Multilingual students' use of translanguaging in science classrooms

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ABSTRACT

This study describes multilingual students' authentic use of their first and second languages in a *translanguaging science classroom*, from a sociocultural perspective. The study is ethnographic, and has followed some lessons each month in a translanguaging science classroom at a primary school for three years. The observed lessons were documented by four video cameras and four audio recorders, while field notes and different types of students' texts and other teaching materials were also collected. In order investigate how language operates, and to realise the meaning semantically, we analysed the students' use of both first and second language to tie *paradigmatic relations*, and how they move in *linguistic loops* between languages and discourses. The results illustrate the ways in which a translanguaging science classroom constitutes a resource in joint negotiations of the scientific content and its related language for multilingual students, and benefits the students' ability to relate and contextualise the science content to prior experience. The creation of translanguaging science classrooms, in which students' experiences and diverse cultural and linguistic resources interweave with school science, and in which multilingual students are enabled and encouraged to use all available language resources, has important implications for science education.

Introduction

According to the European Commission, a record 2.5 million refugee asylum applications were submitted in European Union countries during 2015–2016 (Eurostat, 2017). This development has contributed to a multiplicity of cultures and languages in many European schools, which, we argue, places special demands on the European educational systems in general and on science education in particular. However, in these contexts Cummins (2008) also emphasises the new opportunities for cultural and language encounters, which may be understood as important educational assets and resources in education. When it comes to science education, several research studies (e.g. Lee, 2005; Luykx et al., 2007) indicate that most teachers rarely take advantage of these opportunities that

students bring the classroom. Other studies (Gutiérrez, 2008; Stevenson, 2013) point to positive effects on students' performance when their cultural and language experiences are taken into consideration in science instruction. Moreover, Tan, Barton Calabrese, Turner, and Gutiérrez (2012) show that if the students' background and individual experiences are used as an educational resource, the students' commitment and empowerment tend to increase dramatically. Those authors also argue that an important way of enhancing science education is to make hybrid language spaces and discourses explicit, which implies merging students' everyday worlds with the languages of science.

However, another issue related to this development constitutes the multilingual challenge for science education world-wide and in what ways teachers can offer the best learning conditions for all students. For example, Lee (2005) shows that science teachers often display a lack of experience and professional knowledge about how science instruction could be organised to support multilingual students' needs when it comes to developing their language and conceptual knowledge. In a second language learner perspective, Turkan and Liu (2012) note that if students do not have necessary language skills in the language of instruction, they often have problems obtaining access to the science content, which precludes them from demonstrating their actual knowledge. According to Turkan and Liu (2012), the situation tends to result in a negative spiral in which motivation, interest and knowledge development in relation to the subject area risk becoming reduced. A possible consequence is that teachers working in schools with linguistically diverse student populations and second-language learners tend to lower their expectations regarding the students' skills related to the content of instruction (Van Laere, Aesaert, & van Braak, 2014). This may lead to an excessive focus on student reading and writing skills, rather than focusing on their knowledge development in science. Further, in these contexts Hajer and Meestringa (2014) point to the obvious risk that the subject content and the subject-specific language will become too simplified, which further disadvantages this student group. In contrast, several research studies, in the area of language acquisition, note that second language learners who are allowed to use their first language as a resource in subject-related learning situations develop conceptual subject knowledge to a greater extent than students who are not offered this opportunity (Baker, 2011; Creese & Blackledge, 2010; Reath Warren, 2016; Stevenson, 2013). In these contexts, García and Wei (2014) define these kinds of educational situations, where all language resources are used in order to enhance learning, as *a translanguaging practice*.

The questions in this study are, whether and in what ways multilingual students use available language resources in learning processes in science, and how these resources contribute to strengthen and expand their language and conceptual development in science. Thus, the aim of the present study is to investigate how a translanguaging primary science classroom, in which teachers and students are enabled to use all available language resources, may benefit science learning.

The specific school science discourse

It is almost 100 years since Vygotsky (1978) described human development as an *enculturation* in which learning takes place by adopting the cultural practices and the language use in that specific culture. Accordingly, learning science involves participation in the culture of

science (Gee, 2015; Lemke, 1990) and the process of appropriating ways of thinking, acting, valuing, and talking in this distinctive discourse. However, all students enter school science practice with a 'backpack' full of experiences, which implies that they, in the process of learning, continuously and constantly relate the scientific content to prior experiences (Wallace, 2004; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001). In a *pragmatic* perspective, this situation may be understood as a process in which the scientific content moves on in a continuum between the students' experience and interest (the everyday discourse) and the subject matter knowledge (the academic discourse). Dewey (1902) term this process a *continuous reconstruction*, which implies moving 'the child's present experience into the organised bodies of truth' (p. 11). Consequently, the science classroom may be described as an encounter in which several discursive languages are in use and being negotiated (Jakobsson, Mäkitalo, & Säljö, 2009; Kelly, 2011; Nygård Larsson & Jakobsson, 2017). However, several studies indicate that, in such situations, science learners are often confronted with an implicit language use and words from various discourses, which may connote different meanings in different discourses (Serder & Jakobsson, 2016; Yore & Treagust, 2006). For example, Rincke (2011) illustrates this phenomenon by describing how students develop an understanding of the concept of 'force'. That study shows that students' everyday language and their pre-instructional ideas seem to be closely associated, by using the 'concept of force in the sense of momentum or energy and as being the property of one object' (p. 254). According to Rincke, the students' problem of using the concept in a scientifically correct way can be compared to related situations in foreign language instruction. The students must become familiar with the language of science in the same way as when they learn a new foreign language and culture.

