehended across multiple language backgrounds. The UL ESTA team will now present approaches and strategies that science teachers can adopt to create inclusive and supportive learning environments for all students.

A content and language integrated learning approach (CLIL) to science education

In the realm of science education, the integration of content and language is increasingly recognised as a powerful pedagogical tool. Content and Language Integrated Learning (CLIL) is defined as a dual-focused educational approach where an additional language is used for the learning and teaching of both content and language (Coyle et al., 2010, p.1). Traditionally implemented in immersion or bilingual contexts, CLIL is proving to be adaptable to diverse educational settings, including those outside of bilingual environments, such as Ireland. This adaptability highlights the potential of CLIL to support the simultaneous development of scientific knowledge and language proficiency. A practical illustration of CLIL in action is seen in a science class where students explore the details of the water cycle while improving their English language abilities at the same time. This shows the core principle of CLIL: blending subject-specific content with language learning.

According to Coyle's 4Cs curriculum (2010), a successful CLIL approach should include the following four elements (Coyle, 2007):

1. **Content:** CLIL emphasizes teaching academic subjects using a second or foreign language. The goal is to integrate language learning with the acquisition of subject-specific knowledge.
2. **Communication:** Communication in CLIL involves using language as a tool for learning and expressing ideas within the context of the subject matter.
3. **Cognition:** CLIL aims to develop cognitive skills such as critical thinking, problem-solving, and analysis by engaging students with content in the target language and the language required to support thinking skills.
4. **Culture:** Culture in CLIL includes both the culture of the language being learned, and different cultural perspectives of the subject matter.

Strategies to Support Learners using a CLIL approach in Science Education

To address the diverse linguistic backgrounds of learners, Bentley and Philips (2007), as cited in "Teaching Science through English - a CLIL Approach," suggest several strategies for effective science education in a CLIL context:

- **Enriched Learning Materials:** Integration of more vocabulary and diagrams on worksheets. Provision of additional explanations to enhance comprehension.
- **Language Simplification:** Use simpler language to explain complex scientific concepts and vocabulary.
- **Engagement through Games:** Incorporation of games into the learning process for increased engagement.
- **L1 Support:** Use of the first language (L1) to explain more difficult scientific words.
- **Visual Support:** Provision of vocabulary lists supported by images to aid understanding.
- **Real-Life Connections:** Integration of realia (real-life objects) to connect abstract concepts with tangible examples.
- **Technological Integration:** Use technology to enhance learning experiences and support language development.

Implementing CLIL in Science Classrooms

Implementing Content and Language Integrated Learning (CLIL) in science classrooms involves a thoughtful blend of language instruction and scientific content as outlined in the example below.

Step 1: Understanding CLIL principles:
Familiarize yourself with the CLIL principles outlined above.

Step 2: Identify language demands:
For example, we present below a language-focused approach to teaching the topic of ecosystems.

a) Language-focused approach to teaching concepts: how can you elicit the meaning of ecosystem from your learners?

1. Break the word *ecosystem* into its constituent parts the prefix *eco-* and the noun *system.*
2. Ask learners what words they know beginning with the prefix *eco-* .
3. Learners might suggest words they know from their own experience such as: *eco-friendly, eco-tourism, eco-footprint, ecology.*
4. Elicit meaning of *eco*- from these words –e.g. *eco*- relates to the environment
5. Explain Greek origin of *eco* = oikos that means extended family unit and by extension environment shared by a community.
6. Attention can then be drawn to the term *ecosystem* with a focus on the word *system.*
7. Students can exchange ideas about the meaning of the word *system.*
8. Drawing on their own experience, students might say that a *system* is a way of organising things or that a *system* could be a set of connected things.
9. This can lead to a discussion of what is meant by the term *ecology* and its relationship to the term *ecosystems.*

b) Language-focused approach to identify key vocabulary related to ecosystem(s) that students need to understand as shown in Table 1 below. Language support can be provided at the level of vocabulary related to the topic of ecosystems by creating a word bank. Students will also need scaffolding in the language required to support learning and an example of this is shown in Table 1 where teachers can provide sentence level support to help learners articulate and construct knowledge whilst also developing cognition.

Table 1: Identifying and supporting topic-related vocabulary relating to the topic of ecosystems.

Word-level support	Sentence level support e.g. to explain/describe
Word bank: Ecosystem Terrestrial ecosystem Biotic/abiotic Taxonomy Arthropod Exoskeleton Invertebrate Biodiversity	The differences between an ecosystem and a community are……. Ecosystems can be classified as….. ………….. are examples of biotic factors. ……………..are examples if abiotic factors

Step 3: Plan Hands-on Tasks:
Plan practical, interactive activities that allow students to explore and understand ecosystem concepts (Nikula, 2015). Examples include creating model ecosystems or simulating the

impact of environmental changes on an ecosystem.

Step 4: Integrate Language Skills:
Incorporate language skills (listening, speaking, reading, and writing) into your science lessons. Provide explicit instruction on key vocabulary related to the ecosystem (word banks or glossaries), offer sentence frames for expressing observations and hypotheses, and encourage collaborative language learning through group discussions and presentations.

Step 5: Incorporate Vocabulary Building Strategies:
Develop a list of key ecosystem-related vocabulary and incorporate activities such as vocabulary games, concept mapping, and word charts to reinforce understanding (Filipi, Nguyen and Berry 2023).

Step 7: Foster Language Use in Science:
Encourage students to use language effectively in the context of science (Pun & Macaro 2019). Design activities that prompt students to ask and answer questions using scientific language, fostering language development while reinforcing scientific concepts.

Translanguaging approach to science education

Translanguaging is a linguistic concept that refers to the dynamic and fluid way in which multilingual & bilingual individuals and communities use and blend their languages in communication (García, 2009). In education, translanguaging is used to support students who are learning in a second language or who have multilingual backgrounds. It recognizes the value of using students' home languages and linguistic resources to enhance their understanding of academic content. Translanguaging in science classrooms recognizes that language is a fundamental tool for learning and that students should not be restricted to a single language when engaging with complex scientific content.

Translanguaging acknowledges that language is not a static entity but a dynamic tool for communication (Buxton et al., 2021). Teachers can create an environment that values students' diverse linguistic repertoires, promoting a sense of inclusivity and validating the use of different languages in the science classroom. By embracing translanguaging, science educators can enhance students' engagement with scientific content while simultaneously supporting the development of their language proficiency.

