

Article

# Investigating Language and Culture Awareness of Pre-Service Science Teachers in Ireland

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**Abstract:** Irish classrooms are becoming increasingly diverse across all levels of education due to the sustained inward migration of non-nationals to Ireland. These demographic changes have enriched the linguistic and cultural fabric of Irish society, including the educational landscape of Ireland. However, in addition to the value such diversity brings to Irish classrooms, there exist many challenges as the Irish education system needs to continue to adapt to develop more inclusive and language- and culture-sensitive pedagogical approaches. One of the ways in which the Irish educational system can respond to this challenge is through the adaptation of its pre-service science teacher education programmes to prepare teachers to teach in linguistically and culturally diverse classrooms. Therefore, it is important to investigate the needs of pre-service science teachers to inform updates to existing teacher education programmes to prepare future science teachers to meet this challenge. Consequently, this study has attempted to capture the perceptions, knowledge and attitudes of current pre-service teachers regarding the role of language and culture in science teaching, awareness of the needs of students whose first language is not English or Irish and teachers' knowledge of pedagogical strategies to develop language- and culture-sensitive science teaching approaches. Here, we report data from a survey of pre-service science teachers undertaking science teacher training at Irish universities at the undergraduate and postgraduate levels. The data highlight gaps in trainee teachers' language awareness and their lack of pedagogical knowledge in dealing with language and cultural diversity in science classrooms. Implications for the future development of pre-service science teacher education programmes are discussed.

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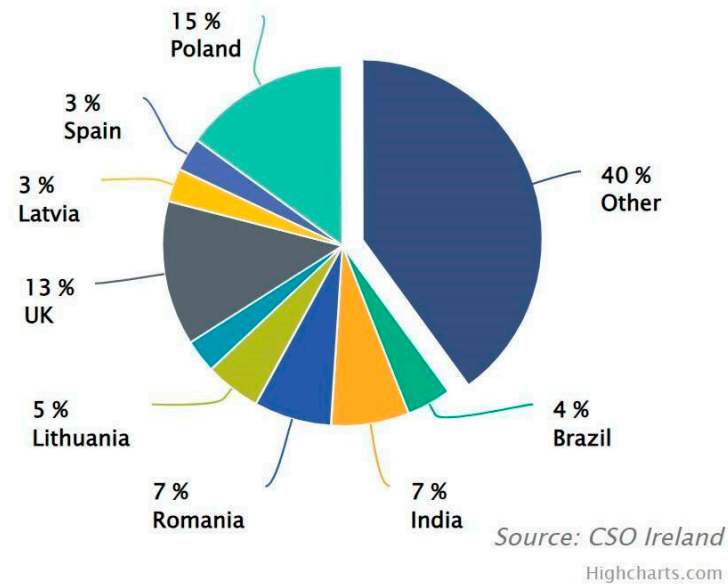
**Keywords:** pre-service science teachers; linguistic diversity; cultural diversity; inclusive science teaching; language-responsive teaching; culture-responsive teaching

## 1. Introduction

Currently, science classrooms in Ireland are becoming increasingly culturally and linguistically diverse, prompting the need for more inclusive pedagogical approaches to address this trend. This is posing particular challenges for science teachers in engaging culturally and linguistically diverse students in the learning and teaching of science in order to provide inclusive, transformational education for all and the advancement of scientific knowledge. The diverse student population in today's science classrooms has resulted in an increased emphasis on the role of science teachers in implementing language- and culture-responsive pedagogical approaches to foster inclusive practices that meet the needs of all learners [1,2] and foster and value multilingualism, a concept referred to as "the multilingual turn" in education [3]. Culturally and linguistically responsive pedagogy values and acknowledges students' cultural and linguistic backgrounds in all aspects of learning and teaching [4] and accommodates all cultural identities and languages in the classroom.

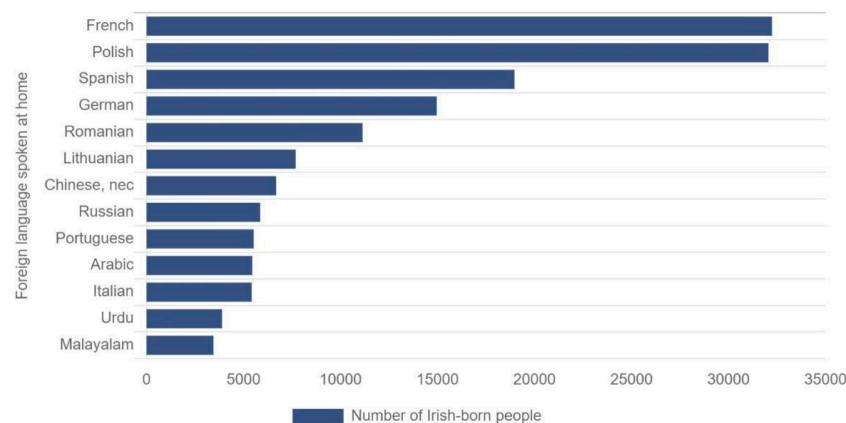
In Ireland, where this study takes place, the educational landscape has been significantly altered by the steady influx of culturally and linguistically diverse students and

families. Irish schools are no longer homogenous in terms of culture, as they once were [4]. As shown in Figure 1, in more recent years, this demographic shift has been sustained by the continued net inward influx of migrants and refugees to the Irish, state as borne out in the most recent census data that show that at least 12% of the population declared themselves as 'non-Irish' [5]. These data do not take account of the additional change in demographics due to the arrival of Ukrainian refugees since the advent of the war in Ukraine.



**Figure 1.** Non-Irish population usually resident and present in the State by citizenship (%) [5].

Furthermore, the CSO data (see Figure 2) reveals the linguistic diversity amongst the Irish population and the range of languages other than English and Irish spoken at home by the Irish-born population.



**Figure 2.** Irish-born population usually resident and present in the State who speak a language other than English or Irish at home, by language spoken [5].

Whilst this growing heterogeneity in culture and language has challenged traditional educational norms to move towards more inclusive and multicultural learning environments, it is necessitating a renewed commitment to develop inclusive classrooms that value the cultural and linguistic background of all students. An important avenue towards achieving this is through the use of language- and culture-responsive pedagogies and resources [6–9]. According to Samuels [10], teachers can achieve this by adapting their instructional strategies to meet the needs of all learners, using language-sensitive materials that incorporate diverse perspectives and developing reflective practices to challenge their

own biases and assumptions. However, this also calls for the inclusion of culture- and language-sensitive pedagogies on pre-service science teacher education programmes.

