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10.1080/13670050.2020.1754752
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To cite this article: Melanie Williams (2020): Fifth graders’ use of gesture and models when translanguaging during a content and language integrated science class in Hong Kong, International Journal of Bilingual Education and Bilingualism, DOI: 10.1080/13670050.2020.1754752

To link to this article: https://doi.org/10.1080/13670050.2020.1754752
Fifth graders’ use of gesture and models when translanguaging during a content and language integrated science class in Hong Kong

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ABSTRACT
Translanguaging in science includes the use of semiotic repertoires complete with non-linguistic modes of meaning (e.g. gesture, tactile) that until recently have gone unnoticed in research into content language integrated learning (CLIL). Currently, there are calls for classroom research in CLIL settings that examines the semiotic processes in the spontaneous translanguaging of emergent bilinguals. In response, this study aims to expand bilingualism research by investigating the ways in which fifth-grade emergent bilinguals’ draw from their semiotic repertoires when translanguaging in content-based science lessons. Multimodal transcriptions made from video recordings of the lessons allow a cross-case analysis of the emergent bilinguals’ shifts from oral to gestural or tactile modes during a biology and physics unit. Findings illustrate that emergent bilinguals use non-linguistic modes to aid their science discourse in four distinct ways: replacement, support, demonstration and imitation. For instance, gestural and tactile meanings replace unknown everyday words and science language during demonstrations. A fine-grained analysis of the semiotic units shows that tactile moves, gesticulations, pantomime and imitation each play a role in the semiotic processes involved when translanguaging in a content-based science class. They allow the expression of ideas, the mediation of language and the unaided flow of discourse.

INTRODUCTION
In a content language integrated learning (CLIL) science class, where language is developed through content learning, emergent bilinguals draw, gesture, touch and use other semiotic resources to make meaning (Lemke 1998; Cope and Kalantzis 2009a; Zhang 2016). The recent heightened awareness of these semiotic potentials is a direct result of today’s societies, where frequent interactions between speakers of diverse backgrounds and new technologies have stimulated a consistent engagement of non-linguistic resources (García and Li 2014; New London Group 1996). According to the theory of multiliteracies, societies long-term use of non-linguistic resources can cause them to evolve into modes of meaning (termed ‘modes’), which harbour different semiotic potentials than the linguistic modes, speaking and writing (Kress 2010). Correspondingly, the theory of translanguaging posits that bilingual students draw from a semiotic repertoire including multiple non-linguistic resources, in addition to a linguistic repertoire, as they communicate (García and Li 2014). This implies the semiotic...
possibilities of non-linguistic modes are of value and may present emergent bilinguals with beneficial outcomes in CLIL contexts and therefore warrant further investigation.

At present, research investigating bilinguals’ use of semiotic repertoires in CLIL settings appears underdeveloped (Lo and Lin 2015). Studies that draw on the theory of translanguaging continue to favour a linguistic focus, such as code-switching (e.g. Gallagher and Colohan 2017; Pavón Vázquez and Ramos Ordóñez 2019; San Isidro and Lasagabaster 2019). Consequently, the semiotic potentials gestural and tactile modes offer emergent bilinguals remain relatively unobserved in content-based science classrooms despite evidence of their benefits in science education research (e.g. Bracey 2017; Hampton and Rodriguez 2001; Jakobson and Axelsson 2017; Unsal et al. 2018; Williams, Tang, and Won 2019; Zwiep et al. 2011) and language research (Belhiah 2013; Dahl and Ludvigsen 2014; Gullberg 2006; Ingerpuu-Rümmel 2018; Lee, Hampel, and Kukulska-Hulme 2019; Peng, Zhang, and Chen 2017; Yam-Liang 2017). As a result, there are currently calls for more classroom research to investigate the semiotic processes involved when bilinguals use translanguaging to decipher content meaning (Lin 2019). With this in mind, this study draws on the theory of multiliteracies, which considers language as a semiotic system, to expand bilingual research and the current understanding of translanguaging in CLIL contexts. From a multiliteracies perspective emergent bilinguals’ use of non-linguistic modes, such as gestural and tactile modes, come into focus.

This article presents information from a larger 9-month study investigating the outcomes of multimodal inquiry science classes for emergent bilinguals in an independent school in Hong Kong. Independent schools teach national curricula from abroad, offer bilingual models with home languages and hire native speakers to service the educational desires of the expatriate communities that speak at least 27 major and minor languages in Hong Kong (Bacon-Shone, Bolton, and Luke 2015). Increasingly independent schools accommodate local Hong Kong families, who no longer subscribe to the government school policies, as well as immigrants from mainland China who may speak a dialect different from Cantonese (Yamato 2003). Alternatively, their decision may be influenced by the important socio-economic status English holds in Hong Kong, as it is seen as a pathway to a good university and future career (Lo and Macaro 2012, 2015). An independent school offers a distinctive research setting which may illuminate new understandings of translanguaging from inside a CLIL science class. This study explores the translanguaging of 10 fifth graders to ascertain how they use their semiotic repertoires to co-construct meaning in science. To do this, each student’s shifts between linguistic and gestural or tactile modes made during science lessons were analysed.

The content-based science classroom

The aim of CLIL is to teach content curricula through a foreign language (Dalton-Puffer 2011). Subjects such as science are frequently referred to as content-based classes and provide emergent bilinguals with a genuine social context for the meaningful use and application of the target language (Lin 2019). However, in content-based science classes emergent bilinguals need an advanced knowledge of the target language to decipher science language and the high volume of content-specific academic language related to concepts in and across science disciplines (Bravo and Cervetti 2014; Fang 2005). Science language has high lexical density, as well as abstraction, technicality, generalisation and authoritativeness (Bruna et al. 2007; Fang 2006). Also present in science language is nominalisation, used to condense a large amount of information into a phrase and assuming the audience has prior knowledge of the subject matter, and transitivity, which indicates agency and the relationship between subject and object in a sentence (New London Group 1996). These aspects of science language may make it unlikely that emergent bilinguals who have not yet achieved the required threshold of a target language will realise the benefits of CLIL (Lo 2015).

Nevertheless, a content-based science class has a variety of non-linguistic resources that can be used to make meaning including diagrams, drawings, experiments, graphs, mathematical formulas and models (Evnitskaya and Morton 2011; Lemke 2000). This is because the employment of multiple
modes is needed to communicate science concepts or carry out science processes, which can be described as the doing of science (Lemke 1990). For example, the formula for velocity together with a written description will make more sense when combined with a demonstration, diagram and/or model. Consequently, unlike other content areas, the nature of science demands the use of multiple modes. The inclusion of non-linguistic resources in science suggests students must draw upon their semiotic repertoires when translanguaging. This is evidenced in classroom research.