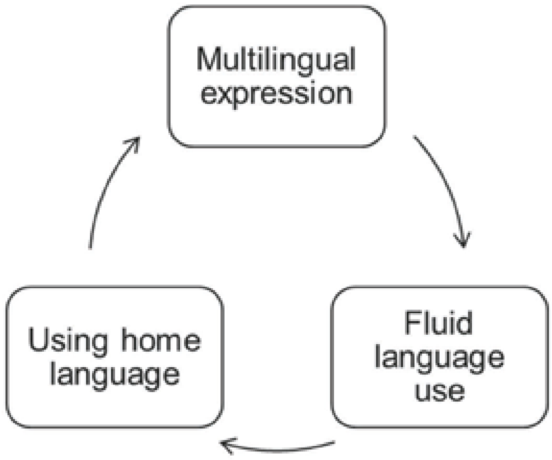

Figure 1: Description of translanguaging

How to use Translanguaging in science classrooms:

- **Multilingual Group Discussions:** Encourage students to discuss scientific concepts in small groups, allowing them to use their native languages freely. This collaborative approach fosters a supportive environment where students can share initial thoughts and interpretations in their familiar linguistic context (Langman et al.,2022).
- **Translanguaging Learning Materials:** Develop learning materials, such as glossaries or visual aids, that incorporate multiple languages. Providing resources in various languages can enhance students' comprehension of scientific terms and concepts (Jakobsson et al., 2022)
- **Bilingual Science Journals:** Introduce bilingual science journals where students can record their observations, questions, and reflections in both English/Irish and their native languages. The journal becomes a personal space for students to connect language with scientific concepts.
- **Interactive Multilingual Science Labs:** Design interactive science labs that encourage students to collaborate using both English and their native languages. Buxton et al., (2021) emphasize the

significance of translanguaging in the practical application of scientific concepts, fostering an environment where language is a dynamic tool for hands-on exploration and experimentation.

- **Bilingual Concept Mapping:** Implement bilingual concept mapping exercises, allowing students to visually represent relationships between scientific terms in both English and their native languages. This approach facilitates a deeper understanding of scientific concepts by connecting linguistic and visual representations (Buxton et al., 2021).
- **Word wall:** Use a translanguaging word wall by incorporating key science vocabulary in multiple languages, encouraging students to contribute terms in their native languages. This activity is useful as it represents all students in the classroom. They can develop better understanding of these terms by finding their equivalence in their first language.

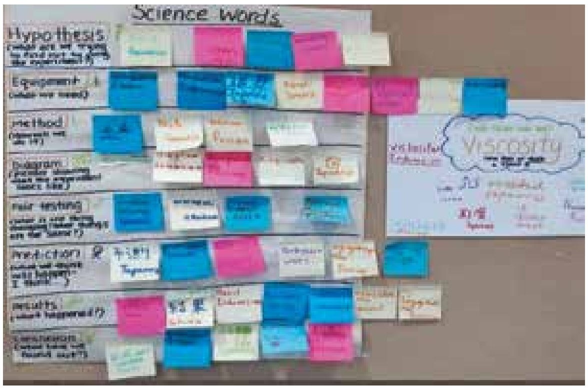

Figure 2: Multilingual science vocabulary word wall (courtesy of a science teacher in a multilingual school in The Netherlands)

- **Bilingual/multilingual assessment:** Assessments can involve projects where students create bilingual/ multilingual scientific presentations. This holistic approach not only improves vocabulary but also fosters a deeper understanding of scientific principles (Childs & O'Farrell, 2003).

Integrating these real-life examples into science classrooms allows educators to leverage the advantages of translanguaging. This approach creates an atmosphere in which students can actively and confidently interact with scientific concepts, drawing upon their varied linguistic capabilities. These strategies not only enrich the acquisition of scientific vocabulary but also cultivate a science learning experience that is more inclusive and participatory for every student.

Practical Implementation of translanguaging approach in science classrooms:

Step 1: Select Key Scientific Terms:
Identify key scientific terms related to climate change that students need to understand. For instance, terms like "greenhouse effect," "carbon footprint," and "renewable energy."

Step 2: Multilingual Definition Cards:
Create definition cards for each selected term, featuring clear explanations in English alongside translations in the languages spoken by the students in the class. Use images to support definitions where possible.

Step 3: Student Contributions:
Encourage students to contribute additional terms or phrases related to climate change in their native languages. This fosters a sense of ownership and inclusivity, drawing on the full linguistic repertoires of the students (Lemmi et al., 2023).

Step 4: Visual Representations:
Include visual representations or images next to each term to reinforce understanding. Images can transcend language barriers, aiding comprehension for all students, regardless of their linguistic background.

Step 5: Interactive Engagement:
If using word wall approach, build in interactivity by incorporating activities where students are encouraged to actively participate. For instance, students can use sticky notes to share personal reflections, questions, or additional terms related to climate change in their native languages.

Step 5: Regular Updates:
Periodically update the word wall to reflect new terms introduced during lessons or terms suggested by students. This ensures that the word wall remains a dynamic and evolving resource.

Challenges and best practices of Translanguaging in science classrooms

Translanguaging in science classrooms presents challenges and opportunities, as explored by Daniel and Pacheco (2016) and Nyimbili & Mwanza (2021) and summarised in Table 2 below. To address differences in language proficiency, teachers can implement linguistic responsive teaching approaches such as scaffolding or encourage peer-peer support. Further support can also be provided using alternative assessment methods, such as project-based assessments, which can offer a more comprehensive reflection of students' understanding. In dealing with time constraints faced by busy teachers in their classrooms, teachers can try to build in flexibility into their lesson planning and plan for integrating language support into the teaching of content. To help navigate the use of native languages in their classrooms, teacher should provide clear guidelines on language use in the classroom. By valuing the language backgrounds of all students, teachers can help to foster inclusive and supportive learning environments. We propose that the above insights and approaches can inform practical strategies for navigating translanguaging dynamics in science education.