The increasing recognition of linguistic and cultural diversity in science classrooms highlights its potential as an asset that enriches scientific inquiry and deepens the understanding of scientific concepts. Research conducted by Brown et al. [11] underscores the significance of not only acknowledging but actively integrating students' cultural backgrounds into science education. By adopting a pedagogical approach that is more responsive to language and culture, educators can effectively help students connect their prior knowledge and experiences to scientific concepts, thereby enhancing their engagement and improving learning outcomes.

For instance, Brown et al.'s [11] research involved implementing an induction course aimed at advancing culturally responsive science education in secondary classrooms. Through this course, teachers were trained to recognise and incorporate diverse cultural perspectives into their science instruction. The findings highlighted the positive impact of culturally responsive teaching practices on student engagement and learning outcomes, indicating that integrating students' cultural backgrounds into science education fosters a deeper understanding of scientific concepts.

Furthermore, Lee [12] presents a research agenda focused on equity for linguistically and culturally diverse students in science education. This agenda underscores the importance of addressing the needs of diverse student populations within the science classroom to ensure equitable learning opportunities. Lee emphasises the significance of a culturally responsive pedagogy and the need for research to explore effective strategies for supporting linguistically and culturally diverse students in science education settings.

Little and Kirwan [13] highlight the importance of adopting teaching practices that are inclusive and cater to the varied needs, abilities, and situations of students. He argues that inclusive language education needs to consider and address the diverse requirements of learners. This involves adapting teaching methods, incorporating diverse perspectives, and utilizing culturally relevant materials. Furthermore, the National Council for Curriculum and Assessment (NCCA) in Ireland underscores the importance of promoting cultural diversity in science education. Their guidelines encourage teachers to integrate culturally relevant examples and contexts into science lessons, allowing for students from diverse backgrounds to see themselves reflected in the scientific content [14].

A number of frameworks have been proposed with guiding principles for the implementation of language- and culture-responsive pedagogical approaches that include teachers developing own language awareness and awareness and knowledge of students' home languages, teachers tolerating the use of home languages in the classroom, teachers using multi-modality for greater engagement and accessibility, teachers using multiple resources to meet the needs of diverse learners, teachers developing interculturally aware classrooms and teachers employing scaffolding strategies to support learning [2,7]. It has been shown that the adoption of culture-responsive pedagogical practices can promote a sense of belonging and relevance for students in culturally diverse classrooms that fosters engagement and the deeper understanding of scientific concepts [15,16]. Therefore, science educators must be equipped with strategies that not only bridge linguistic gaps but also account for the diverse cultural backgrounds of their students.

However, there are challenges in adopting culture- and language-responsive frameworks in science education due to the disciplinary nature of science. Recent articles and research in the field of science education provide valuable insights into the ongoing discourse around addressing linguistic and cultural diversity in science classrooms [15,17–19]. Science relies heavily on a specific language, characterised by its precise terminology and communication norms. Mönch and Markic [18,19] emphasise the importance of teachers developing pedagogical scientific language knowledge (PSLK), which is crucial for effective science teaching and learning. PSLK is a construct that has built on research into the types of knowledge science teachers need to develop, which include content knowledge, pedagogical knowledge and pedagogical content knowledge [20] cited in [19]. Pedagogical

content knowledge comprises the integration of science content knowledge and pedagogical knowledge by science teachers as they develop their pedagogical practices. However, language plays a role in mediating learning in addition to representing science content [19]. The PSLK construct reflects the importance of science teachers developing language awareness in general, in addition to awareness of the linguistic demands of their subject, their classroom activities and their materials. Therefore, science teacher education programmes need to develop pre-service science teachers' pedagogical scientific language knowledge to facilitate learning for all students in their classrooms [18].

In fact, it can be helpful to broaden our view of the role of language in the classroom to see it as a core element of culture, shaping individuals' identities, worldviews and experiences. In science classrooms, where clear communication is paramount, the interplay between language and culture becomes particularly salient. However, teachers also need to be aware of the important role language plays as an 'epistemic tool' in mediating and scaffolding learning in the classroom. This is theoretically supported by socio-constructivist [21] and interactionist [22,23] theories of learning that posit that learning and knowledge are co-constructed through interaction mediated by language. The central role of language as an epistemic tool is particularly important in linguistically diverse classrooms which call for teachers to develop classroom interactional competence (CIC), a construct which describes 'teachers' and learners' ability to use interaction as a tool for mediating and assisting learning' [24] (p.130). Walsh [24] maintains that teachers can develop CIC in a number of ways: (1) awareness of how to use language to achieve pedagogic goals at different stages of a lesson; (2) adjusting language to scaffold and co-construct meaning with learners; (3) allowing students 'space' for learning by allowing them time to think before making contributions; (4) the ability to use a broad linguistic repertoire in the classroom to mediate learning, e.g., language, signs, symbols, images and gestures; (5) promoting collaboration and mutually respectful classrooms. In the context of science education, language serves as a vehicle for students to engage with and develop an understanding of scientific concepts. It becomes a tool through which learners explore, question and articulate their evolving understanding of the natural world.

In applying more culture- and language-responsive pedagogical approaches in science classrooms, previous studies have used a variety of approaches, such as Content and Language Integrated Learning (CLIL), language scaffolding and translanguaging. Coyle [25] proposed a research agenda for CLIL pedagogies, emphasizing the need to connect language, culture and content learning. In science classrooms, this approach immerses students in a language-rich environment where scientific concepts are explained and discussed in the target language. When combined with hands-on tasks, students are motivated to engage with the language in context, accelerating subject-specific language use and learning [26].

Translanguaging, another valuable pedagogical approach that can be used in linguistically and culturally diverse classrooms, allows students to construct scientific arguments using multiple languages, fostering a sense of inclusivity and cultural awareness [27,28]. By recognizing the value of students' native languages and encouraging them to draw upon their linguistic repertoires, science teachers can enhance students' understanding of science while fostering a culturally responsive and equitable learning environment for students whose native language is different from the language of instruction. According to Karlson [27], a translanguaging science classroom often provides multilingual students with an expanded opportunity to relate the subject matter to their first language and prior experience. This not only improves the students' understanding of the subject, but it also creates a space in which students can relate their everyday experiences to the science subject matter, which contributes to "continuity and empowers science learning" [27].

In the context of pre-service science teacher training, the findings from these studies highlight the need for comprehensive training programs that prepare future science educators to effectively address linguistic and cultural diversity. These programs should emphasise pedagogical strategies that cater to students' diverse linguistic repertoires,

promoting intentional engagement with the rich tapestry of languages present in Irish classrooms. Additionally, as emphasised in the research of Aalto and Mustonen [29] “collaborative learning and critical reflection” should be integral components of pre-service science teacher education as collaborative planning and discussions can help pre-service teachers gain a deeper understanding of the complexities of language and culture and enhance their ability to adapt their teaching practices accordingly. This means incorporating modules or training components that address the needs of diverse student populations and equipping pre-service teachers with the tools to foster inclusive learning environments where language and culture are “valued and respected” [13]. Such an approach is vital not only for the success of students but also for the overall improvement of science education in Ireland.