Several studies demonstrate that the use of semiotic repertoires afforded emergent bilinguals the capacity to participate in co-constructing meaning, which is a goal of CLIL (Lin 2019). For instance, Blair, Haneda, and Bose (2018) investigated heteroglossic spaces in grades 2 and 4 that enabled emergent bi/multilinguals to draw upon their entire semiotic repertoires and countered the perception that English-medium instruction equalled an English only space. Findings showed a teacher was able to create multiple pathways for students to carry out science tasks by using semiotic modes such as music, tactile materials and visuals (Blair, Haneda, and Bose 2018). In another study, Unsal et al. (2018) explored the gesticulations of emergent bilinguals in grades 3 and 7 in Sweden. Findings showed students drew upon their semiotic repertoire to gesticulate when they were unable to describe a phenomenon in words, or when they used words inaccurately. As other students (and the teacher) adopted (i.e. reproduce) them in the discourse that followed, they maintained the flow of communication, even though at times the gesture required interpretation before the discourse could resume (Unsal et al. 2018).

Likewise, positive effects of non-linguistic modes were found in other studies concentrated on language acquisition and science learning, although not all focused on the discursive practices of bilinguals. For instance, studies in science education reveal that the addition of non-linguistic modes provides emergent bilinguals with alternative avenues for meaning-making (e.g. Williams, Tang, and Won 2019), scaffolding opportunities (Bracey 2017), a stimulus for language use (Hampton and Rodriguez 2001; Zwiep et al. 2011) and an increase in content learning (Jakobson and Axelsson 2017). Similarly, studies in language demonstrate gesture can support emergent bilinguals in second language comprehension (Belhiah 2013; Dahl and Ludvigsen 2014), meaning construction and translation (Ingerpuu-Rümmel 2018), complementing oral meanings (Lee, Hampel, and Kukulska-Hulme 2019; Yen-Liang 2017), and by reducing the social distance between the teacher and students (Peng, Zhang, and Chen 2017).

With encouraging outcomes reported in the earlier studies, it is logical to assume similar outcomes may occur in a content-based science class. Yet, at present, there is a lack of classroom data exploring the translanguaging practices including the emergent bilinguals’ semiotic repertoire in CLIL contexts (San Isidro and Lasagabaster 2019). Thus, with these potentials in mind, this study aims to expand an understanding of emergent bilinguals’ use of translanguaging as they draw from and interact with the semiotic resources, gesture and touch, during science discourse.

The following section describes the theoretical framework in this study. First, the theory of multiliteracies explains the view of language adopted. Next, the theory of translanguaging explains how bilinguals communicate using language and describes their natural discursive practice. Finally, the sociocultural learning theory explains how meanings can be made in a content-based science class.

**The theory of multiliteracies: language as a semiotic system**

The theory of multiliteracies suggests that within our multifaceted environment are cultural resources called modes of meaning (or simply ‘modes’) that societies use to communicate and that contribute to form a semiotic system (New London Group 1996). Meanings are designed using linguistic (e.g. oral and written) or non-linguistic modes, such as gestural, image, spatial, tactile and audio modes (Cope and Kalantzis 2009a). From this perspective, emergent bilinguals appear to have a multiplicity of semiotic resources to communicate and make meanings in CLIL science classrooms (New London Group 1996). Of importance in the theory of multiliteracies is how emergent bilinguals can design a meaning through multiple modes. To explain, it is necessary to understand that modes evolve...
within societies and carry with them cultural, social and material influences. Together these influences shape the meaning-making potentials of modes that can cause representations to differ in different societies, for instance, gestures used as greetings differ in different societies.

In addition, these influences yield parallelisms between modes (Kress 2010). For example, it is possible for ‘gesture and speech [to] express the same underlying idea unit but express it in their own ways’ (McNeill 2005, 23). For instance, in a classroom thumbs-up can mean the same as saying, ‘Good job!’. However, gestures do not just embellish oral meanings (Vygotsky 1978). Instead, they work in unison to express a meaning (McNeill 1992; Roth 2001). This allows designers to use multiple modes, shift between modes or re-represent meanings as they design them (Cope and Kalantzis 2009b). With respect to CLIL science classrooms, non-linguistic modes imply emergent bilinguals can make meaning regardless of their diverse language backgrounds. The next step is to comprehend bilingual behaviour with regard to how bilinguals use a semiotic system to communicate; this is part of the following discussion.

Translanguaging using linguistic and semiotic repertoires

With the goal of understanding emergent bilinguals’ use of non-linguistic modes in CLIL science classes, this study adopts the theory of translanguaging to explain how bilinguals communicate. Originally, the term ‘translanguaging’ was coined by Williams (1994) using the Welsh term traws-sieithu (later translated into English by Baker 2001). Since its conception, translanguaging has referred to both the language practices of bilinguals and the pedagogical practices that ensure they occur (García 2009; García and Li 2014). More recently García and Li (2014) presented a perspective of translanguaging that moves beyond the knowledge of two distinct languages and suggests that bilinguals harbour only one linguistic system. In addition, they draw attention to the prefix trans, as it relates to the word transculturación (titled by anthropologist Fernando Ortiz) and emphasise its implication as ‘a process in which a new reality emerges’ (García and Li 2014, 30). Viewed in this way this study defines translanguaging as the dynamic, complex designing of new language practices by a speaker.

While studies investigating the theory of translanguaging are widespread in multilingualism research, studies have remained limited within the context of CLIL (Nikula and Moore 2019). At present research efforts to investigate the implications of translanguaging in CLIL classrooms remain focused on the linguistic repertoire, with definitions in studies describing separate languages (Gallagher and Colohan 2017; Pavón Vázquez and Ramos Ordóñez 2019; San Isidro and Lasagabaster 2019). For example, Gallagher and Colohan (2017) use the term ‘translanguaging’ interchangeably with ‘code switching’ to explore its effectiveness (via dictation) as a technique for grammatical awareness in CLIL geography classes. Similarly, Pavón Vázquez and Ramos Ordóñez (2019) describe translanguaging as ‘a general practice involving the utilisation of two distinct languages’ (36) and use this definition to categorise the students’ use of L1 (their first language). And while San Isidro and Lasagabaster (2019) employ a definition from key scholars in the field (García 2009; Wei 2011), their research interests continue to include a linguistic focus that investigates the role of the L1 in CLIL.