Many studies describe the appropriation of the scientific language as a long and ongoing process for all students. Of course, this also applies to those students who have the instructional language as their mother tongue, but it implies several additional challenges for second-language learners. For example, Thomas and Collier (1997) study shows that it takes five to 10 years before second-language learners can appropriate the subject content on equal terms. By comparison, developing a new language from an everyday language perspective is a considerably faster process that takes an average of two years (Thomas & Collier, 1997). Cummins (2008) argues that the acquisition of the subject-related language is crucial for all students but especially important for multilingual students, which means that the development of subject-related language often becomes a race against time. The multilingual students face a dual task, implying that they have to learn a new language while also learning the subject matter through this language.

Science teaching and learning between an everyday- and a scientific discourse

Several researchers (e.g. Wallace, 2004; Warren et al., 2001) argue that in order to create understanding and engagement in science there is a need for all students to contextualise and relate abstract subject matter to their own concrete and practical everyday experience. Further, Tan et al. (2012) assert that teaching science in compulsory schools includes professional knowledge about how to weave together the science content with the students' life outside of school. However, in these learning situations, the language in use usually moves in a continuum between an everyday discourse and more academic one. The

continuum between these endpoints comprises a *hybrid space* between two different ways of using the language that constitute a kind of *interlanguage discourse* (Lemke, 1990; Olander, 2010). The definition of the concept of 'interlanguage' in this article should not be admixed with another origin of a similar concept; namely the second-language learner's evolving proficiency. Olander (2010) argues that the relations between the everyday and scientific oral expressions are continuous and that 'the colloquial expression has to be taken as a resource in the sense-making of the scientific language' (p. 99). Other research studies stress that educational situations that consciously and explicitly clarify the difference between everyday language and the subject content language provide students 'with multiple avenues to access scientific understandings' (Brown & Spang, 2008, p. 730). Those authors use the term *double talk* to describe the process of relating vernacular and academic discourses. In another study, Brown, Cooks, and Cross (2016) use the construct of *lyricism* to identify the conceptual continuity between students' everyday language use and the scientific language. In the study, the students were asked to express their knowledge about the digestive body system by involving different multimodal expressions. The results indicate that the teaching strategy to using the principle of lyricism (e.g. metaphors, double entendres, personifications, polysemies, similes, and analogies) was paramount in students' construction of hybrid spaces for science learning. The authors also argue that this space provides students 'with access to the practice of generating and creating scientific explanations in their own voice' (p. 454) and to discover similarities between their own language and those used by scientists.

However, in a multilingual science classroom, the interlanguage discourse receives an additional dimension due to the fact that some of the participants' mother tongue is different from the language of instruction. As mentioned, this implies that the instructional language not only moves between different discourses, but also between the participants' first language and the language of instruction. In a study of a multilingual classroom, Karlsson, Nygård Larsson, and Jakobsson (2016) found that second-language learners, in their conversation about the scientific content, move in *linguistic loops* between different discourses and languages (Arabic and Swedish). The result of the study implies that the students commonly use their first language when moving towards an everyday discourse and their second language when approaching the scientific language. The authors conclude by emphasising that the students' intentional use of both languages tends to increase their *discursive mobility* (Nygård Larsson, 2011) and to expand the linguistic space, which in turn facilitates the students' conceptual understanding of the scientific content. These results are partly confirmed in Stevenson's (2013) study of bilingual Latino students of science in a North American context.

A translanguaging practice in 'third space'

The theoretical underpinning of the use of interlanguage and hybrid spaces in science instruction may be found in the Bakhtinian term *heteroglossia* (Bakhtin, 1981), in the sense that languages from different discourses merge and coalesce, but also because of the fact that *voices* from different perspectives come together in this space. That means that the hybrid spaces in science classrooms are mediated from diverse perspectives such as students' experiences, the pedagogical ideals of the teacher and the teachers' ability to compose the dimension of professional science practice with their own

pedagogical ideals. To describe this ambiguous and hybrid space, Bhabha (1994) uses the concept of *third space*; this concept derives from the *theory of hybridity*, which recognises the complexity of students' everyday spaces and multiple resources to make sense of the world. The third space in a science classroom involves a possible space in which the students' unique skills and authentic experiences may be integrated into the school discourse and a space that aims to empowering all students in the science classroom community (Gutiérrez, 2008; Kamberelis & Wehunt, 2012; Wallace, 2004). In this way, the third space (Bhabha, 1994; Soja, 1996) may be associated with the *space of translanguaging* in practice (Wei, 2011). These situations can be described as a model for teaching and learning using multiple linguistic interactions and semiotic interrelationships (that is, oral and written language, signs, gestures and symbols). The multilingual learners are encouraged to use all available linguistic resources and repertoires in their conversation with peers, depending on events and topics and who they are communicating with. When it comes to translanguaging, Jørgensen (2008) considers language on the whole as 'bound up in change'. This means that speakers use features from several national languages, which implies that participants do not simply alternate between two constant languages but instead use all available resources to make themselves understood. The more classical term *code-switching* usually refers to the one-dimensional shift between two autonomous languages, and differs in this sense from Jørgensen's definition of translanguaging.

Research in the area of language development indicates a variety of functions in a translanguaging practice. For example, some studies (García, 2011; García & Wei, 2014) found that children who enter school, at five to six years of age, use all semiotic resources to mediate understanding among each other and to co-construct meaning of what others are saying. In another study, García and Kano (2014) found that students who were beginners in a new language naturally tend to use different resources as a support for expanding their opportunities for understanding. Further, Baker (2011) addresses the advantages and the potential of a translanguaging practice as, for example, a tool for deeper and fuller understanding of the subject content, and a faster development of a subject-related language. In these contexts, Axelsson (2013) highlights the significance of getting attention and recognition to multilingual students' mother tongue and culture as crucial for students' progress and self-confidence in learning.

