# Conceptualising 3D shapes in New Zealand primary classes

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This paper explores three multilingual students' (9 to 11-years-old) conceptual understanding of three-dimensional (3D) shapes as displayed through peer and classroom interactions in two New Zealand primary classes. Bakhtin's dialogic theory and Garfinkel's ethnomethodology inform the theoretical framework. The paper presents two excerpts from audio-video recorded data. Findings suggest that the students use their multilingual capacities to convey their meanings of geometry shapes as they engage in peer and classroom interactions. The paper recommends that it is crucial to explore prosodic features of the language to facilitate the meaning-making process during teaching and learning of geometry.

Multilingualism constitutes the overt or covert existence of multiple languages in mathematics classrooms (Barwell et al., 2019). This presence of various languages in mathematics classes is widely acknowledged as a *resource* for promoting the understanding of mathematical concepts (Adler, 2010). As a result, the strategy of code-switching between the language of instruction and other languages present in students' repertoire is claimed to promote mathematical understanding (Planas & Setati-Phakeng, 2014). It has been argued that code-switching can enable students to blend their multilingual capacities and successfully participate in mathematical activities (Setati & Moschkovich, 2013); however, it has been argued that the nature of language (if it is verb-based or noun-based) influence the ways in which students understand and display their mathematical ideas (Borden, 2013). For example, Borden found that there is no Mi'kmaw (an aboriginal language of Mi'kmaw communities in Nova Scotia) word for the concept of "flatness", that we take-for-granted in mainstream mathematics. Acknowledging the scarcity of research exploring multilingualism in geometry classes, the paper aims to investigate how multilingual students talk about geometric shapes in primary classes. Moreover, in the work of those who have examined language in mathematics education (e.g., Kaur, 2015; Ng & Sinclair, 2015), the exploration of dynamicity of language that incorporates the prosodic patterns of stress and intonation is often ignored. Ward (2019) argued that these prosodic features of language convey meanings and provide social significance to the words in any setting. Moreover, speakers of different languages employ these prosodic patterns differently to signify their focus of interaction (Ward, 2019). For example, Ward and Al Bayyari (2010) found that Arabic speakers construct their utterances in low pitch to signal their intention of continuous listening to the speaker, which is often perceived as rude behaviour by English language speakers.

Thus, acknowledging the dynamic nature of language in contemporary multilingual geometry classes, the present paper aims to address the following research gaps: (i) to explore the processes through which multilingual students construe and display their understanding of geometry shapes as they engage in classroom interactions, and (ii) to develop a critical understanding of how the multilingual context of contemporary geometry classes influences the process of development of geometry concepts.

Two excerpts from two New Zealand primary schools are presented here to address the research question: *How do multilingual students (9 to 11-years-old) discursively construct and reconstruct two-dimensional (2D) shapes and three-dimensional (3D) shapes in New Zealand primary classes?*

## Theoretical Framework

The present study draws its theoretical underpinnings from Bakhtin's (1981) *dialogic theory* and *ethnomethodology* (Garfinkel, 1967). According to Bakhtin, the specification of the meaning is dependent upon the preceding and succeeding dialogues within the dialogic space. Moreover, two opposing language forces operate simultaneously at different levels of interaction. The centripetal force or the "unifying language" (Bakhtin, 1981, p. 269) aims to guarantee mutual understanding of the meanings of utterances by crystallising their meanings, within the domains of prevalent dominant discourses. Concomitantly, the diversifying force or 'heteroglossia' as Bakhtin (1981, p. 270) defined, attempts to decentralise the already established meanings of the utterances by embedding individualised meanings into the language. It is the ongoing interplay of unifying and diversifying language forces in a specific circumstantial context as well as the socio-cultural milieu that informs the particular sphere of communication. Exploration of what is said, when it is said, and how it is said can enable the researcher to tap into these heteroglossic and unitary language forces. Interpretation of what is said, when it is said, and how it is said can be achieved by exploring the *indexical nature* (patterns of stress and intonation) of the language use (Barwell et al., 2019). The ethnomethodological approach of the present study allowed me to explore these indexical properties of the language use as it unfolds within interaction in day-to-day life events.