The continued adoption of varied definitions coupled with researchers’ gravitation towards the linguistic repertoire, shows ‘there has not [yet] been a full shift in epistemological understanding and language, bilingualism and education in the ways in which translanguaging points’ (García and Li 2014, 71). As a result there appears to be an unexploited research interest concerned with the outcomes of emergent bilinguals’ use of their semiotic repertoire in CLIL (Lin 2019; García and Li 2014). More concerning, though, is the notion that since meanings are constructed from a semiotic system, a disregard of the analysis of non-linguistic modes could leave researchers with an incomplete understanding of the semiotic unit (Kress 2010). The next section describes how the semiotic processes occurring during Translanguaging can lead to learning in a content-based science class.
Making meaning by translanguaging in a semiotic system

Researchers studying emergent bilinguals in science and language fields recommend pedagogies that ensure students make meaning through shared experiences which encourage the dialogic co-construction of language (Karlsson, Larsson, and Jakobsson 2018; Lin 2019). This is because learning, as Vygotsky (1978) argues, is deeply rooted in social action and mediated by semiotic systems such as language. In other words, language is the psychological tool responsible for cognitive development as we internalise ideas using language (Vygotsky 1978). Viewed in this way, it appears translanguaging can provide essential practices necessary for the learning process of bilinguals, such as metacognition, metatalk and private speech (García and Li 2014, 90).

Likewise, it follows that all modes used when translanguaging in social interactions are potential mediators of learning. This also applies to emergent bilinguals themselves, since when they participate in the co-construction of science meanings they reveal different perspectives of a science phenomenon that conflict with the ideas of others during a discourse (Vygotsky 1978). This constant confliction of ideas on a social plane, together with additional contributions from those of higher abilities, such as a teammate or teacher, supports internalisation and higher thinking (Vygotsky 1978). From this perspective, we assume every mode and interaction can add value to the meanings construed. However, the parameters of this research prevent an in-depth analysis of all semiotic modes during interactions. Instead, this study focuses on the use of two non-linguistic modes commonly used during face-to-face interactions: the gestural and tactile modes.

**Gestural and tactile modes.** Gestures are numerous in form as they frequently accompany oral meanings with respect to timing, meaning and function (Kendon 1980; McNeill 1992). In this study analysis focuses on two types expected to most relate to the science discourse: gesticulations, considered to be the movement of hands and arms that accompany talking or mental images of talking (Kalantzis et al. 2016), and pantomime, bodily movements that do not require speech but may present as sequence-like demonstrations (Roth 2001). While both gesture and tactile modes include spatial meanings such as the movement of hands and arms, tactile meanings also require direct contact with a material object and occur as emergent bilinguals manipulate materials such as three-dimensional models (Kalantzis et al. 2016). Children make tactile meanings from an early age by using their senses (e.g. touch and taste) to explore their world and objects within it (Vygotsky 1978). Materials can, therefore, help unfamiliar science concepts become familiar (e.g. Whittier and Robinson 2007). For instance, a model demonstrating the rotation of the Earth (an abstract concept) allows science meanings to be made (e.g. Jakobson and Axelsson 2017). In addition, by imitating the actions of people using objects, children learn how objects function (Vygotsky 1978).

The next section presents information regarding the methods and analysis used to discover how the emergent bilinguals use their semiotic repertoire, in particular the gestures and tactile manipulations of artefacts in a content-based science class.

**Methods**

**Research context**

This study was conducted in a fifth-grade content-based science class, taught in English, at an independent school in Hong Kong. Unlike government schools, this independent school entwined Confucian culture with Western culture, which disseminated from two separate departments, Chinese and English. Constructivist teaching and learning philosophies predominantly came from the English department, where lessons were mostly delivered by expatriate English-speaking teachers from abroad. The bilingual school model was considered to be partial immersion (Lin and Man 2009). It required the language of instruction to alternate, beginning with 70% instruction in Putonghua (Standard Mandarin) in kindergarten, decreasing to 60% in third grade and then equally shared with English in fourth grade and onwards. Consequently, the language of instruction in science also
altered. Science began in Putonghua until third grade, when three lessons in English were added each week. By fourth grade, science lessons in English increased to five a week. The science disciplines were also divided between the languages. For example, the delivery of life science occurred in both languages, whereas the language of instruction in physics and chemistry was English, in Earth science it was Putonghua. By seventh grade, all the science lessons were in English.

This paper presents data from two contrasting science units in fifth grade, a life science unit focused on the human body with investigations into three systems, and a physics unit focused on forces in motion with investigations into Newton’s laws of motion. The lesson topics (Table 1) linked to the school’s science curriculum, which drew from an eclectic mix of international curricula including Hong Kong, Taiwan and the United States. At the time of the study, the Next Generation Science Standards were being incorporated to maintain current shifts such as the adoption of science and engineering practices (National Research Council 2012). In this study, the inquiry science lessons were based on the thinking frames approach (Newberry and Gilbert 2016).

In the approach, a puzzling phenomenon is presented usually through a demonstration or experiment that explores a real-life phenomenon and is linked to an associated inquiry question (see Table 1). In response, student groups consecutively construct a verbal, pictorial and written explanation. To promote ideas during the initial co-construction of the explanation four placemats (e.g. life, forces, matter, energy) with images, mathematical formulas and words representing science concepts are made available (Cams Hill Science Consortium 2008). Translating the verbal explanation into a pictorial image prompts further discourse that enables conceptions to be discussed, argued, and justified until a final consensus is reached. Finally, the students transfer the explanation into a written form by deciphering the sequence.

### Participants and data collection

The participants remained consistent for the 6 months of the study. Purposeful sampling ensured that all of the participants came from one of the 10 fifth-grade classes (Creswell 2014). According to standardised testing, this class had a high percentage of students with below-grade-level English. Out of 19, a sample of 10 students (10–11 years old) participated. The participants were typical of those students attending the independent school as all came from affluent families and all had Chinese heritage. This demographic may have been a result of the dominant Confucian culture in the early years of school and the increased exposure to English in the upper years, that attracted families from Hong Kong and mainland China. The emergent bilinguals all spoke various degrees of English and Putonghua and several also spoke Cantonese. In contrast, the 37-year-old teacher was monolingual in English. She was currently managing science in the English department at the primary school.

Two video cameras recorded the six lessons, each was approximately 40 min in length. Each camera focused on a group of five participants. The small number of participants ensured they were all visible by the camera. This allowed all the modes used by the students’ (from their language and semiotic repertoires) to be recorded. The data formed part of a larger study which followed the ethical considerations of an Australian university.