The appropriation of the subject-specific language in science

The specialised subject-specific language in science education constitutes a challenge in the learning processes for most students (e.g. Serder & Jakobsson, 2016; Wellington & Osborne, 2001). As mentioned, this challenge is clearly even greater for second-language learners (Seah & Yore, 2017; Turkan & Liu, 2012). Research studies show that the written language in school science contexts is often characterised by high lexical density, abstraction, and technicality (Martin & Veel, 1998). In this way, the scientific language transforms students' concrete life experiences into abstract entities, which can be referred to as a process of *nominalisation* (Halliday, 1998). Halliday asserts that the subject-specific use of nominalisations and passive forms is a grammatical functional technology for describing and organising the subject content. Another linguistic technology is the use of interconnecting, descriptive and clarifying words and phrases to express *semantic relationships* between similar or disparate phenomena (Halliday,

1998). This enables the scientist to construct categories and classes, thereby establishing taxonomic relationships (Fang, 2006). Lemke (2012) argues that the aim of developing an understanding of these relations is central in all meaning-making processes in science instruction. This means that the scientific concepts usually get their meaning by being organised taxonomically through semantic relations into larger thematic patterns (Lemke, 1990; 2012). In this way, they convey the specialised and logical structure of scientific knowledge and language in the shape of interconnecting, describing, and clarifying words and phrases for the learner. Halliday and Matthiessen (2004) divide the semantic relations into *syntagmatic* and *paradigmatic* relations. The syntagmatic relations are based on relationships between words in an utterance/sentence and are often derived from different word classes (such as snow-skiing), while the paradigmatic relations link words from similar word classes, and involve taxonomic relations. One of the taxonomic relations that is often used to structure and organise the science content is meronym relations (part and whole relations or two parts of the same whole, e.g. tree-tree trunk). In this way, the paradigmatic relations are often used in the organisation of the science content, which makes them very important in learning science. Research studies (Perraudin & Mounoud, 2009) show that adults tend to use paradigmatic relations to a higher degree than children, who are most likely to use syntagmatic relations. This suggests that the understanding of the meaning of words, and how they are semantically related, are linked to the ability to use paradigmatic relations (Namei, 2002). In these contexts, Verhallen and Schoonen (1998) show that multilingual students who only use their second language in school and their first language in everyday discourse tend to use less paradigmatic associations than other students. This is in line with a Swedish study (Salameh, 2011) that shows that Swedish-Arabic students in primary schools who received instruction in both Swedish and Arabic use a significant higher portion of paradigmatic relation than the control group.

The aim of the study

The aim of the present study is to investigate whether – and, if so, in what ways – a *translanguaging science classroom* (TSC), in which students are enabled and encouraged to use all available language resources, benefits learning in science. More specifically, we aim to analyse multilingual students' authentic use of both first and second languages as tools for understanding and to relate the science content to their prior experiences. The research questions are as follows:

- To what extent do multilingual students use available language resources in a translanguaging science classroom?
- In what ways can a translanguaging classroom have an impact on students' learning in science?
- In what ways does the students' use of both their first and second language have an impact on the ability to develop paradigmatic relations of subject-related concepts and words?

Context, methods and analysis

Setting and participants

This study was conducted at a multicultural primary school located in a large town in Southern Sweden and followed science lessons in a class one week a month over three years (approximately the same group of 20 students from Grades 4 to 6). In the first year, all of the students had Arabic as their mother tongue; during the implementation of the study, students with other mother tongues came to the class. There were two teachers in the class with different subject specialisations; Louise (Social science and Swedish) and Anna (Natural science and Mathematics). However, they were never in the class at the same time. Further, Fatima, a mother-tongue teacher in Arabic, supported the students with multilingual study guidance one science lesson each week. The multilingual study guidance implies that the mother-tongue teacher helps the students to clarify the meaning of words and phrases by translating them into Arabic or Swedish. She also discusses and explains the subject matter and the school's expectations for the students.

All of the participants in the classroom had the opportunity and were encouraged to use all available language and semiotic resources, such as first and second languages, gestures and illustrations, to create understanding of the subject matter; this defines the classroom as a translanguaging practice (Wei, 2011).

Methods, considerations and data collection

An important starting point in the analyses is that human development and learning, both linguistically and cognitively, take place in social activities and practices while using language and other semiotic resources. This epistemological view on students meaning making and human development derives from a sociocultural framework (Jakobsson & Davidsson, 2012; Säljö, 2010; Vygotsky, 1978; Wertsch, 2007). The essence of using this framework in research is to focus on how learners interact with accessible artefacts as well, as with other people, and to study how these situations may have an impact on the participants' actions and thoughts. In this view, experiences, languages and thoughts both are individually and collectively internalised or appropriated through interactions in social contexts (Säljö, 2010). Simultaneously, García and Wei (2014) argue that the epistemological theory behind the affirmation of a translanguaging practice conceives all language expressions and relationships as equally important (García & Wei, 2014). This implies that, in a translanguaging classroom, the participants are encouraged to use different semiotic resources from various discourses to mediate meaning about the scientific content.

In the data collection, the authentic everyday interaction and communication between the students themselves and the teacher-student interactions have been in focus. Additionally, in these situations the participants' meaning-making processes, their utterances, hypotheses and interpretations, together with their written production, were important focal points. This also includes situations in which the students used their everyday experiences and wording in both languages in order to relate to the subject content. These parts of the data collection were mainly related to the research question of how and to what extent the students actually used the different language recourses in a translanguaging classroom, and whether these situations facilitated their understanding about the

science content. In order to capture and collect the students' language use in these situations, an ethnographic data collection and research design was used (e.g. Marcus, 1995; Willis & Trondman, 2002). This means that the strategy was a non-participant observation and sought to avoid interfering with the students' and teachers' actions.