Consequently, this study seeks to explore pre-service science teachers’ perceptions and experiences regarding linguistic and cultural diversity, as well as their awareness of language in mediating learning, with a specific focus on the Irish context. This research is motivated by the need to inform teacher education programs, curriculum development and classroom practices to better prepare teachers for the multicultural reality of the contemporary educational landscape in Ireland.

Considering the above context and rationale, this study seeks to address the following research questions:

1. How do pre-service science teachers in Ireland perceive and experience linguistic and cultural diversity in science classrooms?
2. What are the implications of these perceptions and experiences for pre-service science teacher education in Ireland?

The primary aim of this study is to explore the perceptions and experiences of pre-service science teachers regarding linguistic and cultural diversity in Irish classrooms. By gaining insights into their perceptions, this research aims to contribute to the broader goal of enhancing science education programmes to prepare teachers to teach in diverse science classrooms.

This study is situated within the broader context of the Erasmus+-funded Educating Science Teachers for All (ESTA) project, a transnational initiative aimed at professionalizing university science teacher educators in the realm of cultural and linguistic diversity. Equipped with enhanced expertise, these science teacher educators, in turn, play a pivotal role in disseminating knowledge and best practices to pre- and in-service science teachers in their respective home countries. This study represents a crucial component of the ESTA project, contributing essential insights into the Irish context.

## 2. Materials and Methods

The research design of this study involves a combination of qualitative and quantitative methodologies. It employs a descriptive approach integrating frequency and percentage calculations. The study collected data through an online survey administered to science education students at both undergraduate and postgraduate levels in various universities in Ireland.

Despite being a small-scale study, we contend that the survey serves as a valid instrument for several reasons. It enabled us to reach pre-service science teachers across multiple universities in Ireland. The survey was designed to capture pre-service science teachers’ awareness of the multiple dimensions of diversity in Irish science classrooms, with a particular focus on linguistic and cultural diversity (CLD). Additionally, we aimed to explore their attitudes towards accommodating such diversity and their familiarity with pedagogical approaches to support CLD students. The survey comprised a mix of closed and open-ended questions, specifically designed to address our research questions.

The survey underwent validation by two academics specialised in second language teaching, who were actively engaged in the Educating for Science Teachers for All (ESTA) project, alongside colleagues from SSPC, the Science Foundation Ireland Research Centre for Pharmaceuticals, with expertise in science education. Originally intended as an evaluation



tool for pre-service science teacher training seminars emphasising linguistic and cultural diversity within the ESTA project, each survey question was thoroughly reviewed by a team comprising university science educators and language instructors.

Specifically, this study focused on science education students at both the undergraduate (UG) and postgraduate (PG) levels at the university of Limerick and other Irish universities and aimed to assess their understanding of the challenges and benefits of linguistic and cultural diversity in science classrooms and their knowledge of pedagogical approaches to support multilingual and multicultural students in Irish science classrooms.

The sampling criteria for this study were defined through purposive sampling, targeting pre-service science education students across various universities in Ireland. Specifically, the focus was on individuals enrolled in undergraduate and postgraduate science education programmes. Regarding linguistic diversity, it is notable that while a majority of the sampled pre-service teachers had English as their native language, a significant subset were proficient in speaking Irish and other languages fluently. This linguistic diversity within the sample is a particular emphasis of the study, as it aligns with the research objectives to exploring attitudes and familiarity with pedagogical approaches towards supporting culturally and linguistically diverse (CLD) students in Irish science classrooms. Thus, the inclusion of individuals with fluency in other languages than English enhances the study's capacity to investigate the complexities of linguistic diversity and its implications for science education in Ireland.

An online survey (full survey available in Supplementary materials) was designed using the Qualtrics platform (<https://www.qualtrics.com>) [accessed on 5 December 2023] and was distributed to the teacher candidates through their respective lecturers and science pedagogy module coordinators. Ethical approval for this research, including the survey, was obtained from the Ethics Committee of the Faculty of Arts, Humanities, and Social Sciences at the University of Limerick.

The survey invitation was sent to course directors of Postgraduate Master of Education (PME) and undergraduate Science Education programs at the following universities: University of Limerick (UL), Trinity College Dublin (TCD), Maynooth University (MU), University College Cork (UCC), University of Galway and Dublin City University (DCU), University College Dublin (UCD), Maynooth University (MU), University of Galway, University College Cork (UCC) and the University of Limerick (UL) responded to the email and subsequently distributed the survey questions.

The survey instrument used in this study included a wide range of questions, ranging from demographic information to multiple-choice questions, with open-ended questions aiming to assess participants' knowledge, understanding and awareness of linguistic and cultural diversity in Irish science classrooms. It was not necessary for participants to have teaching experience, as it was possible for them to reply to the survey questions based on their own teaching and/or learning experiences in classroom settings. It is important to note that participation in the survey was entirely voluntary and not linked to any module assignment or assessment. Additionally, the survey was structured to ensure the anonymity of participants, as no identifying information was collected.

The survey was administered to students at Stages 3, 4 and 5 (the term "stage" refers to a specific level or phase of academic progression within the modular programme structure at University College Dublin (UCD)) in Science Education in University College Dublin; PME students in Science Education in University College Cork; PME students in Science Education in the University of Galway; Year 3 and Year 4 undergraduate students in the Science Education program at Maynooth University; Year 2 undergraduate students in Science Education and PME students in Science Education at the University of Limerick.

The survey data that were generated informed the development of guest lectures on the topic of 'Language and Culture responsive teaching in science classrooms' which were delivered as part of the curriculum of science pedagogy modules taken by undergraduate and postgraduate pre-service science teachers at the University of Limerick. The guest lectures were delivered face-to-face with the aim of helping the pre-service teachers un-

derstand the implications of the increasingly linguistically and culturally diverse science classrooms in Ireland for pedagogical practice and to introduce a range of language- and culture-responsive teaching approaches.

Data collection involved a combination of closed and open-ended questions from a sample of 29 participants. It is crucial to emphasise that this study is small-scale in nature. As such, the findings derived from this limited sample cannot be generalised to encompass the entire population of pre-service science teachers, neither within Ireland nor on a global scale.

Survey responses obtained via Qualtrics were transferred to an Excel spreadsheet and exported to SPSS for examination. Data were analysed with IBM SPSS V23. Analysis results were presented as frequency (percentage) for categorical variables.