<table>
<thead>
<tr>
<th>Science lesson topic</th>
<th>Inquiry question</th>
<th>Tactile material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory system</td>
<td>How do our lungs work?</td>
<td>1 working lung model</td>
</tr>
<tr>
<td>Circulatory system</td>
<td>Why are cells so small?</td>
<td>1 cube made of smaller cubes</td>
</tr>
<tr>
<td>Digestive system</td>
<td>Why can we eat upside down?</td>
<td>None</td>
</tr>
<tr>
<td>Newton’s 1st law of motion</td>
<td>Why do the coins stay on the bottle?</td>
<td>1 glass bottle, note and coins</td>
</tr>
<tr>
<td>Newton’s 3rd law of motion</td>
<td>How does the balloon car work?</td>
<td>2 balloon cars</td>
</tr>
<tr>
<td>Newton’s 2nd law of motion</td>
<td>How does the rocket launcher work?</td>
<td>1 rocket launcher</td>
</tr>
</tbody>
</table>

Table 1. The science topic, inquiry question and tactile materials for each lesson.
**Approach to data analysis**

Recordings were crucial in this study, as the meanings made were multimodal (Kress 2000, 2010). Thus it was necessary to view one mode (such as gesture) in context with others to gain an in-depth conception of the meaning (McNeill 2005). Consequently, the inspection of each mode shift required the identification of the modes surrounding the shift and their projected meanings. To achieve this, the unit of analysis needed to encompass all the signs (or representations) used, from multiple modes, to design a meaning. Therefore, a semiotic unit (Williams, Tang, and Won 2019; Wright 2011), also referred to as an idea unit (McNeill 2005) or semiotic bundle (Radford and Sabena 2015), was chosen. The semiotic unit permitted a fine-grained level of analysis (over a shorter time period) of the mode shifts used in the design of each meaning (Tang, Delgado, and Moje 2014).

Semiotic units often occur during discourse with multiple participants. Therefore, they were predicted to differ between the student groups and were expected to be influenced by the arrival of a participant (e.g. the teacher) or a material (e.g. a working model). The semiotic units required the implementation of boundaries, as they did not have definitive ones. Boundaries were added as an idea changed or a new meaning evolved, such as when a proceeding meaning deviated from the previous one. For example, as Anna’s group was attempting to draw the diaphragm, a student asked, ‘why don’t we dissect the diaphragm?’ The question related to a future experience when they would dissect a heart. The question instigated the beginning of a new semiotic unit that proceeded into a discourse about who had touched a heart or lung. New meanings frequently occurred in this way, following a designer change, a question (by either a student or the teacher), or after the sharing of a personal experience. In this example, Anna was a new designer and asked a diverging question.

**Data coding and analysis**

To enable an examination of the multiple semiotic units, a diachronic analysis was chosen (Radford and Sabena 2015). This allowed a cross-case analysis of each participant’s mode shifts, since comparisons between multiple semiotic units could be made. To achieve this, it was necessary to use a structuration table to sequence the events from each video in a timeline format (Kelly and Chen 1999). This helped identify and separate semiotic units that were not related to the science phenomenon, as unrelated discourse frequently occurred in the social setting. Next, the oral, gestural and tactile modes of the related semiotic units were recorded via multimodal transcription, seen in Table 2 (Bezemer and Mavers 2011). The affordances of the transcription style ensured interpretations were critically reviewed, which increased reflexivity (Cohen, Manion, and Morrison 2011). For instance, the oral mode (speech) was transcribed using words, while gestures and tactile moves were represented with still images (from the raw video), written descriptions and, later, codes.

Coding of the multimodal transcripts occurred in two phases. First, gestures and tactile moves were identified within semiotic units by replaying the video in slow motion, sometimes multiple times. Next, each semiotic unit was interpreted to discern in what ways the emergent bilinguals shifted between linguistic (oral) and non-linguistic (gestural and tactile) modes. The mode shifts were coded to allow each emergent bilingual’s mode shifts to be compared. The following will explain the coding of gestures, tactile moves and mode shifts.

**Phase 1: identification and coding of gestural and tactile modes**

Gestures in associated semiotic units were coded according to McNeill’s (1992) gesture taxonomy, which is frequently employed in education contexts (Roth 2001). In it four distinct gesticulations (the movement of arms and hands) are described. However, ‘beats’, or motor gestures (Krauss, Chen, and Gottesman 2000) considered to be repetitive, rhythmic, non-pictorial movements used to provide structure to communication, were not considered relevant. Instead, three gesticulations
were recorded in this study: deictic gestures used to point to concrete or abstract forms; iconic gestures associated with concrete materials and processes (which as a result have a transparent relationship with what they are referring to); and, in contrast, metaphoric gestures, which give illustrative properties to abstract forms through movement (see Table 3). Pantomimes that included entire body movements were also identified and coded (Figure 1).

Representations within a tactile mode include the touch, handling, manoeuvring and repositioning of an item. In this study, these are referred to as tactile moves, for example making a working model work. Due to the close relationship between gestural and tactile modes of meaning, representations within a tactile mode may include gesticulations directly related to an item’s (e.g. a model’s) attributes, for example gesticulating the direction of airflow from a rocket launcher by pointing (Kalantzis et al. 2016). Similarly, this could also be depicted by retracing the airflow direction by moving a hand or finger along the plastic tube, as seen in Table 1. Therefore at times gestures

Table 2. Example of the multimodal transcription of a forces and motion lesson.

<table>
<thead>
<tr>
<th>Time</th>
<th>Verbal mode</th>
<th>Gestural and tactile modes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:13</td>
<td>Nick: <em>air comes in</em></td>
<td><img src="image1.png" alt="Image" /></td>
<td>moves hand along tube in one direction</td>
</tr>
<tr>
<td>1:14</td>
<td>Nick: <em>and</em></td>
<td><img src="image2.png" alt="Image" /></td>
<td></td>
</tr>
<tr>
<td>1:15</td>
<td>Nick: <em>if this is there</em></td>
<td><img src="image3.png" alt="Image" /></td>
<td>assembles model correctly</td>
</tr>
</tbody>
</table>

Table 3. Coding of the gesticulations.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Didactic gesture</td>
</tr>
<tr>
<td>I</td>
<td>Iconic gesture</td>
</tr>
<tr>
<td>M</td>
<td>Metaphoric gesture</td>
</tr>
</tbody>
</table>

What’s that called? air coming out draw those dot dot dot things
and tactile moves coincided. Consequently, gestures and tactile moves that occurred simultaneously were recorded as both.

Phase 2: identification and coding of mode shifts
To identify shifts between linguistic (oral) and non-linguistic (gestural and tactile) modes, inspections of semiotic units focused on three things: (1) for incomplete oral sentences; (2) for the use of gestural and/or tactile modes in combination with an oral mode and (3) for the use of gestural and/or tactile modes without an oral mode. The initial coding of mode shifts evolved as the quantity of shifts examined multiplied. The decision to include mode shifts came from this study’s motivation, emergent bilinguals’ science meaning-making in a content-based classroom. Therefore, a prerequisite for a shift to be included was that it helped an emergent bilingual to communicate an idea. For instance, in Example 1 a semiotic unit begins following a question by Ajay. Upon answering, two emergent bilinguals (Stacey and Anna) shift modes to communicate their ideas. Although their shifts differed, both aided the communication of their idea and were subsequently included.