The data material comprises of recordings from four video cameras and audio recorders, the researchers' field notes and the collection of different types of students' written texts and other teaching materials. The total video recordings consist of 117 h of student and teacher interactions in the classroom (see Figure 1).

According to Mondada (2006), this type of data collection and the recordings of everyday situations in classrooms strive to increase the credibility of the analyses of students' language use and to minimise researchers' possible bias and impartiality. However, in the initial data collection stage, some camera effects (Mondada, 2006) occurred among the participants, which resulted in both the students and the teachers talking about the recording and turning occasionally to the camera. Nevertheless, as the study progressed, it seemed that this effect gradually declined. The data collection has addressed the ethical considerations and the permissions required to film students in classroom situations. The teacher, the students and their parents/guardians were all informed about the study and about participation being voluntary.

The analytic procedure

The analytic procedure in this study consists of three separable but interrelated phases. In the first phase of the analysis, all the collected data were carefully reviewed, and the content-related situations when students and teachers use both languages (Swedish and Arabic) in interactions were selected for further analysis (approximately 10 h). In the second phase, the situated function of using both first and second languages were analysed and compared to similar situations in other studies (Baker, 2011; García & Kano, 2014; Msimanga & Lelliott, 2014; Reath Warren, 2016; and Stevenson, 2013). This part of the analysis revealed a pronounced complexity of the students' use of both first and second languages and suggested the use of several different functions simultaneously (Rampton, 2014). Therefore, a more detailed focus on these functions was required in the third phase. This implied investigating the language functions in relation to the specific context and situation when it was used, and analysing the use of first- and second language in discursive shifts. In the result chapter, we use Karlsson et al. (2016) concept of *linguistic*

Grade	Lessons	Number of audio players	Number of video cameras	Total recorded movies/film
4	11	3	3	3 x 11h = 33h
5	11	4	4	4 x 11h = 44h
6	10	4	4	4 x 10h = 40h
				In total 117h

Figure 1. Total video and audio recordings.

loops (between languages and discourses) to describe these situations. Further, in this phase we also focused on *the paradigmatic relations*, which relates to how the students' language in use operates at a micro level when they realise the meaning semantically (Halliday & Matthiessen, 2004). We will return to these issues in the results and discussion sections.

The transcription was performed together with an Arabic-speaking translator and reviewed by two teachers whose mother tongue is Arabic. The exact pronunciation of single words and precise measurements of the pauses were excluded in the excerpts, as they do not add any significant function to our analysis. To make the transcriptions more readable, written language rules are followed. The recordings were transcribed into the language that was spoken (Swedish and Arabic) and then this transcription was translated into English. The speakers' origin utterances in Swedish or Arabic are available in Appendix 1. The utterances in which both Swedish and Arabic are used are printed twice (first in Arabic and English and then in English only). To facilitate the reader, the last column provides a contextual description of the situation.

Results

The results section describes the use of language in students' continuous reconstruction of meaning, in negotiations about subject-specific words, and when relating to the scientific language in Swedish and Arabic. To illustrate these processes, four typical conversation sequences from Grade 4 (Excerpt 1–3) and Grade 5 (Excerpt 4) are chosen.

The continuous reconstruction of meaning

In the first excerpt, the students (in Grade 4) have just taken part in an instructive film about photosynthesis, in which one introduces several new words and expressions, both subject-specific (such as chlorophyll) and more general and everyday words. The Swedish-speaking teacher Louise selects some of the words used in the film and the students are expected to explain these words to each other in small groups. The sample consists of concrete words such as 'leaves', 'flowers', 'stalks', 'pine needles', 'tree trunk' and 'branches', but also more abstract scientific words as 'chlorophyll', 'solar radiation', 'nutrients', 'carbon dioxide', 'oxygen', 'glucose', and 'stomatas'. The first example starts when Hussein turns to Khadija to discuss the word 'chlorophyll' and formulates a question in Arabic, but pronounces the word 'chlorophyll' in Swedish (Figure 2).

In this conversation, Hussein asks Khadija if she knows what 'chlorophyll' is, but, instead of answering, Khadija focuses on helping Hussein with the pronunciation of the word (2, 4). However, Hussein returns a number of times to the question and then tries to answer the question by himself by suggesting: 'what was found inside / that we saw at [the excursion in] Skogstofta' (5). By that, he indicates that he relates the word 'chlorophyll' to something that is found inside the tree. Hussein further clarifies his statement by referring to a joint experience of plants and trees from the excursion (5, 6), where both Hussein and Khadija had seen resin coming out of a tree when they pushed on the tree bark. Khadija's response implies that she remembers the event by answering 'that it is not tree bark' (7) and that the 'tree bark is the black on the tree' (8). Nevertheless, her response (7, 8) shows that she misunderstands Hussein, as she interprets his question