The qualitative data were collected through open-ended responses to selected survey questions. In the multiple-choice questions, survey respondents were presented with the options of “yes”, “no”, and “don’t know”, with a “please specify” section provided for each question. This allowed responders to add their narratives or additional thoughts if they wished to do so. This was done to ensure that respondents could provide clear and concise answers, thereby facilitating the subsequent analysis of qualitative data.

All data, including qualitative responses, were entered into SPSS for descriptive (percentage) analysis. It is important to note that while quantitative data primarily drove the descriptive statistical analysis, qualitative data provided additional context and depth to support and complement the quantitative findings. It is worth mentioning that while the study provides a descriptive analysis, correlations were not examined. Each question was analysed descriptively, presenting percentages without exploring correlations. The qualitative data were presented as “qualitative notes” in the tables.

The survey was adapted to our study context from our ESTA project’s “Pre-service Teacher Questionnaire”, which was originally designed as an evaluation survey of pre-service science teacher training seminars focusing on linguistic and cultural diversity. The Pre-service teacher questionnaire was initially adapted from Khrais [30].

The survey questions were categorised into four groups based on the scope of their contents. (See Table 1).

**Table 1.** Survey group details.

Group Number	Group Description	Question Numbers
Group 1	Demographics of participants	Questions 1–4
Group 2	Pre-service teachers’ awareness of linguistic and cultural diversity in the classroom and in teacher education programmes: challenges, strategies and experiences	Questions 5–11
Group 3	Pre-service science teachers’ attitudes towards linguistic and cultural diversity in the classroom	Questions 13, 14, 15, 20, 21, 22
Group 4	Pre-service science teachers’ attitudes toward the materials, lesson plans and training needed to teach in linguistically and culturally diverse classrooms	Questions 12, 16–19, 23

### 3. Results

The study examined the demographic characteristics of participants, the thematic focus areas (representing the main topics or subject areas within teacher education programmes) and the perspectives, experiences and attitudes of pre-service science teachers regarding linguistic and cultural diversity in the classroom.

#### 3.1. Demographics of Participants

Table 2, covering survey questions 1 to 4, presents demographic information pertaining to the participants. A significant proportion (46.2%) of the participants were students at the University of Limerick. The majority (56%) were enrolled in the Professional Master’s

in Education (PME) teacher education program. English was the primary language for a substantial majority (88%) of the participants, while 72% reported bilingual and multi-lingual capabilities, encompassing proficiency in English, Irish, Spanish, German, French and Italian.

**Table 2.** Descriptive statistics of demographic data.

	Frequency	Percent
Q1. University name		
Maynooth University	5	19.2
University College Cork	4	15.4
University College Dublin	2	7.7
University of Galway	3	11.5
University of Limerick	12	46.2
Q2. Type of teacher education programme		
Primary degree with teacher education	11	44
Professional master's in education (PME)	14	56
Q3. First (native) language		
English	22	88
Irish	4	16
Q4. Languages spoken fluently		
English	25	100
French	1	4
German	1	4
Irish	12	48
Italian	1	4
Spanish	3	12

In survey question 5, we queried pre-service teachers regarding whether any of the topics listed in Table 3—such as cultural diversity, linguistic diversity, inclusive pedagogies and special needs—had been addressed in their teacher education programme. Furthermore, in question 6, which was open-ended, we asked those who responded in the affirmative to specify the topics that had been covered. The results are presented in Table 4.

**Table 3.** Thematic areas covered in pre-service science teachers' science teacher education programme.

	Theme	Frequency	Percent
1	Linguistic Diversity (series of lectures/tutorials)	3	20.0%
2	Linguistic Diversity (one lecture)	12	80.0%
3	Linguistic Diversity (one tutorial)	12	80.0%
4	Cultural Diversity (series of lectures/tutorials)	5	26.3%
5	Cultural Diversity (one lecture)	10	52.6%
6	Cultural Diversity (one tutorial)	10	52.6%
7	Cultural Diversity (module syllabus)	4	21.1%
8	Inclusive Pedagogies (series of lectures/tutorials)	7	43.8%
9	Inclusive Pedagogies (one lecture)	8	50.0%
10	Inclusive Pedagogies (one tutorial)	8	50.0%
11	Inclusive Pedagogies (module syllabus)	2	12.5%
12	Special Needs (series of lectures/tutorials)	7	43.8%
13	Special Needs (one lecture)	8	50.0%
14	Special Needs (one tutorial)	8	50.0%
15	Special Needs (module syllabus)	2	12.5%



**Table 4.** The topics covered in relation to the above areas based on Q6 responses.

	Topic	Frequency	Percent
1	AEN disability	1	25%
2	Briefly touched on—maybe translating lessons, etc., or how to work with SNA	1	25%
3	Educate together schools	1	25%
4	SEN	1	25%
5	Technology for universal design	1	25%
6	UDL for planning for learning	1	25%

Pre-service teachers in the study engaged with a variety of thematic areas in their science education programmes, focusing on special needs, inclusive pedagogies, linguistic diversity, cultural diversity and inclusive and innovative methodologies such as Universal Design for Learning (UDL) and technology integration. Table 3 visually represents the thematic areas that participants encountered in their teacher education programme. Linguistic diversity was predominantly covered in single lessons, with a notable minority receiving it through series or training sessions. Similarly, cultural diversity was commonly addressed in both single lectures and tutorials, but was less often integrated into module syllabi. Inclusive pedagogies saw a similar pattern, with a significant proportion covered in single sessions and a minority explicitly included in syllabi. Special needs education mirrored these trends, indicating a widespread reliance on individual sessions rather than systematic integration into curriculum planning. Furthermore, responses to additional inquiries highlighted the diverse areas of focus, ranging from discussions on specific disabilities to strategies for universal design and inclusive teaching strategies such as a universal design for learning.

### 3.2. Pre-Service Science Teachers' Perception of Linguistic and Cultural Diversity in Science Education

In order to answer the first research question of this study, which aimed to investigate how pre-service science teachers in Ireland perceive and experience cultural and linguistic diversity in science classrooms, it was first necessary to determine their awareness of the dimensions of diversity that currently exist. Survey question 7 asked pre-service science teachers about the various dimensions of diversity they perceived or experienced in science classrooms.

The responses provided by participants are detailed in Table 5.

**Table 5.** Dimensions of diversity in science classrooms.

	Dimension of Diversity	Frequency	Percent
1	Different ability levels	18	90%
2	Different culture	13	65%
3	Different learning styles and motivation	17	85%
4	Other	2	10%
5	Special education needs	16	80%
6	Students who do not speak English and/or Irish as their first language	14	70%

Based on the responses to the survey questions related to the diversity they have experienced in the science classroom, it is evident that pre-service science teachers recognise the diverse needs of their students, with a majority (90%) noting differences in ability levels, followed by considerations for different learning styles and motivations (85%) and special educational needs (80%). Additionally, a significant portion acknowledged the presence of

students from various cultural backgrounds and those who do not speak English/Irish as their primary language.