Example 1:
1. Ajay: Why can’t your skin expand?
2. Stacey: Because then it will break and you will … (gesticulation)
3. Anna: Yeah! It will … (gesticulation)
4. Stacey: and it will rip it apart

In each instance, interpretations of mode shifts were based on three things: the representation produced, the context of the semiotic unit within the larger discourse and the knowledge of each emergent bilingual. English levels were imperative to making accurate interpretations, so emergent bilinguals’ standardised English assessments (Australian Council for Educational Research (ACER) and Oxford Placement Test) were collected. For instance, in Example 1 it could appear that Stacey gesticulated because she did not have the vocabulary to express her idea in an oral form. However, knowledge of Stacey’s English ability and review of the recording showed that Anna spoke enthusiastically (turn 3) over Stacey, which resulted in Stacey pausing until Anna had finished.

Trustworthiness
Interpretations remained trustworthy (Guba and Lincoln 1989), as the multiple cases allowed for the triangulation of data that enabled the credibility of results. For instance, to authenticate the interpretations of mode shifts, raw video footage was reviewed in a timely manner (often multiple times) and compared to the other shifts found. In addition, the teacher-researcher, who had prior knowledge of the participants, had the opportunity to clarify shifts in context. Nevertheless, the collection of information regarding each emergent bilingual’s English ability levels preceded the interpretations. Also, if
Interpretations of the data

This section first presents quantitative data to show how frequently each emergent bilingual shifted to gestural and tactile modes and the ways these shifts occurred. Subsequent results include more detailed and descriptive information from selected semiotic units and provide examples of the mode shifts that occurred through tactile moves, gesticulations, imitation and pantomime. Table 4 differentiates between gesture types and depicts the frequency with which the 10 students shifted from an oral mode to a gestural or tactile mode. It shows that, of the 10, 8 shifted to a gestural mode and 6 shifted to a tactile mode to aid their science discourse. Most gestures used by the emergent bilinguals were representative (usually iconic), followed by deictic (pointing), while only five students used pantomime. Gestural shifts were utilised more than tactile shifts, though this finding appeared to relate to the students’ access to the models. In four of the lessons, the two groups shared one model only. The duration each group had with a model varied, and within a group, one individual usually manipulated the model. One lesson on the human body did not include a model (see Table 1).

The results in Table 4 show that Nick (group 1) and Yasmine (group 2) shifted to a gestural mode more frequently than the other emergent bilinguals in their groups. Both students also received the lowest achievement scores in the standardised English assessments. However, due to the small sample size a relationship between these findings cannot be established. In contrast, two students from group 2 (Nadia and Jane) did not appear to shift to gestural or tactile modes during oral representations. This may be a result of Nadia’s frequent absence from the science lessons and Jane’s lack of participation during science.

Next, Table 5 shows the ways the students used mode shifts in science and how frequently they did so. It suggests emergent bilinguals across both groups shifted to gestural and tactile modes when communicating or making meaning in science in four distinct ways: (1) replacement, a deictic gesture or tactile move (e.g. touch of an object) used simultaneously with a pronoun (e.g. ‘this’, ‘that’) which replaced a noun; (2) support, a gesticulation or tactile move provided with an oral representation to embellish the meaning; (3) demonstration, a movement (iconic, metaphoric or pantomime) that replaced an oral description requiring verbs, adverbs and positional language (e.g. shape, size, location and direction) and actions such as vomiting (for instance, in Example 1, the code for Anna’s shift (turn 3) from an oral to a gestural mode was ‘demonstrate’, because her gesticulation completed an idea she had begun verbally, but the code for Stacey’s shift (turns 2 and 4) was ‘support’, because her gesticulation added further meaning to an idea presented entirely in an

Table 4. Number of gestural and tactile shifts made by the emergent bilinguals to aid their science discourse.

<table>
<thead>
<tr>
<th></th>
<th>Iconic</th>
<th>Metaphoric</th>
<th>Deictic</th>
<th>Pantomime</th>
<th>Tactile</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavender</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Nadia</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nick</td>
<td>13</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>11</td>
<td>34</td>
</tr>
<tr>
<td>Jacinda</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Jane</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ajay</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Anna</td>
<td>15</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Koko</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Stacey</td>
<td>14</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>Yasmine</td>
<td>24</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>81</td>
<td>10</td>
<td>18</td>
<td>5</td>
<td>27</td>
<td>141</td>
</tr>
</tbody>
</table>

an interpretation could not be authenticated it was removed. The following discussion presents the final interpretations that address the research question.
oral mode); (4) imitation, a gestural or tactile movement copied from another participant (or the teacher) during a discourse. The data suggests (Table 5) that many emergent bilinguals shifted to gesturalization to demonstrate a meaning, and the majority (seven) appeared to use it more frequently than any other shift.

Table 6 provides details about the timing of the gestural and tactile shifts that occurred relative to an oral representation (a verbal sentence). However, as it was difficult to qualify what movements facilitated the production of speech, there is limited data regarding the gestural and tactile moves that preceded an oral representation. Nevertheless, findings showed that emergent bilinguals more frequently shifted to gestural and tactile modes while simultaneously providing oral representations, for instance in mid-sentence. For the shifts coded as replacement and support this was an expected outcome. However, regardless of their position, demonstrations usually succeeded expressions such as ‘this big’, ‘this way’, ‘it goes’, ‘it kinda’ and ‘like this’. In addition, demonstrations that occurred without an oral mode were usually responses to the teacher’s oral questions. On these occasions students frequently answered through a gestural mode only. Likewise, most imitations occurred without an oral mode; instead the students joined the science discourse by unobtrusively imitating the gesture of another emergent bilingual or the teacher.

The mode shifts replacement, support and demonstration, frequently occurred as emergent bilinguals became confronted with an unknown or an uncertain linguistic representation. At times, the absent everyday words or academic science vocabulary were conspicuous, as seen in Table 7. In most circumstances, a gestural mode (e.g. iconic, metaphoric and pantomime) with its spatial affinances replaced the words that described either a movement or the ways things travelled, including food, force, vomit, the diaphragm, the lungs, air particles, a car and a rocket. In contrast, tactile moves and deictic gestures often replaced the names of a model or of body parts, and the direction of a force or movement. Consequently, gesture types and tactile moves were employed by the emergent bilinguals for different purposes. Examples of each will follow.