Turn	Person	Transcription	Arabic	Contextual description
1.	Hussein:	**To^rfin haye** / chlo-chlo-rophyll **Do you know this** / chlo-chlo-rophyll	تعرفين هاي	Hussein asks Khadija: '**Do you know this** [question] / [what is chlorophyll?]'
2.	Khadija:	Chlorophyll		Khadija pronounces the word 'chlorophyll'.
3.	Hussein:	Chlo-chlo-chlo		Hussein is trying to repeat the word.
4.	Khadija:	Chlorophyll yes		Khadija repeats the word 'chlorophyll' once again, and sounds a bit annoyed.
5.	Hussein:	What is chlo-ro-chloro / **hathi** the tree which / **almawgoda bi** / **shefnaha bi** Skogstofta What is chlo-ro-chloro / **that** tree which / **that what was found inside** / **that we saw** at Skogstofta	هاتشي الموجودة ب شفناها ب	Hussein repeats the question and refers to a joint experience from an excursion to a forest called Skogstofta in Grade 3, where both Hussein and Khadija had seen resin coming out of a tree when they pushed on the tree bark: 'What is [chlorophyll?] / **that** tree which / **that what was found inside** [the tree] / **that** [tree] we saw at Skogstofta'.
6.	Hussein:	**Hathiche / al** tree bark that you can press **That one / which has** tree bark that you can press	هايتشي ال	Hussein further explains which tree he means.
7.	Khadija:	No / it is not tree bark / it is not tree bark		Khadija answers: 'No, it [chlorophyll] is not tree bark'.
8.	Khadija:	Tree bark is the black on the tree		And she further explains: 'Tree bark is the black [part] on the tree [trunk]'.

Figure 2. Excerpt 1: 121113D3 [22:30–22:52]; Khadija, Hussein and Aya.

and statements as if he is asking whether the tree bark is the same as chlorophyll. It seems as though the joint experience from the excursion have created some kind of confusion about the concept and the excerpt indicates that Hussein probably confused the word chlorophyll with resin.

We interpret this situation as Hussein contextualising the abstract notion of chlorophyll by relating it to a practical and concrete experience of trees. In this situation, Hussein uses both Arabic and Swedish languages to express his understanding in an everyday discourse, as well as in a more scientific discourse. In this way, we argue, Hussein moves in a *linguistic loop* (Karlsson et al., 2016) between languages and discourses that may enable him to relate practical experiences of the world to a more abstract scientific content. However, in this example he does not succeed in connecting the concept of chlorophyll with his prior experiences, which results in confusion. When Hussein describes what he thinks was chlorophyll, he uses Arabic to relate the Swedish word chlorophyll to his experiences of trees. Thus, the interconnecting phrase that expresses the paradigmatic meronym relation (part and whole relation) between chlorophyll and the tree is expressed by the Arabic utterance 'almawgoda ib' (what was found inside) while the subject-specific word chlorophyll is expressed in Swedish. He also uses Arabic to locate and identify which tree they were pushing on the excursion.

This first excerpt constitutes an example that occurs frequently in the empirical material in the study. Students often express scientific concepts and words (such as chlorophyll) in their second language, while explanatory, descriptive and interconnecting words and phrases used to tie semantic relations are often expressed in the student's first language.

Negotiation about subject-specific words

The second excerpt is chosen from a situation directly related to the former and involves the same group of students. However, in this situation Aya also participates and the conversation starts when she asks Khadija in Swedish what a 'tree trunk' is (Figure 3).

Aya, who had been in Sweden for about a year at the time of the conversation, asks Khadija to explain the word tree trunk. In the communication that follows, Khadija and Aya use both Arabic and Swedish to move on in the meaning-making process. They also use gestures to illustrate the thickness of a tree trunk (15, 16). Khadija explains the meronym relation between the tree trunk and tree by saying in Arabic: 'hay malt elshagre' (it is that which belongs to the tree) (13). Just like the previous excerpt, this situation indicates that subject-specific words are primarily expressed in the second language, while the more descriptive everyday phrases are expressed through their first language. Other examples of this are the interconnecting phrases: 'Alqism' (a part) (12, 14), 'el akhirshi minne' (the last piece of) (15), and 'Aakher she' (the last thing) (16, 17). The word 'tree' is mainly expressed in the first language (eshagara), probably because this word belongs to the group of everyday words.

When Khadija and Aya are negotiating the meaning with the word 'tree trunk', the use of their first and second languages seems to be intertwined, similar to the situation when students encounter new words in their first language. Here, it is likely that Khadija uses her

Turn	Person	Transcription	Arabic	Contextual description
9.	Aya:	What tree trunk		Aya asks Khadija in Swedish what a tree trunk is.
10.	Khadija:	Tree trunk / which tree trunk		Khadija wonders what Aya means.
11.	Khadija:	**Malt elshagre** **That which belongs to the tree**	مالت الشجرة	Before Aya has time to respond, Khadija switches to Arabic and asks Aya, '[Do you mean] **that** [tree trunk] **which belongs to the tree?**'
12.	Aya:	What is tree trunk / **Alqism** What is tree trunk / **a part**	القسم	Aya repeats the first question in Swedish and then switches to Arabic when she clarifies the question by asking if the tree trunk is part of the tree: 'What is tree trunk? / [Is the tree trunk] **a part** [of the tree]?'
13.	Khadija:	Tree trunk / **hay malt elshagre** Tree trunk / **it is that which belongs to the tree**	هاي مالت الشجرة	Khadija answers, 'tree trunk / **it is that which belongs to the tree**'.
14.	Aya:	**Alqism** A part	القسم	Aya once again asks in Arabic if [the tree trunk is] **a part** [of the tree].
15.	Khadija:	Yes **el akhirshi minne…** Yes **the last piece of…**	آخر شيئ من...	Khadija clarifies further in Arabic: 'Yes, [the tree trunk is] **the last piece of** [the tree]'. Simultaneously, she displays with her hand the thickness of a tree trunk.
16.	Aya:	Aha **Aakher she** Aha **the last thing**	آخر شيئ	Aya exclaims, 'Aha! [The tree trunk is the] **last thing** [of the tree]' and shows with both her hands the thickness of a tree trunk.
17.	Khadija:	Yes / **Aakher she** Yes / **the last thing**	آخر شيئ	Khadija confirms, 'Yes / **The last thing** [of the tree]'.