Table 2: Challenges and best practices in using translanguaging in science classrooms (Daniel & Pacheco, 2016; Nyimbili & Mwanza, 2021)

Challenge	**Language proficiency variation**	**Assessment**	**Time Constraint**	**Classroom management**	**Stigma and identity**
Strategies to overcome challenges	Provide scaffolding, peer support	Alternative assessment methods such as project-based assessments or portfolios, to better reflect students' understandings	Flexible lesson plans, integrate language support	Create clear guidelines for when and how native languages can be used in the classroom	Inclusive and supportive classroom environment

Pre-service science teacher workshop on language and culture-responsive teaching

The UL ESTA team surveyed pre-service science teachers at undergraduate and postgraduate level at the University of Limerick regarding their knowledge of pedagogical approaches to teaching in linguistic and culturally diverse science classrooms. When students were asked about teaching strategies that can be used in a linguistically diverse classroom, many students were unaware of language-sensitive strategies (Figure 3). However, teachers did acknowledge that it was the responsibility of science teachers to support the teaching of both content and language and that they need specific training to teach in linguistically and culturally diverse classrooms.

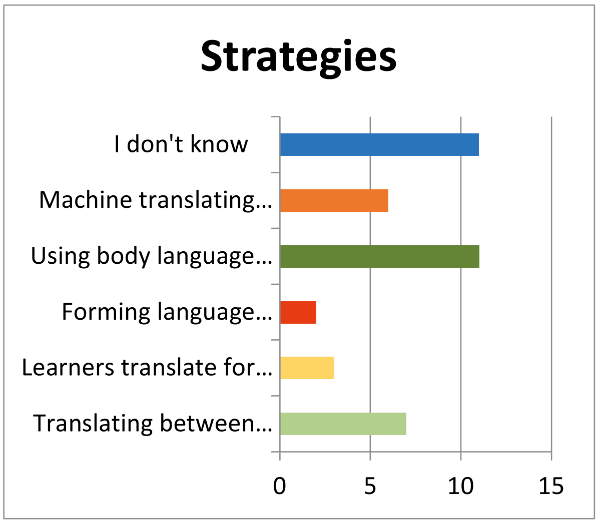

Figure 3: Pre-service teachers survey of language-sensitive strategies (N = 31)

The UL team delivered a workshop on language and culture-sensitive teaching to the pre-service teachers as part of their pedagogy module. The

CLIL and Translanguaging activities presented above in this paper formed part of the workshop. When the pre-service teachers were surveyed after the workshop and asked if they would be willing to implement the strategies and activities introduced in the workshop in their teaching, 68% said they would, whilst 19% were unsure.

Conclusion

In conclusion, as Irish classrooms become more linguistically and culturally diverse, the need for effective pedagogical strategies becomes crucial. In this paper, the UL ESTA team have drawn on the work of the ESTA project to provide guidelines and approaches to help science teachers in meeting the challenge of teaching scientific vocabulary to both non-native speakers and native English/Irish speakers in the increasingly diverse Irish educational landscape. By introducing practical multilingual approaches like Content and Language-Integrated Learning (CLIL) and Translanguaging, the paper aims to equip science teachers with tangible strategies to create inclusive learning environments. These strategies not only address language barriers, but also foster a deeper understanding of scientific concepts which will benefit all students in their classrooms. As teachers navigate the complexities of multilingual classrooms, it is hoped that this paper provides important insights to enhance their ability to engage and support students from diverse linguistic backgrounds, ensuring an enriched learning experience for all. We conclude by offering readers the following points of reflection in Table 3 to prompt teachers to look at their current and future pedagogical practices.

Table 3: Engaging in reflective practice to develop language and culture sensitive teaching

Reflections
1. How can you create a classroom where all students, including those who speak multiple languages, feel comfortable expressing themselves in different ways? 2. What changes or improvements can you make to your science materials so that they support the use of different languages and communication styles?

We have also provided a checklist (see Table 4), which teachers can use in auditing their current and future pedagogical practices as they begin to implement more language and culture responsive teaching to help develop inclusive science classrooms for all.

Table 4: Checklist for teachers to guide implementation of language and culture responsive pedagogical practices to support multilingual and multicultural learners in science classrooms.

Language and culture responsive teaching checklist (adapted from Dale & Tanner (2012) cited in Banegas 2015)
Check prior knowledge of topic at the start of lessons
Check what language related to the topic the learners know at the start of lessons
Provide scaffolding and peer support
New topics introduced by hands-on activities
Encourage home language use in small group discussions
Learners talk to each other when activating prior knowledge
Include images for better comprehension
Teacher encourages pair-work and group-work

Teacher uses multi-modal resources to support understanding of scientific vocabulary
Teacher uses multiple strategies to develop reading and listening skills
Teacher works actively to develop learner thinking skills
A variety of activities used to help learners practise and use vocabulary
Learners guided in noticing how topic-related language is used
Teacher helps learners notice differences between L1 and L2
Learners actively use a personal vocabulary file in class
Learners are helped to learn subject-specific terminology
Teacher discusses ways of learning words with their learners

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Impact of the ESTA Project in Bosnia-Herzgovina

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Introduction

Bosnia and Herzegovina (B&H) is a small country in the heart of Europe and very rich in linguistic and cultural diversity. Still, during teacher education, the curricula lack focus on diversity and heterogeneity in the classroom. For this reason, the Erasmus+ project entitled Educating Science Teachers for All (ESTA) was a great opportunity to explore and put an emphasis on the importance of sensitizing teachers to these issues and to provide teachers with an adequate basis on how to deal with them in their classrooms. At the Faculty of Science in Sarajevo, among five departments that have programs for educating future science teachers, at the Department of Chemistry students who complete the study program for chemistry can teach chemistry in the 8th and 9th grades of primary school (students' age 13-15 years) and in secondary school (students' age 15-19 years). However, primary school students already encounter scientific terms in the lower grades of primary school, more precisely from 3rd to 5th grade (age 8-11). These concepts are introduced within the subjects 'My Environment' and 'Nature'. These subjects are taught by the teachers who are educated at the Faculty of Educational Sciences. To ensure quality chemistry education and the acquisition of systematized knowledge in the field of chemistry, the cooperation of chemistry teachers and the teachers who teach lower grades is important. The idea of promoting cooperation between teachers in higher and lower grades with an emphasis on recognizing and respecting heterogeneity and diversity in the classroom contributed to the achievement of the goals of the ESTA project.