Excerpt 1: gesticulation and imitation

Excerpt 1 (see also Appendix) illustrates how an emergent bilingual, Yasmine, shifted modes to produce an iconic gesture when experiencing a linguistic obstacle. This allowed her to express her

Table 5. The ways emergent bilinguals used gestures or tactile shifts.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Replace</th>
<th>Support</th>
<th>Demonstrate</th>
<th>Imitate</th>
<th>Replace</th>
<th>Support</th>
<th>Demonstrate</th>
<th>Imitate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavender</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Nick</td>
<td>3</td>
<td>8</td>
<td>10</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>7</td>
<td></td>
<td>32</td>
</tr>
<tr>
<td>Jacinda</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ajay</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Anna</td>
<td>0</td>
<td>3</td>
<td>13</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>Koko</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Stacey</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Yasmine</td>
<td>0</td>
<td>9</td>
<td>15</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>26</td>
<td>67</td>
<td>11</td>
<td>12</td>
<td>3</td>
<td>12</td>
<td></td>
<td>137</td>
</tr>
</tbody>
</table>

Table 6. The location of gestural and tactile shifts in relation to an oral mode.

<table>
<thead>
<tr>
<th>Relative to oral mode</th>
<th>Replace</th>
<th>Support</th>
<th>Demonstrate</th>
<th>Imitate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Simultaneously</td>
<td>12</td>
<td>20</td>
<td>39</td>
<td>0</td>
<td>71</td>
</tr>
<tr>
<td>Following</td>
<td>6</td>
<td>8</td>
<td>30</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>No oral mode</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>29</td>
<td>79</td>
<td>11</td>
<td>137</td>
</tr>
</tbody>
</table>
idea. The excerpt comes from the forces in motion lesson 2, where Newton’s third law of motion is applied to explain how the balloon car worked. The semiotic unit begins as the teacher verbally asks the students to think about the impact that the wheels have on the movement of the car.

Excerpt 1
1. Teacher: First of all, why do we have … Why don’t we have a square wheel? (Holds the car in one hand, and turns a wheel with the other)
2. Anna: because it wouldn’t
3. Yasmine: It won’t (Interlocks fingers moves each hand up and down like a seesaw)
4. Stacey: It won’t turn.
5. Anna: It won’t roll. (Rotates her hand with a pointed finger around in a circle)
6. Yasmine: Yeah. It won’t roll (Imitates Anna’s gesticulation)
7. Ajay: It won’t roll.
8. Teacher: so, we actually need …
9. Yasmine: a (Moves her hands into a shape as if she was holding an imaginary ball)
10. Anna: circle
11. Teacher: Aha, and then we also need this thing (Runs finger along the axle)

In turn 3, Yasmine responds to the teacher’s verbal question using a linguistic representation (‘It won’t’) to design her meaning. However, shortly afterwards she shifts to an iconic gesticulation and demonstrates her meaning instead. In this case, we can assume that the teacher’s tactile move (turn 1) of a physical object (car or wheel) or oral representation (square) provides the stimulus that provokes internal representations for Yasmine and the others. The production of multiple internal representations afforded Yasmine the ability to shift between them. This meant she was able to communicate her idea, regardless of her inability to express an accurate word in the target language.

In addition, Excerpt 1 shows that Anna’s sharing of an everyday word gave Yasmine the opportunity to hear and visualise other representations. Anna (turn 5) simultaneously represents a matching oral and gestural meaning of the concept ‘roll’. In this instance, Yasmine reappropriates both Anna’s linguistic and gestural representations to confirm her understanding. It is unclear which of Anna’s representations supports Yasmine’s meaning-making; nevertheless, to confirm her agreement with the meaning she imitates both, synchronously verbally repeating the everyday word ‘roll’ and imitating the matching gesticulation.

In a similar circumstance moments later (turn 9), she uses another iconic gesticulation to answer the teacher’s verbal question. Again, she demonstrates her understanding through gesture, a representation that matches Anna’s academic word ‘circle’. In both instances, Yasmine demonstrates her meaning through a non-linguistic mode. Given Yasmine’s current level of English (ranked lowest in her group), her choice to gesticulate instead of verbalising her answer may imply she did not have the vocabulary necessary to communicate in an oral mode. Regardless of her English ability, Yasmine’s mode shifts afforded her the ability to overcome her linguistic obstacle (the everyday word) and express her meaning.

### Table 7. Everyday and academic words replaced by a gestural and/or tactile shift.

<table>
<thead>
<tr>
<th>Forces in motion</th>
<th>Human body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic words</td>
<td></td>
</tr>
<tr>
<td>acceleration</td>
<td>deflate</td>
</tr>
<tr>
<td>action</td>
<td>expand</td>
</tr>
<tr>
<td>reaction</td>
<td>contract</td>
</tr>
<tr>
<td>force</td>
<td>forces/move</td>
</tr>
<tr>
<td>air particle</td>
<td>relax</td>
</tr>
<tr>
<td>balance</td>
<td>pressure</td>
</tr>
<tr>
<td>deflate</td>
<td>diaphragm</td>
</tr>
<tr>
<td>Everyday words</td>
<td></td>
</tr>
<tr>
<td>bounce</td>
<td>bigger</td>
</tr>
<tr>
<td>blast off</td>
<td>tube</td>
</tr>
<tr>
<td>roll</td>
<td>big</td>
</tr>
<tr>
<td>bigger</td>
<td>vomit</td>
</tr>
<tr>
<td>arrow</td>
<td></td>
</tr>
<tr>
<td>shorter</td>
<td></td>
</tr>
<tr>
<td>circle</td>
<td></td>
</tr>
</tbody>
</table>

In turn 3, Yasmine responds to the teacher’s verbal question using a linguistic representation (‘It won’t’) to design her meaning. However, shortly afterwards she shifts to an iconic gesticulation and demonstrates her meaning instead. In this case, we can assume that the teacher’s tactile move (turn 1) of a physical object (car or wheel) or oral representation (square) provides the stimulus that provokes internal representations for Yasmine and the others. The production of multiple internal representations afforded Yasmine the ability to shift between them. This meant she was able to communicate her idea, regardless of her inability to express an accurate word in the target language.

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In a similar circumstance moments later (turn 9), she uses another iconic gesticulation to answer the teacher’s verbal question. Again, she demonstrates her understanding through gesture, a representation that matches Anna’s academic word ‘circle’. In both instances, Yasmine demonstrates her meaning through a non-linguistic mode. Given Yasmine’s current level of English (ranked lowest in her group), her choice to gesticulate instead of verbalising her answer may imply she did not have the vocabulary necessary to communicate in an oral mode. Regardless of her English ability, Yasmine’s mode shifts afforded her the ability to overcome her linguistic obstacle (the everyday word) and express her meaning.
Finally, the teacher’s continuation of the discourse in turn 8 and 11 authenticates the emergent bilinguals’ suppositions and gestures. Thereby, their mode shifting sustained the flow of science ideas in the collaborative multimodal discourse.