The participants were then asked questions to investigate their attitudes or experience of cultural and language diversity in Irish science classrooms. Table 6 above provides a comprehensive overview of the collected data, including the challenges encountered in science classrooms and labs (Q8) and strategies for teaching students whose native language is not English or Irish (Q9).

**Table 6.** Challenges and strategies.

Q8: Challenges Students Encounter in Science Classrooms and Labs		Frequency	Percent
1	Complex/Abstract Concepts	15	78.9%
2	Designing and Conducting Experiments	6	31.6%
3	High-Level Cognitive Skills	14	73.7%
4	Other (Please Specify)	2	10.5%
5	Reading and Comprehension	9	47.4%
6	Relating Concepts to Real Life	10	52.6%
7	Subject-Related Language	16	84.2%
8	Writing	7	36.8%
9	Behavioral Issues	1	50.0%
10	Concentration Issues	1	50.0%
Strategies for Non-Native English/Irish Speakers		Frequency	Percent
1	Forming Language Groups	4	22.2%
2	I Don't Know	9	50.0%
3	Learners Translate for Their Peers	3	16.7%
4	Machine Translation Tools (e.g., Google translate, Deepl)	8	44.4%
5	Translating Between Classroom and Learner's Home Language	7	38.9%
6	Using Body Language and Gestures	10	55.6%

The analysis reveals that scientific terminology is recognised as challenging by pre-service science teachers, as highlighted by 84.2% of participants identifying subject-related language as a major challenge in science education. The data, especially the high percentages of respondents noting difficulties posed by complex/abstract concepts (78.9%) and the need for high-level cognitive skills (73.7%), emphasise pre-service teachers' recognition of the cognitive demands inherent in the discipline of science. This indicates an acknowledgment of these challenges, suggesting a significant move towards pedagogical strategies that are better aligned with the linguistic demands of science education, advocating for a language-responsive approach to teaching science.

In order to investigate participants' awareness or experience of learning and teaching strategies that could be used in linguistically diverse classrooms, participants were asked in Q9 to select strategies they thought might be useful. Table 6 presents pre-service science teachers' responses, and it is worth noting here that this most likely reflects their awareness of the strategies, given that many may lack teaching experience. A predominant number of respondents selected specific approaches, with notable practices including the use of body language and gestures (55.6%), using machine translation tools such as Google Translate and Deepl (44.4%), translating between the languages of the classroom and learners' home native language 38.9%, forming language groups (22.2%) and peer translation (16.7%). However, a notable proportion of participants indicated uncertainty regarding the specific strategies to use when teaching in multilingual classrooms.

To further explore how participants perceive or are aware of the challenges faced by students from culturally and linguistically diverse classrooms, respondents were provided with an open-ended question (Q10) which asked them to identify additional challenges students might face. Table 7 presents data on pre-service science teachers' perceptions of the additional challenges faced by students from diverse cultural and language backgrounds. It can be seen that a clear majority (83.3%) recognise that linguistic and cultural diversity introduces significant hurdles in the educational process. These include language barriers,

participation difficulties, challenges in forming social connections, risks of misinterpretation and struggles with scientific terminology, all of which culminate in a broader issue of content comprehension. Notably, participants highlighted that this linguistic challenge transcends linguistic backgrounds, claiming that even native English-speaking students struggle with scientific terms. As one respondent put it, “if English isn’t their first language, they are already disadvantaged”. From their experiences and views, “science is a language in itself”, and it can be difficult for students to keep up with directions when struggling with language. On the other hand, a smaller fraction (16.7%) saw potential benefits of having CLD students in the classroom, pointing to the acceptance of varied scientific viewpoints and practices as a positive contribution of cultural diversity. This dichotomy not only illustrates the complex interplay between cultural diversity and educational outcomes but also suggests that while linguistic and cultural differences pose challenges, they also offer unique opportunities for enriching the educational landscape with diverse perspectives.

**Table 7.** Additional challenges for students from diverse cultural and language backgrounds.

Response to Q10	Frequency	Percent	Qualitative Responses
Maybe	4	16.7%	Acceptance of various scientific views and practices.
Yes	20	83.3%	Language barriers, difficulty in participation and making friends, risk of misinterpretation, scientific terminology challenges and overall difficulty with content comprehension due to language.

To further probe the perceptions of pre-service teachers regarding the presence of culturally and linguistically diverse (CLD) students in science classrooms, respondents were asked an open-ended question, inviting them to provide their perception of the benefit of having CLD students in science classrooms. Table 8 presents qualitative responses to 11, which show that pre-service science teachers perceive CLD students as contributing a wealth of benefits that enrich the learning environment.

**Table 8.** Qualitative insights into the benefits of CLD students in the science classroom.

Benefit	Frequency	Percent
Broader studies from native country	1	8.3%
Cultural awareness	3	25%
Different science experiences and examples	1	8.3%
Varied views	1	8.3%
Views based on cultural values	1	8.3%
Direct translations in language	1	8.3%
Linguistic awareness	1	8.3%
New perspectives and problem-solving techniques	1	8.3%
Different angles of seeing things	1	8.3%
Global unity and learning from each other	1	8.3%

Notably, these students bring cultural awareness. Their presence also introduces diverse perspectives and experiences in the realm of science and linguistic awareness. Moreover, their inclusion fosters an environment where students collectively learn from each other and gain fresh perspectives. These findings underscore the significance of embracing diversity in education, highlighting the various dimensions through which culturally and linguistically diverse students enhance the educational experience for all.

### 3.3. Pre-Service Science Teachers' Perspectives on Supporting CLD Students: Attitudes and Knowledge Required in the Classroom

This study further investigated the attitudes of pre-service science teachers towards having cultural and linguistic diversity in science classrooms by asking them to respond to a number of questions (presented in Table 9). Table 9 presents the varied attitudes towards linguistic and cultural diversity among respondents, demonstrating a range of opinions on the responsibilities of science teachers, the importance of cultural and linguistic knowledge in teaching and the influence of one's culture on the understanding of others. Qualitative notes provide insights into the nuances of each aspect, reflecting respondents' perception of the complexity of navigating these issues within the classroom.