The CLIL concept

The role of language presents diverse and challenging aspects in the instruction and comprehension of chemistry, particularly considering the evolving nature and diverse backgrounds of students in terms of skills, language, and cultural upbringing. The significance of communication skills is evident through various classroom activities like reading, writing, listening, and speaking, each demanding distinct facets of language utilization (Markic & Childs, 2016). It is important to note that when teaching the language of chemistry, educators typically employ the spoken language of the country where they teach. The scientific language specific to chemistry, sometimes known as "chemish," is crucial for effective communication and comprehension within the field. However, it also poses a significant challenge in the teaching and learning of chemistry within a school environment (Mönch & Markic, 2022). To overcome this challenge the concept of CLIL (Content and Language Integrated Learning) served as an excellent base for choosing methods for the implementation of workshops within the ESTA project. Implementing CLIL in the classroom offers numerous advantages. It not only enriches language acquisition by familiarizing students with subject-specific vocabulary and language structures, but also concurrently enhances their understanding of the content being studied. Learning content through a different language tends to be more engaging and motivating for students. It provides a practical application of language skills, thereby rendering the learning process more meaningful and applicable. Following the benefits of CLIL, several segments in the creation of workshop materials have been selected and integrated: visualization, group work, and digital equipment. Incorporating group work, visualization, and digital equipment in a CLIL classroom can significantly enrich the learning process, promoting language development, content understanding, and valuable 21st-century skills.

Design of exercise materials

Laboratory exercises for primary and secondary school in-service and pre-service chemistry teachers

Each laboratory exercise was prepared in five versions: in Bosnian and Croatian (using the Latin alphabet), in Serbian (using the Cyrillic alphabet), in English (using the Latin alphabet), and pictorial material (presenting each step in the form of a picture, without text) (see Figure 1). The exercises concerned physical and chemical changes in substances and the determination of energy from food. This type of material preparation was chosen to sensitize the participants to how the learning process can be hindered if the material delivered to the students was in a language or alphabet they are not familiar with.

Figure 1: Segments of the exercise material Energy from food in different alphabets and pictorial material

Figure 2: Equipment and materials for the exercise Energy from Food (Phywe CobraSmart Thermocouple sensor was used to measure temperature changes

Laboratory exercises involved contemporary digital laboratory tools and IT devices (such as pH, temperature, and conductivity sensors), tablets, and respective applications for collecting and analyzing data. Figure 2 shows the equipment and materials for the exercise 'Energy from Food.'

Workshop implementation

Workshops were held with in-service chemistry teachers from primary and secondary schools and with students of the Faculty of Educational Sciences. Pre-service chemistry teachers participated in both groups. Each workshop lasted several hours and alternated between lectures and laboratory exercises.

Workshop for primary and secondary school chemistry teachers:

The workshop was intentionally structured to engage teachers in a dual capacity, fostering an enriched learning experience. Primarily serving as teachers, the workshops were crafted to provide professional development. Additionally, teachers were positioned in a student-like role, allowing them to encounter situations resembling those faced by their students. This approach sought to sensitize teachers to effectively work in diverse and heterogeneous classrooms.

Implementation of the ICT:

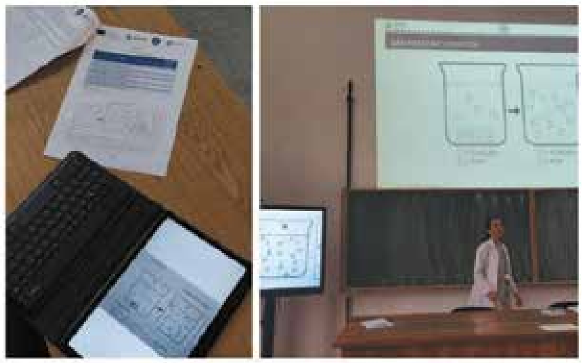

Figure 3: An example of using ICT for task sharing and joint discussion.

Teachers were exposed to learning about new equipment, new types of exercises, and new words. The ESTA team monitored how they managed in a new situation. Research has shown that many teachers in numerous countries often display hesitancy toward adopting changes and incorporating new methodologies into their teaching practices. The decision to introduce digital devices during the workshop was made not only to elevate the quality of teaching but also to respectfully address this resistance among teachers. An example of using ICT to promote the active involvement of participants in a problem-solving task is shown in Figure 3.

Implementation of group work:

For each exercise, each group used material in a different language or alphabet typical for B&H. It was observed that the participants communicated with each other more intensively when they received material in a language or alphabet that they knew less or used less often. In each group, one of the participants who was more familiar with the exercise material spontaneously became the group leader and explained the exercise task in more detail. This situation allowed the participants, faced with a novel situation and encountering unfamiliar elements, to subsequently ease into a more comfortable state. As a result, they were able to actively engage in the exercise segment that aligned better with their familiarity and experience. Figures 4 and 5 show the workshop participants solving tasks together.

Figure 4: Participants solve the exercise tasks together.

Figure 5: Participants show motivation by continuing to solve the tasks during the break.

Implementation of visualization:
Each group received visual material - without text - for a specific exercise as a procedure (see Figure 6). After viewing the material, the participants began to discuss, define the procedure, and make notes. This was a clear indication that each participant would acquire some new knowledge, i.e. expand their “chemish” vocabulary. Another visual tool that has been used is *MeasureApp* application, which allowed the participants to observe certain changes during the exercise by observing the tablet screen (movement of the curve on the graph, numerical values, etc.). Observations were used for discussion and solving tasks in the worksheet. They also helped in creating and expressing a critical opinion on the topic that the exercise concerned.

Figure 6: Segments of pictorial material for the Energy from Food exercise

As one of the most important segments of learning chemistry, the submicroscopic part, i.e. the level of particles, was represented in the exercises (see Figure 7). In the context of "chemish" vocabulary, through this type of task, the names of compounds, types of particles are learned, and the behaviour of particles is defined.