Undertaking ethnomethodology with Bakhtin's dialogic theory as a theoretical foundation helps us to acknowledge that knowing is construed as an ongoing action that takes place within ongoing interactions. Therefore, in this paper, I aim to explore the processes through which meanings of geometric shapes are appropriated and developed from moment to moment during classroom interaction, on the one hand; while developing a critical understanding of dominant mathematical discourse that influences the process of meaning-making of geometry shapes in multilingual mathematics class, on the other.

## Methodology

In this paper, I report on three multilingual students' (9-11-years-old) discursive constructions of 2D and 3D shapes in two primary schools (School A and School B). Participants from diverse ethnic and linguistic backgrounds volunteered to participate, and informed consent was obtained from participants and their parents before participation. Data were primarily gathered through classroom observations in School A, and audio-visual recordings of the whole class and group interactions in six geometry lessons School B, as well as field notes in both settings. Short semi-structured interviews were conducted with the two classroom teachers to seek clarification about the lessons. Six (two from School A and four from School B) short audio-recorded focus group interviews were also conducted with the students to explore their understanding of shapes and their properties.

For data analysis, participants' *utterances* were considered as the unit of analysis. To explore students' discursive constructions about 3D shapes, video- and audio-recorded data were viewed repeatedly to identify the relevant key moments. Only moments where students either identified or described the shape or its properties were considered as *key moments*. The key moments were then subjected to two levels of analysis; (i) micro-level and (ii) macro-level. At the micro-level of analysis, several Conversation Analysis (CA) techniques were employed to explore the circumstantial organisation of talk-in-interaction that aids in the conceptual development of the geometric concepts of shapes and their properties. The interactions were transcribed using a simplified version of Jefferson (2004) transcription

conventions (see Appendix A for transcript key). The transcribed data enabled me to identify the subtle prosodic patterns that participants used to convey their meanings with-in talk-in-interactions. The macro-level analysis used an adapted version of Paul Sullivan's (2012) analytical approach, coding each key moment in terms of participants, genres and discourses used, and emotional registers. This coding enabled me to identify the dominant discourses that influence the meaning-making process of geometric shapes.

# Analysis and Discussion

This section presents the analysis of two key moments (from School A and School B) in which students discursively constructed "cube" as "3D Square", and a 'triangular prism' as "3D Triangle".

## *Micro-level analysis*

*Key moment 1: "yeah- just a three-d square."* The first key moment is presented from the focus group interview conducted in School A. The focus group interview was held on the same day after the third lesson on shapes had been taught. In previous lessons, students were taught about 2D and 3D shapes, and their properties. The focus group interview (with a group of five students) was audio-recorded, and transcribed data is presented in Excerpt 1. R denotes the researcher in the transcript. Lily is a monolingual English speaker. Amir and Liu are bilingual students with Arabic and Chinese as their respective home languages. In Excerpt 1, students were asked to talk about shapes.

Excerpt 1

| 7 | Lily: | so:: (.6) we counted how many ↓edges so ^if it was |
|---|---|---|
| 8 | | (1.0)a^ like a SQUARE(.)it had like |
| 9 | | twe↑lve(.6)edge:s |
| 10 | R: | okay |
| 11 | Amir: | ^yeah^ |
| 12 | Lili: | a:n::: twelve co:rner:[s |
| 13 | Amir: | ^no^ |
| 14 | R: | so was it a square? |
| 15 | Amir: | cube. |
| 16 | Lily: | yeah (1.0)↑cube(.)which is really same as a square |
| 17 | Amir: | ^its just three d^ |
| 18 | R: | is it is it same as square |
| 19 | Amir: | [yeah] its #just the three d square# |
| 20 | Lily: | [yeah] |
| 21 | R: | whats exa:ctly three d |
| 22 | Amir: | ↓a three d [>is when it pops ou:t< |
| 23 | Lily: | [a three d is like when it pops out? |
| 24 | Amir: | ↓yeah three dimensiona:l |
| 25 | Lily: | li↑ke(.) a square if you draw it like this |
| 26 | R: | yeah |
| 27 | Lili: | he it (.5) ↑wont be: a three ↑d: itll just be a |
| 28 | | nor:mal squa:re? |
| 29 | Liu: | ^its like [this^ |
| 30 | Lily: | and then a three D:: is when you do >that an then |
| 31 | | another square inside ↑then <you join them up> |
| 32 | | toge↑ther? ((Lily drew the cube there on a piece of paper)) |
| 33 | Lily: | an then a normal square is just like(1.0) four |
| 34 | | line:s |
| 35 | Amir: | Yup |