Figure 3. Excerpt 2: 121113D3 [20:03–20:13]; Khadija, Hussein and Aya.

first language in response to Aya's linguistic preferences, in order to create a fuller understanding of the subject content, which seems to facilitate the meaning-making process and contribute to developing the second language (Baker, 2011).

The next excerpt (3) is an example of how a translanguaging science classroom may promote multilingual students' language skills and thereby facilitate their learning in science. The conversation starts when Rayan points to the word 'stalk' on the paper and reasons loudly in Arabic about this word. All three of the students have been in Sweden since preschool, which implies that that they may have developed language skills in their second language further than Aya in the previous excerpt (Figure 4).

Rayan ratiocinates verbally about the word 'stalk' in Arabic, arguing that the word 'says something about the flower' and asking herself how a flower is actually built (18). In this sense, she uses the everyday word 'flower' but refers to the whole plant with all its parts. This implies, that there is an obvious risk for her to mix up the way in which ways the words are used in different discourses and to overlook the word 'flower' as the reproductive structure in plants. However, she argues that the 'stalk' may be related to the construction of the flower (18). In this way, Rayan's argument can be interpreted as a kind of movement from an everyday discourse to a more scientific, and that she expresses the meronym relation between 'stalk' and the plant while using her first language. Nonetheless, when she is not able to define the word by herself, she turns to the idea that a 'stalk' could be related to trees (22). After that, and in order to progress in the negotiation about the word, the students use a plastic potted plant to help them concretise the word 'stalk'. Rayan takes the potted plant in her hands and focuses on the branches, which seems to make it easier for her to come closer to the problem. However, the green plastic potted plant had neither a 'tree trunk' nor a 'stalk', but only branches. First, Hanan terms the branches as 'tree trunk' but corrects herself and says, 'No, it is not [a] "stalk"' (26). At this moment, the group does not figure out what a 'stalk' is, and Hanan suggests that they should move on to the next word. Thus, the situation in excerpt 3 constitutes an example of where the students become stuck in their meaning-making process. It turns out that there is a particular difficulty with these words in relation to their use in the Arabic language. We will return to this in the next excerpt.

Relating the scientific language in Swedish and Arabic

In the last example (in Grade 5), the Swedish teacher (Louise) and the students take turns reading a text about the structure of a tree and its growth in a whole-class situation. When they come to the words 'tree trunk' and 'stalk', the teacher asks one of the students to draw a 'tree trunk' and a 'stalk' on the whiteboard. One of the students draws a tree with a 'tree trunk' and a plant with a 'stalk' to illustrate the words. Louise points to the picture and asks the students about the Arabic word for 'tree trunk'. None of the students respond to the question, which leads to the Arabic-speaking teacher Fatima expressing that they should be able to answer this question. Louise repeats the question (Figure 5).

A common situation in this kind of classroom is that students explain the meaning of words and concepts to each other in both languages. An example of this occurs when Hanan explain the word 'stalk' to Haydar by referring to the picture on the white board (33). The analysis indicates that this type of chatting between students constitutes an important language resource for creating meaning and understanding of the content. In

Turn	Person	Transcription	Arabic	Contextual description
18.	Rayan:	**Keft tkoun elwarde / echi ^an elwarde / hay kelme echi ^an elwarde** How is the flower built / something about the flower / this word says something about the flower	كيف تكون الوردة/ إشي عن الوردة/ هاي كلمة إشي عن الوردة	Rayan ratiocinates loudly in Arabic, '**How is the flower built** [constructed]? / [The stalk describes] **something about the flower / This word** ['stalk'] **says something about the flower**'.
19.	Hanan:	Flowers **ha hiya** flowers Flowers **here is** flowers	هاهي	Hanan points to the word 'flowers' and says, 'Flowers **here is** [the word] flowers'.
20.	Amer:	Flowers…		Amer says, 'Flowers…'
21.	Rayan:	… Stalk / what is stalk called / flower **khalas / kalasna minha / bas** stalk **cho hiya** …Stalk / what is stalk called / flower **enough / we are already finish with it / but** stalk **what is that**	خلاص خلصنا منها باس شوهي	Amer is interrupted by Rayan, who declares that they had already figured out what flowers are and must now describe what a stalk is.
22.	Rayan:	**Hay lkelme same^tha / hay ichi bil** trees **This word I have heard before / it is something on** trees	هاي الكلمة سمعتها هاي إشي بال	Rayan had heard the word 'stalk' before, and relates it to 'trees'.
23.	Hanan:	…		Hanan points with a pen at the potted plastic plant on the table.
24.	Rayan:	…		Rayan then raises the whole potted plant and looks at the branches.
25.	Hanan:	**Hadoul** stalk **These ones** stalk	هادول	Hanan points to the branches and says, '[Are] **these ones** stalk [stalks]?'
26.	Hanan:	**La moch** stalk **No it is not** stalk	لا موش	She then corrects herself and says, '**No, it is not** [a] "stalk"'.
27.	Amer:	…		Rayan is sitting with the plastic potted plant in her hands, and Amer looks at her in a questioning manner.
28.	Rayan:	Investigate		Journana explains to Amer, '[I will] investigate [if there is any stalk]'.
29.	Amer:	What are you doing?		Amer mumbles and asks Rayan what she is doing.
30.	Rayan:	Maybe I will find something		Rayan giggles and says, 'Maybe I will find something'.
31.	Amer:	It says stalk		Amer emphasises, 'It says "stalk"'.
32.	Hanan:	**Khalas** / we pass it **Enough** / we pass it	خلاص	Hanan suggests that they should not go on negotiating about the word 'stalk': '[It is] **enough**; we pass it'.