Figure 7: Examples of tasks related to the representation of the particle level

Laboratory exercises for primary school in-service and pre-service chemistry teachers and students of the Faculty of Educational Sciences:

Figure 8: Discussion and realization of the exercise for acquiring information about sugar

In the workshops for primary school chemistry teachers and students of the Faculty of Educational Sciences, materials taken from the Science on Stage (www.science-on-stage.eu) platform were used. These materials offer different experiments with materials available in everyday life. The exercises are based on activities that include conversation and discussion and are an excellent resource for acquiring knowledge about basic scientific concepts related to natural sciences. In addition to these exercises, the participants were also offered simple exercises that covered the topics found in the curriculum of the subject 'My Environment', (4th grade of primary school, age 9-10). The exercises were designed based on the STEM approach. Tasks included working on text and doing calculations using pictures with data (see Figure 8).

Conclusion

The ESTA project was a great opportunity to promote the importance of respecting heterogeneity and diversity in the classroom. The selection and preparation of activities within the project represented a great challenge as well as the pleasure for the members of the ESTA University of Sarajevo Team. In terms of sensitization, during the workshop, teachers were offered examples of how to design an exercise that will include several segments essential for working in heterogeneous and diverse classrooms. Students had the opportunity to see some of the ideas of how concepts such as chemical changes, rusting, energetic value of food, sugars, and weighing, can be presented to students of lower grades. The reactions of the participants to the activities were positive and a significant step forward was made in promoting the importance of recognition of heterogeneity and diversity, something chemistry teachers lacked during their education and through the work.

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Promotion of ESTA project ideas for chemistry teachers

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Introduction

Bosnia and Herzegovina (B&H) is a country with a long and rich history and it is home to three main ethnic groups: Croats (Roman Catholics), Bosniaks (Muslims) and Serbs (Orthodox) and many minorities (Jews, Roma, Albanians, Montenegrins). It comprises two autonomous entities (the Federation of Bosnia and Herzegovina and Republika Srpska) and a third unit, the Brčko District. In B&H, several educational systems exist side by side, separated according to the ethnic and religious group they belong to. Although they live in the same country, ethnic groups in B&H have different histories, cultures and languages, which they are aware of. Also, it should be noted, that the main ethnic groups in B&H share a significant part of the gene pool that is unique to the Balkan region (Marjanovic *et al*., 2005).

Intercultural education is an important factor in understanding different cultures and establishing positive relations between people, especially for vulnerable individuals and groups (Nuić *et al*., 2023). Language plays various roles in the teaching process, especially given the diversity of the student population in terms of language and culture and other activities that take place in the classroom such as reading, writing, listening, and speaking. All of these activities require language use (Markic *et a.,l* 2016). The view has been expressed that language is perhaps a bigger barrier to learning science than the content itself (Gabel, 1999; Yong, 2003; Pyburn *et al*., 2013). Familiarisation with the language of science necessarily occurs more or less simultaneously with the learning of the science content (Vladušić *et al*., 2016). Therefore, the challenge is to encourage chemistry teachers to develop competencies for an intercultural teaching environment.

To learn how we can more successfully deal with issues of heterogeneity and diversity in chemistry classrooms, we signed up for the Educating Science Teachers for All (ESTA) project. As a part of the ESTA project, workshops about diversity and heterogeneity in chemistry classrooms were given to pre-service and in-service chemistry teachers at the Faculty of Science and Education. The workshops were organised to encourage active learning and almost all participants expressed the need to receive continuing education about this issue (Vladušić at al., 2022). Thus, training courses on diversity-sensitive science teaching were developed, including development of new teaching and learning materials for adaptation to local contexts. The aim of these developments was to achieve better learning outcomes in heterogeneous science classrooms.

The pre-service and in-service chemistry teacher workshops

Here we describe methods, approaches, and activities for pre- and in-service chemistry teachers that take into account new knowledge about how to deal with class heterogeneity and linguistic and cultural diversity. Bosnia and Herzegovina is a country with three official languages: Croatian, Bosnian, and Serbian, so school classes in B&H are often heterogeneous groups. However, most of our pre-service teachers never experienced highly heterogeneous classes. In our science study groups, students work in small groups, but these groups are homogeneous. Students are not aware of the different dimensions of diversity and how it can affect their teaching. Our students are teachers to be, so it is very important to prepare them to deal with heterogeneity and diversity in science classes where there are social, ethnic and cultural differences. Therefore, our workshops are mainly directed towards pedagogical approaches that are sensitive to these differences and the teaching of scientific language. Taking into account the methods, tools and instruments presented by the partners of the ESTA project from the University of Limerick and the University of Education in Ludwigsburg, we have prepared workshops in which we will sensitize the participants to heterogeneity and cultural and linguistic diversity (CLD students). The workshops are designed so that participants receive instructions for solving the experimental task in different languages (Serbian, Croatian, Bosnian or English).

The results from the tasks were analysed together with special reference to linguistic and cultural differences or similarities on any given topic. For these experiments, we used classical procedures, but also instrumental techniques such as spectrometry, chromatography and voltammetry. The goals of such workshops were twofold: to train chemistry teachers for expert work in chemistry and to empower them to successfully transfer their knowledge to students regardless of their cultural or linguistic differences. Chemistry teachers were introduced to the methods and tools of working in heterogeneous classes, such as: methods for language-sensitive teaching and learning; the "Catch and hold" method - how to make science lessons more interesting (Mitchell, 1993); the role-playing method; the flipped classroom; and digital media in science lessons. Content and Language Integrated Learning (CLIL) is an excellent approach to teaching in bilingual or multilingual classrooms (Eren and Martin, 2023). This teaching approach is based on four elements: content (subject knowledge and skills), cognition (thinking skills), culture (teaching based on student experiences) and communication (working in teams and using different communication tools) (Surmont *et al*., 2014). The participants worked individually and in small groups. In addition, the cooperation of in-service and pre-service teachers in the exchange of knowledge and experience during the workshops is interesting and very significant. At the end of the workshop, the teachers filled out the exit questionnaires.

Workshop 1: Sensitization for heterogeneity with essential oils

The workshop consisted of two parts. In the first part, the teachers conducted a chemical analysis of lavender essential oil using the GC/FID analytical technique. The second part of the workshop aimed to train teachers to diagnose problems in heterogeneous classes.

Essential oils are mixtures of volatile, biologically active chemical compounds obtained by distillation from different parts of plants. They are widely used in different cultures for different purposes, such as aromatherapy, folk medicine, cosmetics, pharmacy, official medicine, and the like. As an introductory part, a discussion was held about medicinal and aromatic herbs in different cultures and nationalities. What spices are used in their kitchen? What plants do they use to treat diseases or prepare teas? Which natural flavor do they like the most?