The first question for the focus group interview was not directed to any particular student. Lily self-selected (Line 7) and started with pointing out the property of 3D shapes (i.e., "edges"). However, in her next utterance (Line 8), she used the name of a 2D shape ("square") to signify the 3D shape (cube). Following Lily's turn, in Line 11, Amir showed agreement. However, he constructed his utterance in a low pitch, a prosodic feature used in the Arabic language to convey continued listening and to encourage the speaker to continue their talk (Ward & Al Bayyari, 2010). In Line 12, Lily used stretching the syllables of her utterance, (i) to hold the floor, and (ii) to look for the right words to express her thoughts (Hellermann, 2005). Amir again used the low pitch to convey his intention for continued listening, yet he displayed his disagreement with Lily's suggestion (Line 13) as he said "no". He did this to take part in the discussion without overpowering Lily, the speaker. In Line 14, the researcher asked Lily if the shape the group was referring to was a square. This time Amir self-selected and stated that the shape was a cube, not square (Line 15). He used a falling tone to display (i) his dominance over the knowledge, and (ii) his intent to finish the interaction about this shape. His assertion was met with agreement from Lily (Line 16) with "yeah"; however, she again paused for one second after saying "yeah" (Line 16). Her use of high pitch with the word "cube" (Line 16) indicates her interest in sustaining the topic (Walker, 2017), unlike Amir. She constructed her utterance to show that her use of "square" is correct as both terms- "square" and "cube'", imply the same shape. Again, in Line 17, Amir self-selected and used lower pitch voice to indicate his agreement with Lily's statement again without interrupting the flow of conversation. In Line 18, the researcher once again asked if both names imply the same shape. To this question, both Amir (Line 19) and Lily (Line 20) started answering. However, Lily stopped as Amir continued. Amir argued that cube is "just the 3D square" (Line 19). He used a creaky voice to claim his authority over the knowledge with certainty (Ward, 2019). Lily (Line 20) again approved Amir's statement with "yeah"; however, she did not provide any explanation of why she agrees that a cube is "just the 3D square". It is noteworthy that, in Line 22, Amir used faster speech along with a lower pitch voice again to signify his authority over his knowledge (Ward & Al Bayyari, 2010). In Line 23, Lily again self-selected and she constructed her utterance using *high rising terminal* (HRT), denoted by '?', a conversational solidarity marker used in New Zealand English, which is used to check whether the other members of the group agree with her (Warren, 2016). In Lines 25, 27, 28, 30-34, Lily constructed her utterances to justify her previous claim that a "cube, which is really same as a square" (Line 16).

The presented analysis shows that Amir (a multilingual student) often made use of prosodic patterns of his Arabic language in his use of English to convey his understanding of shapes to his listeners. Moreover, through his Arabic language patterns of stress and intonation, he displayed his authority and confidence about his knowing of geometry shapes. Ward and Al Bayyari (2010) noted that Arabic ways of supporting the speakers' utterance with the use of low pitch and faster talk are often perceived negatively as a sign of either anger or disinterest by English speakers.

*Key moment 2: "what's a triangle three-d? A triangular prism!"* The second key moment is presented from the audio-visual recording from the first lesson at the School B. During this lesson, the teacher provided the students with a task called "Shapes in everyday life", and asked them to identify the shapes in the picture given to them. The teacher divided the class into groups for this task. After completing the task, she asked each group to come and present the shapes that they had identified. As they reported the shapes, the teacher wrote the names of the shapes on the whiteboard. The teacher asked a group of three students (Alyssa, Tane, and Olivia) to talk about the shapes. They identified one shape as "triangle

3D". The second key moment (Excerpt 2) is extracted from the transcribed classroom discussion that followed. In Line 547, the teacher reads the names of the shapes from the task sheet. In Line 548, she used a high pitch with "what" to draw students' attention to the coming question (Walker, 2017). Moreover, she stretched the word "triangle" while emphasising "three d". In this utterance, she acknowledged students' conception of three-dimensional shape as "3D triangle". However, she displayed her intention to direct students' attention towards using the geometry term for the identified shape. In Line 549, Ethan (with English as his first language), raised his hand to answer and began to speak without permission from the teacher. The teacher ignored his utterance (Line 550), and selected Yue (bilingual student with English and Chinese) to take the next turn. Yue answered that the shape is a "cube" with a flat pitch. It has been argued that Chinese bilinguals often use flat pitch while using English (Pickering, 2001).