**Excerpt 2: pantomime and re-representation**

Excerpt 2 shows an example of an emergent bilingual shifting to pantomime to re-enact her previous experience. It takes place during a biology lesson focused on the digestive system. The discussion focus is on the ability to drink while upside down. Directly prior to the excerpt, Anna and Yasmine discovered that Koko had tried as well. In the excerpt, they ask if she achieved success.

Excerpt 2
1. Anna: Did you drink it?
2. Yasmine: Did you do it?
3. Koko: (Nodding) And then, and then … (pretends to choke; moves head in jerking motion, mouth open, hands crossed at neck; see Figure 1).
4. Yasmine: (Smiles, nods) Choke.

In this excerpt, Koko responds by verbally expressing her experience but shifts to pantomime (gesture with bodily movements) to communicate her entire meaning. Here, pantomime affords Koko the ability to demonstrate her experience without using words and allows her to continue her idea unaided. In this context pantomime also benefits Koko’s group, as her demonstration provides necessary evidence for the group’s science explanation.

Furthermore, the shift presents the other students (and the teacher) with the opportunity to mediate language by re-representing Yasmine’s meaning into an oral representation. In this case, Yasmine re-represents Koko’s gesture into an oral one. It can be assumed that viewing the pantomime (including the actions and sounds) instigated an inducer-concurrent pairing that allowed Yasmine to internalise a matching oral representation, ‘choke’, that was communicated. In doing so Yasmine confirmed she understood Koko’s pantomime and introduced the group to a new English everyday word. This gave Koko the opportunity to hear and see a linguistic representation of her actions.

This study found a student or teacher frequently re-represented gestures into an oral mode when the designer failed to provide one, or provided an incomplete oral explanation. In fact, during this study the teacher re-represented seven gestures into an oral mode while the students re-represented five. Although the use of pantomime was infrequent during science lessons this study showed it to be of benefit as it enabled students, regardless of their linguistic skills in English, the capacity to communicate and share their personal experiences, as found by other studies with language learners (McCafferty and Rosborough 2014).

**Excerpt 3: tactile moves**

Excerpt 3 shows an example of an emergent bilingual making a tactile meaning. This excerpt is from a lesson on forces in motion that asked ‘How does the rocket launcher work?’. In the excerpt, Nick is explaining to his group how the rocket launcher works. To do this he uses a (broken) model launcher to add meaning to his verbal representations.

Excerpt 3
1. Nick: OK so when you smash (hits the empty plastic bottle hard; it deflates) this the air comes out
2. Lavender: you don’t smash it
3. Nick: step on it
4. Nick: The air comes in (touches a tube and moves his hand along depicting the direction the air travels)
5. Nick: and if this is there (grips and holds up the disconnected launch tube and rocket and puts them into correct working position)
6. Lavender: no
7. Nick: I mean I mean I mean, if these two thingies (touches the end of each blocked-end tube with each of his hands)
8. Nick: Is like blocking the air from coming out
9. Nick: so this is like the only way (air can go) and this is broken (moves hands back to hold launch tube which was broken)
Here, Nick shifts to a tactile mode to allow him to overcome his linguistic gaps, such as the unknown names of model parts. He uses oral representations with demonstrative pronouns such as ‘this’, ‘there’ and ‘these thingies’, as well as tactile moves such as running his hand along a tube, to replace the oral representations necessary to describe the air’s movement and direction. Tactile moves afforded Nick the ability to express himself in science.

**Excerpt 4: non-linguistic discourse**

Students were found to imitate other students (and teacher’s) gestures. Imitations were usually silent but sometimes led to oral representations. The following excerpts show the ways gestural imitation supported the emergent bilinguals’ communication by generating vocabulary, teaching science vocabulary and representing science vocabulary.

The excerpt seen in Figure 2 came from a lesson on forces in motion which explored Newton’s first law of motion, inertia. The data showed how a shared tactile experience from a past science lesson allowed students to recall and re-enact it. Directly before the excerpt the students attempted to decipher what key science vocabulary and concepts related to the phenomenon in this lesson. In this excerpt Stacey introduces a shared experience from a prior science lesson that she believes relates to the science concepts in the phenomenon being discussed. In the prior lesson the students were required to shake the lid of a bottle up and down until the sauce stuck inside the lid came out. The sauce came out as the downward shake of the lid stopped abruptly because the sauce was still in motion. This excerpt begins as Stacey imitates the past event. Yasmine and Koko observe Stacey and appear to recall the experience (demonstrated by facial expressions) and begin to imitate the action through gesture. Although it is unclear if Yasmine imitated Stacy’s gesture or her prior experience, her iconic gesticulation nevertheless led to an oral representation inclusive of academic language for the concepts involved: ‘I think it’s motion and gravity’. It appeared the shared experience facilitated a discourse that advanced the academic language necessary to explain the science phenomenon. As science vocabulary is often also a science concept, deciphering their meanings means emergent bilinguals are simultaneously learning language and science.

**Limitations**

From the purposeful class sample, only 10 students agreed to participate. The small and female-dominated sample prevents generalisations. Video recordings were required to examine the participant’s mode shifts on a slower time scale, however, one fixed camera for each group meant a fixed view. Speech from students with soft voices sometimes had to be deciphered and actions (gestures and tactile moves) created outside the recorded area could not be seen, although careful furniture arranging made this an infrequent occurrence. Member checking following the interpretations of data was not viable in this study.

**Discussion**

In this study, the consideration of language as a semiotic system legitimised the application of the emergent bilinguals’ semiotic repertoires during translanguaging in a content-based science class. The exploration of shifts from oral to gestural and tactile modes led to the categorisation of their different purposes. Some of the functions of shifts coincide with classifications of the gesture-speech relationship by researchers (e.g. Colletta et al. 2015; Yen-Liang 2017). For instance, ‘replacement’ often served to reinforce or complement a linguistic meaning, while ‘demonstration’ and ‘support’ provided integrating, supplementary or complementary information. Sometimes shifts entertained multiple functions so deciphering the context of each shift was vital during the analysis; viewing a semiotic unit as a whole meaning helped to achieve this.
Figure 2. Group 2 students gesticulate and imitate a shared experience.