The participants then received a protocol for the method which they used to analyse the essential oil. They identified 24 compounds in lavender essential oil. The most abundant compounds were linalool and linalyl acetate. They also compared the obtained results with the relevant literature (Talić at al., 2023).

The teachers observed that some compounds have multiple different names and different applications in modern life. In the last part of the workshop, the meaning of certain words in this topic was discussed. Cultural and linguistic differences among the students of our teaching context were diagnosed. Teachers were introduced to the methodology and tools for developing sensitivity to linguistic diversity (CLIL approach).

Workshop 2: DNA isolation from plant material

DNA is the code for life. DNA (or deoxyribonucleic acid) is a long molecule that contains our unique genetic code. It is found in all types of tissues. For DNA to be visible to the naked eye, it can be isolated by a simple process - household chemistry. The goals of the workshop are to develop the ability of students to work independently and think critically. To introduce teaching methods for heterogeneous classes into practice.

After the implementation of the well-known simple method of DNA isolation (NIH, 2023), the teachers considered the application in heterogeneous classes and to identify possible improvements. Suggestions for adaptation for heterogeneous classes are:

- use interactive models of DNA,
- build a *„Sweet DNA Model"* ,
- integrate technology in the classroom, like videos, animations, lab simulations, and mobile apps to enhance the learning experience,
- the questions asked to students with language difficulties should be short and clear, requiring short answers or single-choice questions,
- during the discussion, it is not advisable to use sudden questions, or open questions, for example, "*Tell me everything you know about*...",
- it is good for a student with difficulty to work in pairs or groups.

Workshop 3: Having coffee with the chemist

Workshops focusing on the application of spectrometry were planned and carried out to familiarise students with the terms related to this field of chemistry, followed by recent literature written in the languages that are official in Bosnia and Herzegovina. The concepts fostered by the newer literature are especially meaningful for in-service teachers who may not have had the opportunity to use them recently.

The workshop aimed to help teachers acquire new terms and to recognise and understand already acquired terms in the context of another language. The workshop achieved this through the analysis of coffee or tea using two spectrometric techniques (infrared spectrometry and UV spectrometry). Coffee is particularly interesting because of the cultural heritage shared by the citizens of Bosnia and Herzegovina, so we called the workshop "Having Coffee with a Chemist" to stimulate curiosity.

All participants had instructions for working in the laboratory. The first part of the workshop was related to the preparation of solutions and a short demonstration of how to use spectrophotometers and the analysis of selected samples with comments related to known/unknown terminology in the context of three languages. In the second part, a discussion (over coffee) of the linguistic diversity that was demonstrated during the workshop was planned. All participants could prepare a coffee depending on their preference, with more or less caffeine.

During the discussion, expressions in all three languages (Croatian, Serbian, Bosnian) were used to describe accessories, chemicals, and techniques with which participants are familiar. However, it was acknowledged that it is especially challenging for teachers to acquire knowledge of instrumental techniques, with which they are less familiar, in one of the B&H languages that is not their native language.

Workshop 4: Corrosion protection with eco-friendly inhibitors

In this workshop, students discuss the influence of metal corrosion on the environment, classic toxic and new eco-friendly inhibitors, inhibition efficiency, and the adsorption mechanism of inhibitors on metal. Also, students discuss the meaning of specific words used in this exercise so they can adopt chemical terminology in their different languages.

The electrochemical behaviour of metals through corrosion experiments is necessary to introduce students to the complexity of the language of chemistry language. Corrosion inhibitors are substances that, in small concentrations decrease or prevent the degradation of metal. Unfortunately, many of the inhibitors used are compounds with toxic properties. However, an increasing awareness of health and ecological risks has drawn attention to finding nontoxic and environmentally friendly corrosion inhibitors. Green inhibitors can be used in the form of extracts, essential oils, or pure compounds. The natural compounds are biodegradable, easily available, and non-toxic (Martinović *et al.*, 2023).

In the first part of the exercises, students start a discussion about the influence of metal corrosion on the environment and classic toxic inhibitors versus new eco-friendly inhibitors. Students can then conduct experiments according to the given protocol to study the electrochemical behaviour of metals and alloys in different harsh environments with and without inhibitors.

After calculations, students discuss the results. Does the eco-friendly inhibitor protect the metal surface? What do potentiodynamic polarization parameters (corrosion potential, corrosion current…) mean? Is the inhibition efficiency high enough? How does the inhibitor bond to metal?

The next step is teaching student teachers about conducting diagnostics in linguistic heterogeneous science classes. Suggestions for discussion are to: comment with students on whether they have had difficulty in understanding the scientific or general language terms, which linguistic differences were observed in the exercise methodology, and assess the main differences in the language of chemistry. At the end of the exercise, pre-service teachers use various tools (like creating a Block diagram concept map or multiple-choice questionnaire), which can be used for future teachers' teaching.

Evaluation of workshops

At the end of the workshop, all participants had the opportunity to express their level of satisfaction in writing. Most of the participants responded with the rank of 4 or 5 indicating that participants are highly satisfied with the workshop. It is concluded that the workshop was beneficial to the participants, and they intend to use what they learned to improve their teaching.

At each workshop, attendees were invited to list their likes and dislikes as well as suggest positive constructive changes for the next workshop.

Table 1: Remarks on the workshops: like, dislike, and suggested changes

Type	Remarks
Like	Materials, slides, and handouts Well organized Interactive and informative Open discussion Group work, engagement of all participants
Dislike	Insufficient number of workshops to present such an important topic Not enough number of in-service teachers attending workshops
Suggested changes	More practical example More time for exercises Connect to the Ministry of Education and start a certified program

The participants positively evaluated the workshop objectives, content, and clarity, and they were satisfied with the learning methods and group work that highly contributed to the success of these workshops.