Excerpt 2

| 547 | Teacher: | so they ve got(0.2)square(0.5)two d:(1.0)triangle. |
| 548 | | three d:(0.5) ↑what is: a tri::angle three d |
| 549 | Ethan: | it. is. [a: |
| 550 | Teacher: | [<can anyone remember> what (1.0) a tri (1.0) Yue? |
| 551 | Yue: | cube |
| 552 | Teacher: | CU::BE(0.5)um kori cu:↑be is (1.0)a cube is a bit |
| 553 | | Different (.)um::: Matiu ((teacher smiled and pointed to Matiu)) |
| 554 | Matiu: | tri:angular (0.5)a[:: |
| 555 | Tane: | [prism |
| 556 | Matiu: | prism |
| 557 | Teacher: | triangular prism gre:at. |
| 558 | Garry: | I WAS ABOUT TO SAY Cone (1.0) |

In Line 552, the teacher emphasised the word "cube" by using both increased volume and stretching. She used these prosodic features for two purposes: (i) to get Yue's attention at the start of her utterance, and (ii) "um" as a hedging device (Schegloff, 2007) to produce her next utterance that would implicitly reject the suggestion (Line 552). The teacher selected Matiu (bilingual student with Te Reo Māori and English) as the next speaker (Line 553). Matiu, in Line 554, used stretching and a pause to hold the floor so that he could recall and state the full name of the shape. As Matiu could not recall the full name of the shape, Tane self-selected and constructed his utterance (Line 556) in alignment with the Matiu's utterance. The teacher accepted Tane's response and started writing on the whiteboard as Matiu constructed his utterance (Line 556) in agreement with Tane's response. It should also be noted that the teacher responded positively to Matiu's and Tane's response (Line 557). The teacher used a falling tone with "great" to signify the completion of the task of naming the 3D triangle in geometry language (Jeong, 2016). However, Garry (a bilingual Filipino student) in Line 558, used high volume majorly for two purposes: (i) to draw the teacher's attention to his suggestion of 'cone' as the name for shape in question, (Gries & Miglio, 2014); and (ii) as an attempt to continue the discussion on the possible geometry term for the shape by engaging in a parallel talk, a characteristic of bilingual Filipino students (Speicher, 1993). Speicher (1993) showed that Filipino students often engage in parallel or simultaneous talk to offer their explanation without further delay.

It is evident that though Yue (a bilingual Chinese student) used English as a medium to state her response, she was still learning to use intonational patterns used in English. Moreover, Garry, (a bilingual Filipino student) used multilingual capabilities of the English language and Filipino language to display his intentions. The micro-analysis of this key moment also draws our attention to the different ways multilingual students employ their

language repertoires from a different language to convey their meanings as they participate in classroom interactions.

## *Macro-level analysis*

For this level of analysis, each key moment was coded in terms of: (i) participants, (ii) discourses used, and (iii) emotional registers used (see Table 1). The analysis of the two key moments suggests that a constant struggle between unitary language and heteroglossia can be observed at the overlapping dimensions of language and discourses.

Table 1
*Macro-level analysis of Key Moments*

| Participants | Key moment | Discourses | Emotional registers used |
|---|---|---|---|
| Lily, Amir, Researcher, Liu | 1.*" a three-d square."* | Everyday language (e.g., corners); Geometry specific language (e.g. square) | Authoritative (e.g., Amir-line 17), Uncertainty (e.g., Lily- line 16), |
| Teacher, Yue, Ethan, Matiu, Tane, Garry | 2.*"a triangular prism."* | Everyday language (e.g. 'triangle 3D'); Geometry specific language (e.g. triangle) | Authoritative (e.g., Tane-line 555), |