**Table 9.** Attitudes towards linguistic and cultural diversity.

	Question	Don't Know Freq %	Maybe Freq %	No Freq %	Yes Freq %	Qualitative Responses
1	Q13: Teachers' responsibility to support language needs of non-English/Irish speakers	3 12.00%	8 32.0%	3 12.0%	11 44.0%	Need for school support and translation; not solely teacher's responsibility; language support teacher needed; translations make knowledge accessible. Support is possible with prior translation
2	Q14: Teachers should have knowledge of language and cultural background to support learning	0 0.0%	9 37.5%	2 8.3%	13 54.2%	Cultural sensitivity and inclusivity obtained through language awareness; general student knowledge important; language and cultural knowledge are not teachers' business; knowing a few words would be handy for inclusivity.
3	Q15: Understanding is influenced by one's culture	3 12.0%	10 40.0%	3 12.0%	12 48.0%	Cultural background influences understanding and empathy.
4	Q20: Do you know what is meant by language- and culture-sensitive teaching?	8 32.0%	0 0.0%	0 0.9%	17 68.0%	Teacher awareness of student backgrounds critical.
5	Q21: Use of home language in science classroom affects understanding	0 0.0%	8 33.3%	7 29.2%	9 37.5%	Understanding and communication is key, regardless of language exams in English/Gaelige; the entire book is in English.
6	Q22: Language and cultural background knowledge increase learning	2 8.3%	12 50.0%	0 0.0%	10 41.7%	Inclusion vital for learning; challenge of multilingual science teaching in Ireland.

When asked about the responsibility of science teachers to support the language needs of students whose first language is not English or Irish, 44% of respondents agreed, emphasizing the importance of ensuring all students are engaged and learning, although some mentioned that this should not be the sole focus, while others (32%) remained uncertain but acknowledged the need to address language needs, suggesting a collaborative effort within the school. Similarly, opinions were divided on the importance of science teachers knowing the language and cultural background of their students to support learning. While a majority (54.2%) affirmed the significance of this knowledge, suggesting that it can help make lessons more relatable and personalised, others (37.5%) expressed uncertainty, reflecting differing viewpoints on the extent to which teachers should be expected to possess such understanding. Only 8.3% disagreed, suggesting it is not essential for teachers to know their students' backgrounds: "It's not fully the responsibility of the

teacher E.G. I am studying biology and chemistry and wouldn't be able to speak French so I would find it impossible to be able to translate something on the spot for a student."

The survey delved into broader questions about cultural understanding and its influence on interpersonal relationships and teaching practices. A significant portion (48%) acknowledged that one's own culture does indeed shape their understanding of others, emphasizing the importance of cultural awareness in fostering empathy and building relationships. However, a notable minority (12%) disagreed, asserting that understanding others isn't contingent on shared cultural backgrounds: "you don't need to be from a certain cultural group to be able to be understanding and open to others."

The findings from questions Q15 and Q20 reveal a significant acknowledgment of the impact of cultural background on understanding and empathy, with 48% agreeing that culture influences educational experiences and interpersonal relations within the classroom. Furthermore, a compelling 68% consensus on the critical importance of teacher awareness of student backgrounds underscores the need for language- and culture-sensitive pedagogical approaches. These results highlight the essential role of cultural and linguistic considerations in fostering inclusive, effective learning environments. The presence of uncertainty among respondents regarding both the impact of culture on understanding and the necessity of teacher awareness signals an opportunity for further education and highlights the evolving recognition within the educational community of the importance of integrating diversity into teaching practices.

When respondents were asked if they thought that CLD students would not progress as quickly if allowed to use their home language in the science classroom, opinions were divided, reflecting differing perspectives on the role of the home language in supporting learning and inclusivity. A total of 37.5% believed progress might be hindered, often citing the predominant use of English in educational materials. A total of 29.2% of respondents disagreed that the use of the home language would affect learning, with one respondent stating that 'comprehension matters more than language proficiency'. A further 33.3% were unsure, with some respondents suggesting that other contextual factors may influence learning outcomes: "Once they understand they can learn. Access to learning".

Regarding the importance of knowing CLD students' language and cultural background, 41.7% recognised its significance in fostering inclusive learning environments and enhancing achievement, 50% were undecided, possibly due to perceived language barriers among teachers, and 8.3% expressed uncertainty, highlighting the lack of multilingualism among science educators in Ireland, as seen in this statement from one of the respondents: "There aren't many science teachers in Ireland that are fluent in many languages." It was also stressed by respondents that it was possible to offer support and guidance to learners from different language backgrounds without being fluent in students' native language(s). Overall, the findings revealed varying attitudes among pre-service science teachers regarding the significance of teachers being aware of their students' language and cultural backgrounds. Some respondents indicated that "while it may not be the teacher's business, it should be taken into account to a certain extent".

#### *3.4. Pre-Service Science Teachers' Attitudes toward Materials, Lesson Planning and Training to Teach in Linguistically and Culturally Diverse Classrooms*

To gain insight into the perceptions of pre-service science teachers regarding the support needed to teach in culturally and linguistically diverse classrooms, participants were asked questions regarding the teaching materials, lesson planning and training needs. Table 10 presents pre-service teachers' perceptions in relation to each of these themes.

Regarding the inclusion of linguistic and cultural backgrounds in lesson planning, the data show that participants had varying opinions. Although 45.8% of respondents agreed that such concerns are important, highlighting the necessity for sensitivity to issues that are pertinent to students' linguistic and cultural background, 50% took a neutral position, arguing that the relevance varies depending on the experiences of different teachers and the class topic. Those in favour emphasise the importance of sensitivity, engagement,



multicultural awareness and addressing extra needs for understanding. From a manual analysis of the themes in the open-ended responses to this question, respondents in favour of taking culture and language into consideration when lesson planning talked about the importance of being sensitive to language and culture to promote engagement and support comprehension. This nuance was particularly evident in contexts where the teaching content could potentially be insensitive to certain cultural backgrounds. A respondent elucidated this perspective by stating, “Being sensitive to issues that don’t affect Irish students but may be present in others’ lives. For example, teaching about Chernobyl”.

**Table 10.** Attitudes towards materials, lesson planning and training in CLD classrooms.

	Question	Maybe Freq %	No Freq %	Yes Freq %	Qualitative Responses
1	Q12: Consider cultural background in lesson planning	12 50.0%	1 4.2%	11 45.8%	Sensitive issues; multicultural awareness; addressing extra needs for understanding is critical.
2	Q16: Time consuming to support CLD students	6 24.0%	5 20.0%	14 56.0%	Extra planning; extensive knowledge and teaching styles needed; time-consuming but essential.
3	Q17: Materials reflect cultural contributions to science	3 12.0%	4 16.0%	18 72.0%	Communal work; importance of multiple languages.
4	Q18: Materials reflect culturally based assumptions	8 32.0%	1 4.0%	11 44.0%	Science is based on facts but cultural perspectives can enrich understanding.
5	Q19: Include culture/language in learning outcomes	11 44.0%	6 24.0%	5 20.0%	Engagement in classroom; not just a ‘tick box’ activity; relevance to lab/class is important.
6	Q23: Need specific training for CLD students	9 37.5%	0 0.0%	15 62.5%	All teachers need extra help with CLD and EAL students; not part of standard teacher education.