According to the aims of the ESTA project, questionnaires were distributed at the end of the workshop to the participants (in-service and pre-service teachers) and they responded to each of the following statements by choosing one of the provided responses that indicated their level of agreement (SA = strongly agree, A = agree, N = neither agree nor disagree, D = disagree, SD = strongly disagree). A total of 40 completed questionnaires were received and analyzed. Completed questionnaires' responses were entered in Excel for descriptive analysis. Data were summarised according to the themes in the questionnaire:

- Teachers' Attitudes towards Valuing Students' Culture and Languages
- Teachers' Expectations of CLD Students' Academic Performance
- Negative Attitudes towards Inclusion of CLD Students in Subject Area Classes
- Positive Attitude towards Inclusion of CLD Students in Subject Area Classes
- Teachers' Beliefs about CLD Students Enrolled in their Subject Area Classes
- Teacher Attitudes towards CLD Students' Needs

Most of the teachers consider that students' culture and languages have a strong impact on their learning performance and that all students in science classes can and do have the potential to learn regardless of their diverse cultures or languages, but CLD students must put more effort.

Further, pre-service and in-service science teachers consider that CLD students increase their workload, but they also create a positive educational environment. Also, teachers believe that there is no adequate attention to diversity issues in classrooms and that the individual needs of students are an important part of science lesson plans and science materials should be adapted for CLD students.

Teachers are aware that curricula are the most important educational documents and have a strong influence on the education of students, but the existing curricula in B&H have many shortcomings and are outdated. The education system in Bosnia and Herzegovina needs fundamental changes, and investment in education is the main path to the progress of society.

According to the teachers: teaching science in heterogeneous communities is not at the appropriate level and rests solely on the enthusiasm of the teacher and the education system should train teachers to work in heterogeneous classes. Almost all participants express the need and willingness to receive continuing education about diversity and heterogeneity.

Conclusion

As education helps shape young people's opinions and attitudes, it is essential to the development of sustainable peace in Bosnia and

Herzegovina. The teaching process is still predicated on out-of-date curricula and instructional materials, notwithstanding advancements during the previous 20 years. This means that schools frequently fall short of providing pupils with the skills they need for life in a varied and constantly changing society, especially when combined with a strong ethnic, religious, and gender prejudice (OSCE Mission, 2023). Because they do not promote competencies like critical thinking, multiperspectivity, inclusion, and respect for diversity, innovation, and collaboration among the younger generations, current educational methods impede reconciliation and risk long-term stability.

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□

Why should "Science for all" be one of the science teachers' priorities? Reflections on ESTA project

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The Educating Science Teachers for All (ESTA) project includes eight partners from five countries. Georgia, the Philippines, and Bosnia and Herzegovina are among these countries. In these countries, many young people do not meet basic requirements in science. In international assessments of science performance, all three countries scored very low. Science education in all three countries takes place within political and ethnic differences divides, that translate into linguistic heterogeneity and cultural diversity. As declared in the project, its main objectives were to: (1) Ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes, and (2) to empower and promote the social, economic and political inclusion of all. Thus, irrespective of age, gender, disability, race, ethnicity, origin, religion or economic or other status, the project focuses on gender, social, economic, and cultural diversity and inclusive education.

How did the partners cooperate in order to achieve the project's goals?

The cooperation among the partners was enacted at the beginning of the project by ZOOM video on-line meetings (except of the kick-off meeting in February 2020), due to the COVID-19 pandemic and the corresponding restrictions for travelling. The ESTA courses and curriculum materials focused on issues such as linguistic diversity, teaching scientific vocabulary in multilingual classrooms, culture and ethical diversity, socio-economic status, and gifted students.

The partners started the development phase more quickly than expected, to have enough time for the development using Participatory Action Research, and in these meetings, one could notice the development of relationships of trust between the partners who did not know each other before, as well as sharing ideas and activities. Each partner used different strategies in coping with ESTA's goals. The following will serve as examples:

1. The De la Salle partners described two days of action research activities for in-service teachers' preparation; innovative science technology by students to teachers-training DLSU integrated school teachers; and advertisement in magazines.
The recognition and appreciation of inclusivity and diversity allowed them to become more creative, accepting, understanding and stronger in our resolve to making teachers as "educators" for all.
2. From the Limerick partners one could learn about evaluation, measuring project outputs and deliverables, e.g., Portfolios. Due to the involvement in the project, the Irish classrooms become more linguistically and culturally diverse, and the need for effective pedagogical strategies becomes crucial.
3. The Ludwig-Maximilian University of Munich, and the Ludwigsburg University of Education teams explored the needed knowledge that teachers should have when dealing with the scientific language. They used the model of Pedagogical Scientific Language Knowledge, that was developed to support chemistry teachers in sensitive teaching and learning of scientific language in their chemistry classes.
4. The Philippine Normal University partners claimed that their activities in the framework of the ESTA project enabled their pre-service science students to enhance their perspectives and positive attitudes toward science teaching, as reflected in their inclusive science education, and science teachers' competences and pedagogies.
5. At Ilia State University in Tbilisi, the team members developed courses focusing on elevating the competences of university science teacher educators regarding diversity in science classes, with the focus on language and culture. The pre- and post-questionnaires

disseminated among the course participants showed that their attitudes towards linguistic and cultural diversity were slightly changed at the end of the course. In addition, the ESTA Course is now part of the science teacher preparation program at Ilia State University and will be offered every year to pre-service science teachers. Overall, the implementation of the ESTA project contributed to more inclusive and higher quality science teaching and gave interesting and productive results for Georgian in-service and pre-service science teachers. Similar findings were presented by the team of Telavi State University in implementing the Content and Language Integrated Learning (CLIL) approach, specifically within the context of science education in Georgia.

6. At the University of Sarajevo, Sarajevo, Bosnia and Herzegovina, the team concluded that the ESTA project enabled them to promote the importance of heterogeneity and diversity in the classroom. During the workshops, teachers were given examples of how to design and implement materials that will be essential for working in heterogeneous and diverse classrooms. The reactions of the participants to the activities were encouraging in promoting the importance of recognition of heterogeneity and diversity.

Various channels were used for dissemination, in which the partners informed people about their joint meeting and work: Teacher workshops; Facebook - the project has a page, as well as three groups for national teams; Twitter and Instagram; a new form of newsletters; contributions to national and international conferences, e.g., EUROVARIETY, GDCP; further publications are in preparation; meetings with different stake holders, policy makers, and local school administrations; the project website (www.esta-project.eu), comprised of three main sections. The ASANA project platform management enabled exchange of the documents as well as sharing all the other information.