Figure 4. Excerpt 3: 121113D2 [22:17–22:35]; Rayan, Hanan and Amer.

these situations, it seems important that the teacher supports and encourages the students' attempts to relate important words and concepts between the two languages. The excerpt establishes that negotiations about the words scaffold the students' language development in both languages, which enhances the students' understanding of the science content. Thus, the teachers also enhance the students' first language, which becomes a resource in the negotiation of the meaning of the words 'tree trunk' and 'stalk'. The difficulty in

Turn	Person	Transcription	Arabic	Contextual description
33.	Louise:	Stalk / is there any word in Arabic / that on the flower show …?		The teacher repeats the question and asks Hanan (who is sitting with Haydar) to show him the stalk in the picture in front of them.
34.	Adnan:	**Gid^** **Tree trunk**	جدع	Then, Adnan says, '**tree trunk**' in Arabic.
35.	Zein:	That is tree		Zein remarks that this is incorrect.
[14:35-14:57]		(…..)		Hanan quietly whispers something to Haydar and then turns to the mother-tongue teacher to ask her something.
36.	Fatima:	It is called the same / **Zay maqolt / gid^ chagara wa gid^ elwarde** It is called the same / **as I said / the tree trunk to the tree and the tree trunk to the flower**	زي ماقلت،/جدع الشجرة وجدع الوردة	Then, the mother-tongue teacher explains for the class that 'tree trunk' and 'stalk' corresponds to the same Arabic word 'gid^'.
37.	Hanan:	Do they have the same name?		Hanan (the student from excerpt 3, who suggests that they should pass over the word 'stalk' (32)) asks, 'Do they ["tree trunk" and "stalk"] have the same name [gid^ in Arabic]?'
38.	Fatima:	Yes **gid^ cha**… Yes **the trunk to the thr**…	يا، جدع الش	The mother-tongue teacher confirms Hanan's question
29.	Louise:	…Does it have the same name on a flower as on…?		But is interrupted by the Swedish-speaking teacher, who seems surprised.
40.	Fatima:	…Yes it has the same name / **gid^ chagara wa gid^ elwarde** …Yes it has the same name / **the tree trunk to the tree and the tree trunk to the flower**	يا، جدع الشجرة وجدع الوردة	Once again, the mother-tongue teacher confirms.
41.	Furkan:	Listen / the tree's and the flower's		Furkan becomes eager and turns to the Swedish-speaking teacher and explains to her, 'Listen, the tree's [tree trunk] and the flower's [tree trunk]'.
42.	Hanan:	Then you just add tree and flower		Also, Hanan is eager and asks the mother-tongue teacher once again.
43.	Zein:	The tree's trunk and the flower's trunk		Zein also becomes agitated and translates to the Swedish-speaking teacher.
44.	Fatima:	Yes we add / we just add the word tree or flower		The mother-tongue teacher answers Hanan's question.

Figure 5. Excerpt 4: 140513D2 [14:28–15:16]; A whole-class conversation.

this case is that, in Arabic, the same word is used for stalk and tree trunk, which creates confusion among the students. The conversation could be interpreted as the students actually knowing how the Arabic word 'gid^' is used in an Arabic-speaking context but probably not in a Swedish speaking science classroom context (34, 35). In this situation, the mother-tongue teacher (Fatima) becomes a resource, when she clarifies the meaning of the words by using the Arabic expressions: 'gid^ chagara wa gid^ elwarde' (the tree trunk to the tree and the tree trunk to the flower) (36, 40). She adds the word 'chagara' ('tree'), and the word 'elwarde' ('flower') to the word 'gid^' ('tree trunk') to explain the meaning of the words 'tree trunk' and 'stalk' (44). It is possible to assert that, without this support, it could have been nearly impossible to get the students to understand the difference between the languages and move on in their understanding of the content. In the Arabic language, the word 'Saq' is an academic word for 'stalk' and is rarely used in an everyday or in a primary school contexts.

The excerpt displays a well-known language phenomenon whereby words in one language do not always have a simple corresponding word in another language. In science education contexts, this circumstance entails special difficulties for second-language students in science. The complexity of learning science with the help of the first language is confirmed by other studies (e.g. Ünsal, Jakobson, Molander, & Wickman, 2016). In the present study, however, the result of the analysis clearly indicates that the translanguaging practice, in which the students are encouraged to use all available language resources, facilitates and strengthens the students' meaning making processes, which enables them to develop their knowledge in science.

Discussion

The empirical part of this study illustrates a *translanguaging science classroom* when multilingual students are allowed and encouraged to use all their language resources to make sense of a scientific content in primary school. This means that the students use both their first and second languages in meaning-making activities and in student-to-student negotiations about the significance of specific words in order to facilitate their understanding. However, the chosen examples display the specific problems that these students encounter when they are expected to learn new subject content in science by using their second language but also how they overcome some of the problems in joint negotiations about the meaning of specific words with help of their mother tongue. Earlier research (e.g. Wallace, 2004; Warren et al., 2001) show that the acquisition of the scientific language is a complex and continuous process for all students. Multilingual and diverse science classrooms have an additional dimension in that some of the participants' mother tongue is different from the language of instruction. This implies that the instructional language not only moves between different discourses (scientific and everyday) but also between the students' first language and the language of instruction. Several research studies show that an important element in a successful science instruction is the ability of teaching to weave together the science content with the students' life outside of school (e.g. Brown & Spang, 2008; Olander, 2010; Tan et al., 2012). Moreover, these studies note that when this *intertwining process* between different perspectives becomes an explicit aim of the instruction, the scientific content can become meaningful. This implies an educational situation of an aware use of *hybrid spaces* (Lemke, 2012) between discourses and national