A significant finding from the study reveals that a majority, comprising 56% of respondents, perceived providing support to CLD students as time-consuming. One respondent articulated this sentiment, stating, “It’s not fully the responsibility of the teacher. I am studying biology and chemistry and wouldn’t be able to speak French so I would find it impossible to be able to translate something on the spot for a student.” Additionally, respondents who agreed with this notion highlighted the necessity for increased planning, extensive pedagogical content knowledge and the acknowledgment that catering to diverse backgrounds adds complexity to teaching. Another respondent underscored the challenge, noting that the time-consuming nature of teaching science coincides with the additional needs of culturally and linguistically diverse students, thereby intensifying the burden on teachers. They remarked, “I think delivering science to students can be time-consuming in general, so having to provide extra support for students linguistically can definitely exacerbate that”.

When it comes to acknowledging cultural influence in science education and the inclusion of cultural contributions in science materials, a significant majority (72%) of respondents believe that science materials should incorporate the contributions of people from diverse cultures to scientific knowledge. This underscores the importance of recognizing and celebrating the diverse perspectives and contributions within the field of science. Suggestions provided by respondents, such as promoting communal and communicative work and providing materials in various languages, indicate a desire for inclusivity and

accessibility in science education, as exemplified in this response: “It shouldn’t be a tick box activity that we mention all countries, so no one feels left out, however if there is an opportunity to include a discovery from a country that a student in your class is from then it is important to include such”.

A total of 44% of the pre-service science teachers agreed that assumptions, perspectives and problems within scientific fields were often culturally based and influenced, as captured in this response: “science is based on facts, and it is important to highlight that the science that we teach may be favourable to the global north and their discoveries.” This highlights the need for teachers to consider cultural influences in their science curriculum and teaching methods. Respondents who support this notion emphasise the importance of incorporating cultural perspectives into science education to provide a more comprehensive understanding of scientific concepts. When asked about including learning outcomes related to culture and language in science lesson plans, 44% of respondents answered ‘Maybe’. This suggests a willingness to consider the integration of culture and language into learning objectives, with supporting comments from the pre-service teachers emphasizing the benefits of increased engagement and learning for all students: “Every student should be learning and engaged in the classroom.” Conversely, 24% of respondents oppose the inclusion of cultural and linguistic learning outcomes in science lesson plans, as illustrated by one comment: “If it is not pertinent to the laboratory or the class, then no. Sometimes, continuously emphasizing something segregates the student and practically makes them a target for other students.” A different viewpoint emphasises prioritizing content over language. Yet, the fact remains that students are ultimately evaluated in either English or Gaelic, underscoring the significance of the language used in schooling, as is perceived by pre-service science teachers: “No, if they are able to take in the content and knowledge it doesn’t matter what language they use to process it. However, the exam will be in English/ Gaelige”.

Although pre-service science teachers expressed views that supporting the language needs of learners may be time-consuming and detract from time needed to deliver the curriculum, 62.5% of the respondents asserted the necessity for specialised training to deal with linguistic and cultural diversity. One participant articulated this viewpoint by stating, “I believe all teachers should receive additional support for culturally and linguistically diverse and English as an additional language students; this does not appear to be adequately provided in the PME programs.” Examining the issue from pre-service science teachers’ standpoint, the narrative data reveal a worry about having the time or skills to engage with non-native speakers. One respondent expressed the need for training to effectively assist such students, emphasising that the fear of interaction, particularly when language barriers are significant, may lead to these students being overlooked and potentially left behind: “Yes, it would be very helpful if we had some training in this area to help us help the students. Many teachers could be afraid to interact with these students if they don’t speak much English and it could result in these students being left behind.”

#### 4. Discussion

The findings of this study highlight the prior knowledge and awareness of pre-service science teachers regarding teaching in linguistically and culturally diverse classrooms in Ireland. Although our findings show that there is a degree of awareness amongst pre-service science teachers about the growing diversity in science classrooms in Ireland, there is a lack of awareness of the epistemic role of language in mediating learning and insufficient knowledge of pedagogical approaches to support culture- and language-sensitive teaching.

The changing demographics of Irish schools, as discussed by Parker-Jenkins and Masterson [4], necessitate a re-evaluation of traditional pedagogical approaches, emphasising the importance of training pre-service science teachers in culture- and language-sensitive teaching to foster inclusive practices and classrooms.

One notable result emerging from the study is the significance of scientific language in linguistically diverse science classrooms. The scientific terminology itself is difficult for

native speakers and even more difficult for non-native speakers. The findings resonate with previous research by Mönch and Markic [18,19] and Ricketts et al. [16], highlighting the challenges posed by the precise terminology and communication norms inherent in scientific language. The participants identified scientific vocabulary as a barrier to understanding scientific concepts for both native and non-native English-speaking students in the science classroom. This aligns with the argument made by Karlsson et al. [27] regarding the importance of recognising and utilising students' native languages in science classrooms, emphasising the continuity and empowerment of science learning. In this regard, employing translanguaging approaches to support the use of home languages in the science classroom enables students to link scientific words to equivalent terms in their home languages. Translanguaging provides opportunities for students, regardless of their linguistic background, to connect the subject matter to their first language and everyday experiences.

The findings regarding pre-service science teachers' attitudes toward linguistic and cultural diversity reveal a nuanced perspective. While a substantial proportion recognised the responsibility of science teachers to accommodate language needs, practical challenges were acknowledged. The perceived time-consuming nature of providing support to students with diverse linguistic and cultural backgrounds was a significant concern among participants. This aligns with the broader literature, where the inclusion of linguistic and cultural diversity in science education is recognised as essential but presents practical challenges for teachers [11].

To address linguistic and cultural diversity, participants suggested that strategies such as body language, direct translation and the use of machine translation tools could be used. The participants' awareness of the challenges in teaching non-native speakers and their strategies to overcome language barriers demonstrate a progressive mindset. However, the uncertainty reported by a notable proportion of participants indicates a need for more comprehensive training programmes. These programmes should focus on improving strategies for handling linguistic and cultural diversity in the classroom, ensuring that science teachers are well-equipped to navigate challenges and provide inclusive and effective teaching.