In addition, team members were invited to seminar workshops, internal events at the universities, and teacher associations as speakers where they presented the project as well. The partners also presented the project to their pre-service science teachers in their teaching programs, on their institutions' websites and designed stickers with the ESTA logo which will be attached to the digital devices used in the seminars and trainings.

Impact of the project

The partners cooperated well and addressed their responsibilities in line with the project application. The outbreak of the COVID-19 pandemic caused deviations from the original timetable and the program in several regards. The partners were affected in varying degrees, but this is understandable. Nevertheless, based on the received input from the on-line and face-to-face workshops, the portfolios, tools, and materials were prepared by the partners in an excellent way.

In summary, there is no doubt that the ESTA project was successful, and it is suggested that it may contribute a lot to science education. The consortium coordinators, together with its work package leaders and members, accomplished good work according the objectives, especially during the COVID-19 pandemic. I participated in almost all the ESTA meetings, gave my feedback, and was impressed by the friendly, trustful and the open atmosphere, together with the fruitful development of the project. I should also mention the fact that my recommendations were obtained after each meeting, discussed, and directly implemented. No doubt that the project was successful, and its outcomes will contribute a lot to diversity and inclusion in science education.

Biography

Dr. Rachel Mamlok-Naaman *studied chemistry and chemistry education. She was the head of: (1) the National Center for Chemistry Teachers, (2) the chemistry group, (3) the chemistry teachers' Master program in the framework of the Rothschild-Weizmann, and (4) projects in the framework of the European Union. In addition, Dr. Mamlok-Naaman is the chair of EuCheMS DivCED, an ACS titular member, and serves on editorial and advisory boards of science education journals and organizations. Her publications are related to student learning and teachers' professional development. Her awards consist of two from the Weizmann Institute - 1990-Bar-Ner (for teaching), and 2006-Maxine Singer for professional development of chemistry teachers; ACS award (2018) for incorporation of sustainability into the chemistry curriculum; IUPAC award for 2020 distinguished women in chemistry and chemistry engineering.*

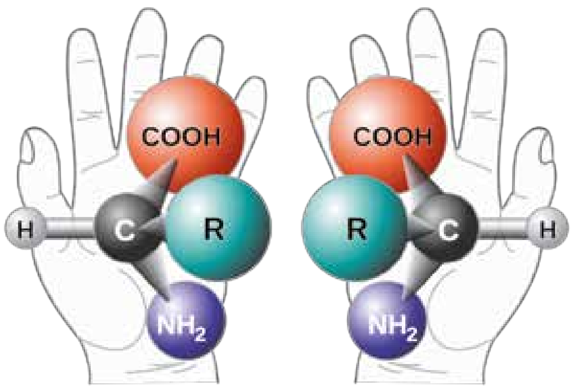
□

Chemlingo: Handy chemistry

Peter E. Childs

I don't know about you but as a non-organic chemist I find the terminology of optical isomerism confusing. Louis Pasteur first identified optical isomers of tartaric acid from the different shape of their crystals in the deposits from wine. From their effect on the rotation of the plane of polarised light, the two types were described as either dextro-rotatory (D-) or laevo-rotatory (L-), from the Latin for right (*dextro*) or left (*laevo*). A mixture of the two has no optical effect and was called racemic after racemic acid, obtained from grapes. The name came from the French and Latin for grapes as racemic acid was isolated from grape juice.

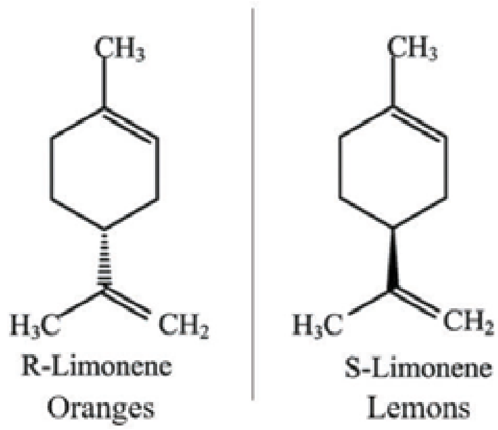
The optical isomers are also known as enantiomers, from the Greek *enantios* = opposite, and arise from the presence of an asymmetric carbon – one with four different substituents. Such molecules can exist in a right-handed and left-handed form which are non-superimposable, like a pair of gloves.



(https://upload.wikimedia.org/wikipedia/commons/e/e8/Chirality_with_hands.svg)

A new type of isomerism was thus introduced into chemistry, called optical isomerism (from its effect on polarised light), also known as stereoisomerism, and it has spawned its own language which has evolved over the years, creating confusion in its wake.

This phenomenon is also known as chirality from the Greek word for hand (*kheir*), a term coined by Lord Kelvin in 1894. When only one enantiomer is present the substance is known as enantiopure. Enantiomers can have different physical, chemical and biological properties and so the purity of drugs, for example, can be very important. One enantiomer of thalidomide produced birth defects but the other did not, but the drug as marketed contained a mixture of the two isomers and led to malformed babies. The two optical isomers (l)-(-)-limonene and (d)-(+)-limonene smell differently, although they have the same chemical properties, because they react differently with the receptors in the nose. (+ and – are also used to indicate the direction of optical rotation.)



The symbols R and S are also to distinguish optical isomers and these come from the Latin for right (*rectus*) and left (*sinister*) and refer to the absolute configuration. I hope this short treatment hasn't left you more confused than when you started.

□

Diary

2024

ISTA Annual Conference
1-2 March 2024
SETU, Waterford
ISTA

9th EuChemS Chemistry Congress
7-11 July 2024
Dublin, Ireland
EuChemS 2024

27th. International Conference on Chemical Education
"Power of Chemistry Education for Advancing SDGs"
15-19 July 2024
Pattaya, Thailand
27th IUPAC International Conference on Chemistry Education - ICCE 2024 (icce2024thailand.com)

BCCE 2024
"Distilling Solutions for Chemical Education"
28 July-1 August 24

16th ECRICE 2024
"Chemical Education for Sustainable Development: Empowering Education Communities"
5-7 Sept. 2024
NOVA, Lisbon, Portugal
Home | 16 European Conference on Research in Chemical Education :: 5-7 September 2024 (chemistry.pt)

43rd ChemEd-Ireland
19 October 2024
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- **The sulfur story: Sulfates**
- **Amazing minerals: Gypsum**
- **Kathleen Lonsdale**

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