On the dimension of language, both classes catered to multilingual students with varying degree of proficiency in their different languages, including English. New Zealand Curriculum (Ministry of Education, 2007) encourage and uphold the value of diversity of languages (p. 10), thus, promotes the use of *Te Reo Māori* in classes. However, the use of English as the medium of instruction in both multilingual classes highlights the unitary language forces. It is interesting to note that the heteroglossic language forces are evident in the ways in which students made use of their prosodic features from their multilingual repertoire. For example, the use of HRT by Lily (Line 28 in Excerpt 1) to check the conversational solidarity with other members highlights the influence of *Te Reo Māori,* (an Indigenous language of New Zealand with an official status gained in 1987) on her English (Stubbe & Holmes, 2000). Similarly, Yue's utterance (Line 551, Excerpt 2) display the ongoing interplay of (i) centrifugal force embedded in her use of intonations (use of flat pitch), and (ii) the centripetal force of using English as a medium of communication.

On the dimension of discourse, two different discourses are at play in both the key moments. In both the key moments, participants used everyday language and geometry-specific language to display their understanding of three-dimensional shapes. In Excerpt 1, Lily started her utterances using geometry-specific language (e.g., "square" and "edges"). The use of geometry-specific language directs our attention to the embeddedness of unitary language force in her utterances. It is possible that she used these specific terms to keep her utterances in alignment with the dominant geometry discourse. However, the use of "corners" (Line 12, Excerpt 1) shows the embedded heteroglossia as the word corner" is laden with geometry meanings as well as everyday meanings. Moreover, the use of terms like "normal square" and "3D square" in her later utterances also draws our attention to the ongoing dialogic tensions between the centripetal and centrifugal language forces. The phrase of "normal" with "square" uses both everyday language and geometry-specific language. "Normal" implies an everyday understanding of "square", however, by specifying "square" Lily shows her geometry understanding of shape as a four-lined shape. Similarly, in Excerpt 2, the teacher's utterance (Line 548) also highlights the presence of heteroglossia and unitary language force. The phrase "triangle three d" emphasises the understanding that

it is a triangle shape, which is three-dimensional. Thus, the geometry unitary language forces are used to define the shape as "triangle", yet the meaning of "three d" implies a solid shape, highlighting heteroglossia by providing it with everyday meaning. The intent of the teacher's utterance (Excerpt 2, Line 548) was to promote the use of geometry-specific language, that is, to direct students' utterances to align with the dominant geometry discourse.

The analysis highlighted two noteworthy findings. First, it was found that multilingual students can make use of subtle yet significant prosodic features from their repertoire of multiple languages to display their meanings during peer and classroom interactions. Second, the students construct three-dimensional shapes in reference to the two-dimensional shapes that they know. It is interesting to note that the students and teacher did not question the idea of "3D square" or "3D triangle"; instead, the meanings of these terms were discursively constructed in those particular moments. The analysis showed that the use of these terms in students' utterance is confident, signifying their authority over their knowledge. Thus, it can be argued that students used these discursive constructions not only to make sense of shape but also to negotiate the meaning of it as they engaged in the conversation.

## Conclusion

The paper explored discursive constructions of the multilingual (9 to 11-year-old) students as they engaged in group and whole-class interactions. The paper reported on two excerpts from two New Zealand primary classrooms. The use of multilingual repertoire by multilingual students draws our attention to the growing need to develop understanding of these nuances to better support the practices of teaching and learning. Moreover, Bakhtin's dialogic theory enabled me to explore the discursive constructions and reconstructions that students used to display their understanding of geometric shapes. It is evident that a variety of meanings may emerge as the interaction proceeds. The present analysis contributes to the knowledge base in geometry education classroom-based research, specifically in relation to multilingual classrooms. Moreover, this present exploration of the multilingual aspects of primary classes will be fruitful in developing a diverse knowledge base for teachers and researchers for promoting effective teaching and learning practices.

*Appendix A- Transcript key*

| ↑ Higher Pitch | ↓ Lower Pitch | > < Faster talk | ^ Whispering | . Falling Intonation | (.) Silence for 1/10th of second | # Creaky Voice |
|---|---|---|---|---|---|---|
| : Stretch | [ ] Overlaps | < > Slower talk | Underline-Emphasis | ? Rising Intonation | CAPs Volume Increase | (n.0) Silence for n seconds |

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