<table>
<thead>
<tr>
<th>Stacey (0:02-0:04)</th>
<th>Yasmine (0:04-0:06)</th>
<th>Koko (0:06-0:08)</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Image 1]</td>
<td>![Image 2]</td>
<td>![Image 3]</td>
</tr>
<tr>
<td>![Image 7]</td>
<td>![Image 8]</td>
<td>![Image 9]</td>
</tr>
<tr>
<td>![Image 10]</td>
<td>![Image 11]</td>
<td>![Image 12]</td>
</tr>
<tr>
<td>![Image 13]</td>
<td>![Image 14]</td>
<td>![Image 15]</td>
</tr>
<tr>
<td>![Image 16]</td>
<td>![Image 17]</td>
<td>![Image 18]</td>
</tr>
</tbody>
</table>

Yasmine (0:09) I think its motion and gravity
One major conclusion from this study, revealed translanguaging was an appropriate process for achieving the goals of CLIL. Students were able to use and practice the target language in science as they could replace a noun by touching or pointing to an object as well as continue an oral meaning (in the target language) through gesture. These two shifts, replacement and demonstration, respectively, also confirmed the findings of studies that reported gestures acted as bridges that filled linguistic gaps (e.g. Unsal et al. 2018). From a dominant linguistic perspective, it appeared the students drew upon alternate resources to overcome their limitations in the target language. However, as it is necessary to move beyond a linguistic centric view of language, this study considers the possibility that in certain shifts the semiotic potentials of a gestural or tactile move had more semiotic value and purpose than a linguistic representation. For instance, in the shift ‘support’ the semiotic potentials of gestures enhanced specific spatial details of a meaning. This shift had further implications for meaning making in science and leads to the next conclusion.

Another major conclusion was that translanguaging functioned as a semiotic process for CLIL. The students’ seamless integration of their semiotic repertoire with their language repertoire allowed science discourse to flow and consequently led to the learning of science. Students shifted between oral and gestural or tactile modes spontaneously and purposefully, which corresponded with studies in CLIL contexts that reported shifts from the target language to the students’ L1 (e.g. Pavón Vázquez and Ramos Ordoñez 2019). Moreover, gestural and tactile moves provided students with alternate ways to communicate and make meaning of the science content, also comparable to the use of L1. This confirmed the findings of Blair, Haneda, and Bose (2018) who suggested when translanguaging, the use of different modes provided multiple pathways to meaning. As gestural and tactile meanings differed from linguistic meanings, they also provided additional details of a meaning via spatial movements and touch. The additional information shows why the integration of modes is essential for science reasoning and sense-making and suggests the integration of students’ semiotic and linguistic repertoires while translanguaging during content-based science class may lead to deeper understandings of the content (Lemke 2000; Williams, Tang, and Won 2019).

An additional conclusion showed translanguaging functioned as a pedagogical scaffold which harmonised with the findings of Lin and He (2017). Results showed that, in line with Lee, Hampel, and Kukulksa-Hulme (2019) gesture during group interactions afforded the students scaffolding opportunities. The more knowledgeable emergent bilinguals (or the teacher) translated meanings from non-linguistic modes to an oral mode thereby enhancing science and language learning (Vygotsky 1978). Thus gestural translations promoted knowledge of the vocabulary and content, corresponding to the findings of Ingerpuu-Rümmel (2018). This occurred in a similar manner as described by Unsal et al. (2018). First, as group members actively participated, they drew upon their semiotic resources as necessary to complete an idea. Next, another participant translated the gestural or tactile meanings into either an everyday or academic word in the target language. Finally, the associated science discourse continued. This showed, when learning science in CLIL contexts, the use of non-linguistic modes presented similar benefits to the use of the L1 for emergent bilinguals, such as enhanced comprehension of science content (e.g. Gallagher and Colohan 2017; Pavón Vázquez and Ramos Ordoñez 2019). As a multiplicity of non-linguistic modes exists, more exploration of their implications in CLIL classroom settings is recommended.

Finally, a noteworthy discovery in this study was that very few emergent bilinguals drew upon alternate linguistic resources (e.g. L1) from their language repertoire when translanguaging. This may have been the result of the language dichotomy between the teacher, who was a monolingual English speaker, and the emergent bilinguals, who were fluent in either Putonghua or Cantonese. Another possibility encompasses the broader school policies. These disseminated traditional views of learning in separate languages and which have led many schools in Hong Kong to enforce an English-only rule in classes such as science (Perez-Milans 2017). These policies make it conceivable that in this study, the emergent bilinguals did not realise they were allowed to use their L1. Nevertheless, an assumption can be made that the constraint on their linguistic repertoire caused the emergent bilinguals to draw more frequently from their semiotic repertoire, particularly to overcome
deficiencies in the target language. This finding makes more sense when we consider that the emergent bilinguals who most frequently employed their semiotic repertoire were also those severely limited by the target language. This assumption is in accordance with other studies that found a lack of proficiency in the target language was a pivotal aspect associated with the use of gestures (Gullberg 2006) and use (and overuse) of the L1 (e.g. Pavón Vázquez and Ramos Ordóñez 2019). However, due to the small sample size, more studies that analyse the use of communication repertoires during translanguaging are needed to confirm this inference.

Conclusion

To expand current understandings of translanguaging, this study drew upon the theory of multiliteracies that conveyed language as a semiotic system. This viewpoint attempted to uncover the semiotic repertoire and expose the gestural and tactile modes used by emergent bilinguals in a content-based science class in Hong Kong. Based on the results obtained, this study can conclude translanguaging afforded the students the ability to participate in science discourse, practice the target language, mediate the target language and make-meaning of science content. Findings from this study also suggest that the use of gestural and tactile modes may have similar benefits to the use of the students’ L1. This study provided information currently lacking on the use of the semiotic repertoire during translanguaging in a content-based science class.

On a final note, this study encourages researchers to move beyond a view of translanguaging as separate language entities and instead move towards a view of language as a semiotic system. Bilingual research investigating the classroom use of translanguaging must encompass methodologies where the analysis can include semiotic units (such as this study) or speech/action events (Lin and He 2017) or ensembles of meaning (Lin 2019). It is these conceptions that will ensure the simultaneous examination of linguistic and semiotic repertoires and will provide a more comprehensive understanding of translanguaging in CLIL settings such as science.

Acknowledgements

The author wants to thank the editor and anonymous reviewer for their useful critical comments on an earlier draft of the paper. Special thanks to Nicola Johnson for her consistent support. This manuscript forms part of the author’s Ph.D. at Curtin University, Australia.

Disclosure statement

No potential conflict of interest was reported by the author.

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Appendix

Table A1. Mode shifts to iconic gesticulations used to express ideas in forces in motion lesson 2.

1. Teacher: First of all, why are the wheels round? Why don’t we have a square wheel?
2. Anna: because it wouldn’t
3. Yasmine: it won’t
4. Stacey: it won’t turn
5. Anna: it won’t roll
6. Yasmine: yeah it won’t
7. Ajay: it won’t roll
8. Yasmine: roll
9. Teacher: OK so we actually need
10. Yasmine: a
11. Anna: circle