In terms of ascertaining the perceptions of pre-service science teachers regarding the importance of including diverse cultural perspectives at the lesson planning stage, our results show a mixed response from participants. However, the fact that some topics may be sensitive to students from different cultural backgrounds emphasises the need for teachers to adopt a differentiated approach that is appropriate to the teaching context and the cultural backgrounds of the learners. This is consistent with the focus on cultural relevance in science education [31], which highlights how important it is to acknowledge and consider the cultural backgrounds of students when teaching science. In this sense, science teachers can adopt a contextual approach to designing lesson plans, considering the diverse opinions and sensitivities associated with different cultural backgrounds. Embracing cultural relevance in science education, as highlighted by Laughter and Adams [31], can serve as a valuable guide in acknowledging and incorporating the cultural diversity of students in the teaching process. The findings of this study concur with other studies supporting the importance of embracing culture in science teaching, as the pre-service teachers did recognise the enriching aspects of diverse student perspectives. The acknowledgment of the importance of including cultural backgrounds in lesson planning indicates a nuanced understanding of the relevance of cultural sensitivity in science education.

This study highlights the diverse range of attitudes among pre-service science teachers, indicating different levels of acknowledgement of science teachers' responsibility to support the language needs of their students, especially those whose first language is not English or Irish, as well as practical challenges in accommodating linguistic and cultural diversity. The data from our survey suggest a need for specialised training for pre-service science teachers to fill the gap that currently exists in science teacher education programmes in Ireland.

It is important to note that the survey questions were designed with the specific intent of evaluating the existing knowledge and awareness of pre-service science teachers regarding linguistic and cultural diversity within science classrooms in Ireland. The goal was to use the survey findings to tailor a lecture aimed at addressing the areas where additional training and support were deemed necessary for the students.

Following the analysis of the survey results, we developed a lecture for the pre-service science teachers aimed at providing them with insights into linguistic and cultural diversity, its significance within the Irish student demographic and effective strategies for engaging with linguistically and culturally diverse learners. The lecture was delivered to pre-service science teachers enrolled at the University of Limerick. The lecture was on the topic of “Language and Culture Responsive Science Teaching”, and it was delivered as a guest lecture on a course pedagogy module. In this lecture, we introduced concepts such as Content- and Language-Integrated Learning (CLIL) and translanguaging as methods for teaching subjects, particularly science, in linguistically and culturally diverse classrooms. Subsequently, hands-on teaching activities were introduced, enabling students to integrate these pedagogical approaches into their activities. Feedback on these interventions was positive, indicating a desire for more emphasis on language- and culture-responsive teaching practices within pre-service science teacher education programmes.

In short, in response to the first research question, pre-service science teachers in Ireland perceive linguistic and cultural diversity in science classrooms as both challenging and enriching. They recognise the linguistic barriers posed by scientific terminology, particularly for non-native English-speaking students. However, they also acknowledge the potential benefits of embracing students’ diverse cultural backgrounds, emphasizing the importance of inclusive practices for fostering meaningful learning experiences. Regarding the second research question, the implications of these perceptions and experiences for pre-service science teacher education in Ireland are significant. The findings show the need for teacher training programmes to include strategies for addressing linguistic and cultural diversity effectively. This includes equipping future educators with the tools and resources to navigate language barriers, integrate culturally relevant examples into lesson plans and foster a supportive learning environment for all students, regardless of their linguistic or cultural backgrounds.

## 5. Conclusions

In conclusion, this study contributes insights into the perceptions and experiences of pre-service science teachers regarding linguistic and cultural diversity in Irish science classrooms. The findings show that pre-service science teachers are largely aware of the increasing diversity in Irish science classrooms, including cultural and linguistic diversity. Cultural and linguistic diversity was perceived by the pre-service science teachers as both challenging and enriching in the classroom. The pre-service science teachers surveyed in this study identified scientific vocabulary and the abstract nature of many scientific concepts as posing particular linguistic barriers in the classroom. The findings revealed that pre-service teachers were largely unaware of strategies to use in culturally and linguistically diverse classrooms, which calls for more language and culturally responsive teaching practice. The study aligns with the literature on inclusive pedagogies, emphasizing the need for science teachers to adapt their strategies to bridge linguistic gaps and recognise the diverse cultural backgrounds of their students. Based on the survey findings, we call for comprehensive training programmes that could equip future science teachers with the tools to address linguistic and cultural diversity effectively, emphasizing intentional engagement with the rich tapestry of languages present in Irish classrooms.

In moving forward, it is essential to consider the discussion we raised in the broader context of educational policy and practice. The National Council for Curriculum and Assessment’s (NCCA’s) emphasis on promoting cultural diversity in science education aligns with our recommendations for incorporating culturally relevant examples and contexts in science lessons. Future research should explore the effectiveness of specific

pedagogical interventions, such as CLIL and translanguaging, in enhancing language and culture awareness in science classrooms.

## 6. Limitations and Further Recommendations

This study primarily focused on pre-service science teachers at the University of Limerick, with only a limited response from other universities in Ireland. This narrow sampling may not fully represent the diversity and perspectives of all pre-service science teachers across the country, potentially limiting the generalizability of the findings. Additionally, this study primarily provides a snapshot of pre-service science teachers' perceptions and experiences at a single point in time. Thus, it does not offer insights into how these perceptions may change over time or throughout their teaching careers. Longitudinal data could provide a more comprehensive understanding of the development of language and culture awareness among science teachers. This study relies on self-reported data from participants, which can be subject to response bias. Participants may provide socially desirable responses rather than accurate reflections of their experiences and attitudes. Future research could benefit from a combination of self-report data and observational or qualitative data to triangulate findings.

Collaborative efforts among universities and institutions in Ireland, as exemplified by the Erasmus+ ESTA project, should continue and expand. Sharing the best practices and knowledge about language- and culture-sensitive science education can lead to more effective teacher preparation programmes and, ultimately, more inclusive classrooms.

This survey forms part of the research undertaken by the Educating Science Teachers for All (ESTA) project. The project aims to support science teachers in developing language- and culture-sensitive teaching approaches in increasingly diverse science classrooms. This project is funded by the Erasmus+ programme and the project leads in the University of Limerick are from SSPC, The Science Foundation Ireland Research Centre for Pharmaceuticals and the School of Modern Language and Applied Linguistics.

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## Abbreviations

CIC	Classroom Interactional Competence
CLD	Culturally and Linguistically Diverse
CLIL	Content and Language Integrated Learning



CSO	Central Statistics Office
DCU	Dublin City University
ESTA	Educating Science Teachers for All
MU	Maynooth University
NCCA	National Council for Curriculum and Assessment
PG	Postgraduate
PME	Professional Master of Education
PSLK	Pedagogical Scientific Language Knowledge
SSPC	The Science Foundation Ireland Research Centre for Pharmaceuticals
TCD	Trinity College Dublin
UCC	University College Cork
UDL	Universal Design for Learning
UG	Undergraduate
UL	University of Limerick

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