languages. We argue that this requires the difference between the everyday language use and the subject content language to be consciously and explicitly clarified by using all available language resources. For example, in the present study this means that the multilingual students' use of both first and second languages often appears when they relate and contextualise the abstract content to their everyday experience. In the first excerpt, one of the students uses both Arabic and Swedish to clarify a question about chlorophyll by relating the word to a joint experience from an excursion. In this situation, we argue, the student moves in a kind of *linguistic loop* (Karlsson et al., 2016) between everyday expressions in his mother tongue (Arabic), and more subject-specific expressions in his second language (Swedish). Thus, we argue that the prior experience and the use of everyday expressions in Arabic may be a powerful resource in his meaning-making processes in science. In our analysis of the students' work, it can be seen that this phenomenon is common throughout the material. As mentioned, this means that in the joint negotiations about the scientific content, the subject-specific words are often expressed in second language, while the descriptive, clarifying and interconnecting words and phrases are commonly expressed in the first language. In a semantic perspective, it becomes important for all students and especially for multilingual students to have access to this kind of interconnecting words in their meaning-making processes. For example, to clarify the paradigmatic meronym relation (part and whole relation) between 'tree trunk' and 'tree', the students in the second excerpt use their first language to express that the 'tree trunk' 'is that which belongs to the tree' (13). Another example is when one of the students clarifies a similar relation between the word 'stalk' and 'plant' in her first language, which helps her to distinguish the everyday meaning of the word 'flower' from a more scientific meaning or definition of plants.

We argue that these examples clearly indicate that students' use of both their first and second language constitutes an important resource for tying semantic relationships between subject-specific words and everyday words, which helps develop a deeper understanding of the subject matter. These results correspond to Salameh's (2011) finding that multilingual students who receive instruction in both first and second languages develop more *paradigmatic relations*, than students who only receive instructions in their second language. The result is also in line with a study from South Africa, which shows that learners' use of home languages is a resource to create conceptual understanding in science (Msimanga & Lelliott, 2014).

However, the Swedish-speaking teacher was not, by herself, able to illustrate the relations between Arabic and Swedish expressions or to elucidate the scientific content in the students' first language. Therefore, it is important to emphasise that the extra resource that the mother-tongue teacher constituted may have had an impact on the students' language and knowledge development in this study. An example of this is when the mother-tongue teacher (Fatima) clarifies the meaning of the words 'tree trunk' and 'stalk' by relating to the Arabic expressions. Nevertheless, if such a resource is not always available, it is possible to organise the science classroom from the perspective that language- and content-related conversations between students are allowed in order to facilitate understanding and increase learning.

As a conclusion, we would like to emphasise that a *translanguaging science classroom* in which students' cultural and language background is foregrounded and appropriated creates the prerequisites for all students' knowledge development in science. In this way, this classroom contributes and facilitates the creation of a specific *third space*

(Soja, 1996) where students have 'access to the practice of generating and creating scientific explanations in their own voice' (Brown et al., 2016, p. 454). Tan et al. (2012) stress that these kind of classrooms give students greater opportunities to participate in the science instruction contexts, to influence their learning situation and to put students in a position as co-constructors of their own learning.

Finally, an important question is what the consequences would be if multilingual students are not enabled to use all their available language resources in science education contexts.

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Appendix 1

The speakers' origin utterances in Swedish or Arabic

(1) **To^rfin haye** / klo-klo-rofyll
(2) Klorofyll
(3) Klo-klo-klo
(4) Klorofyll ja
(5) Vad är kro-ro-kloro / **hathi** trädet som / **almawgoda ib** / **shefnaha** Skogstofta
(6) **Hathiche al** bark som man kan trycka på
(7) Nej det är inte bark det är inte bark
(8) Bark är dom svarta till trädet
(9) Vad stam
(10) Stam / vilken stam
(11) **Malt elshagre**
(12) Vad är stam / **Alqism**
(13) Stam / **hay malt elshagre**
(14) **Alqism**
(15) Jaa **el akhirshi minne** …
(16) … Aha **Aakher she**
(17) Ja / **Aakher she**
(18) **Keft tkoun elwarde** / **echi ^an elwarde** / **hay kelme echi ^an elwarde**
(19) Blommor **ha hiya** blommor
(20) Blommor …
(21) … Stjälk / vad kallas stjälk / blomma **khalas** / **kalasna minha** / **bas** stjälk **cho hiya**
(22) **Hay lkelme same^tha** / **hay ichi bil** träd
(23) …
(24) …
(25) **Hadoul** stam
(26) **La moch** stam

(27) …
(28) Undersöker
(29) Vad gör du
(30) Jag kanske hittar någonting
(31) Det står stjälk
(32) **Khalas** / vi hoppar över
(33) Stjälk / finns det något ord på arabiska / det på blomman visa …
(34) **Gid^**
(35) Det är träd
(36) Det heter samma / **Zay maqolt / gid^ chagara wa gid^ elwarde**
(37) Heter det samma sak
(38) Ja **gid^ cha** …
(39) … Heter det samma sak på blomma som på …
(40) … Ja det heter samma / **gid^ chagara wa gid^ elwarde**
(41) Asså trädets och blommans
(42) Då lägger man bara till träd och blomma
(43) Trädets stam och blommans stam
(44) Ja vi lägger / vi lägger till bara ordet träd eller blomma