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Multimodal Discourse Analysis on Mathematics Instruction: A Case Study in Indonesian Primary School

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ABSTRACT

Mathematics has been taken into account as one of the prominent subjects in various levels of formal education. The most common issues related to learning mathematics are more likely perceived by students in primary schools as they begin to develop their critical literacy skills, including mathematics register, calculation, concepts, and principles. Therefore, this research aimed at (1) identifying types of multimodal texts used for mathematics instruction and (2) knowing how semiotic resources create meaning in terms of the mathematical concept. The research setting was SDN 08 Sei Wain, Balikpapan Utara, East Kalimantan participated by the fifth-grade students. The data collection procedure included observation and questionnaires, while data analysis was derived qualitatively. The result of the research was expected to be an insightful reference for primary teachers, policymakers, and stakeholders to improve the quality of learning in primary education.

Keywords: *multimodal texts, causal explanation, mathematics instruction*

ABSTRAK

Matematika telah diperhitungkan sebagai salah satu mata pelajaran unggulan di berbagai jenjang pendidikan formal. Masalah paling umum yang terkait dengan pembelajaran matematika lebih mungkin dirasakan oleh siswa di sekolah dasar ketika mereka mulai mengembangkan keterampilan literasi kritis mereka, termasuk register matematika, perhitungan, konsep, dan prinsip. Oleh karena itu, penelitian ini pada (1) mengidentifikasi jenis teks multimodal yang digunakan untuk pembelajaran matematika dan (2) mengetahui bagaimana sumber semiotik menciptakan makna dalam hal konsep matematika. Setting penelitian di SDN 08 Sei Wain, Balikpapan Utara, Kalimantan Timur diikuti oleh siswa kelas V. Prosedur pengumpulan data meliputi observasi dan angket, sedangkan analisis data dilakukan secara kualitatif. Hasil penelitian ini diharapkan dapat menjadi referensi yang berwawasan bagi guru sekolah dasar, pembuat kebijakan, dan pemangku kepentingan untuk meningkatkan kualitas pembelajaran di pendidikan dasar.

Kata kunci: *multimodal texts, causal explanation, pembelajaran matematika*

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INTRODUCTION

Mathematics has been taken into account as one of the major focuses in various levels of formal instruction as students begin to develop their critical literacy skills. The subject has created several significant problems for students due to its complexity. A study by Nordin (2005) on Students' Perception of Teaching and Learning Mathematics found that the students encountered problems regarding calculations, understanding concepts, and principles. As far as this study is concerned, the conceptualization within the language of science is the central issue. The complexity of the concepts is usually correlated with the nature of science language; they are semiotic hybrids, simultaneously and essentially verbal, mathematical, visual-graphical, and actional-operational (Lemke, 1998).

In addition to the complexity of science language, Halliday and Martin (1994) argue that the general scientific discourse is described as constantly creating new conceptual objects that populate its domain and can be arrayed in various syntactic relations, primarily of coexistence and causality with other states. Other complexities within the language of science are also related to the recognition and appropriate manipulation of verbal objects, which correspond to conceptual objects (Bazerman, 1998). These complexities may cause problems for the students. These difficulties may arise in recognizing the semantic relations among synonymous, antonymous, hyponymous, or sequentially linked terms. Moreover, the difficulties in registers are apparently reflected in Malay secondary school students (Nordin, 2005), suggesting that a significant hindrance to understanding mathematical instruction led them to achieve relatively low scores in the subject, especially when it was delivered in the English language.

Regarding the complexity of mathematical concepts, therefore, causal explanation discourse in mathematics instruction has been one determinative factor of successful learning. To be operationally identified, causal explanation discourse in this research is defined as communicative practices to explain why an abstract and/or not readily observable process occur (Veel, 1997). In this study, the observed processes are some mathematical concepts taught in primary school.

In addition to the complexity of mathematical concepts, classroom discourse is also another challenge. Meaningful classroom discourse contributes to students' understanding by promoting effective communication and articulation of thought (Anderson, 2017). Some innovative teaching practices have brought technology to classrooms. Anderson (2017) also argued that in mathematics teaching, the teachers and the students must be very well acknowledged for the use of application-based technology to enhance students' mathematical discourse. In other ways, interpersonal communication between students and teachers is another influential factor towards successful learning. The development of teacher affording and constraining positioning influences learning engagement (Anderson, 2017). He then claims explicitly that teachers in this situation afford the sharing of mathematical know-how from the position of appropriator, curer, and provoker. Meanwhile, the controller, proprietor, and protector position has been found to constrain the sharing of mathematical know-how. Finally, the teachers' positioning influences opportunities for student engagement.

The Discourse on Mathematics and Multimodality

In general, discourse refers to the ways of behaving, interacting, valuing, thinking, believing, speaking, and often reading and writing that are accepted as instances of particular roles (or types of people) by specific groups of people (Gee,2003).To be specific, discourse can be understood as the patterns of language that can be identified as bound to a particular community and context (Reeves, 2005).

Concerning mathematics teaching in secondary schools, the teaching of both mainstream and theoretical applications is introduced (Mohan & Slater, 2005). Interestingly, they point out that the students have been exposed to expert-like mathematical discourse, which requires them to identify a developmental path of cause in the form of both written and oral texts. Consequently, the students need to understand mathematics discourse to accomplish the task and other learning challenges. However, research into the vocabulary of science suggested that the use of scientific words does not necessarily demonstrate conceptual understanding (Raiker, 1992). On the other hand, reform-oriented mathematics curricula, designed to promote mathematical discourse, were increasingly being adopted by schools serving large numbers of ELL and the Connected Math Project (CMP) which was the implementation of the curricula. Interestingly, this study found that teachers' use of standard language fell into two categories: (a) modeling and (b) eliciting student practice. Therefore, based on several previous studies, the use of multimodal texts is considered valuable in delivering the mathematical concept and facilitating the students in learning mathematics.

Central to the theory of multimodality is the social semiotics resources where the notion, the visual, the written, the auditory, and the haptics (the sense of the touch) are all interrelated and contribute to meaning (Kress and Van Leeuwen, 2010). Cope and Kalantzis (2009), Kern (2006), and Lemke (2005) extended the social semiotic theory of communication to describe various ways serving as resources for critical interpretations of texts and building on individuals' various subjectivities. Meanwhile, Jewitt (2008) suggested that teachers may use multimodal texts as the basis for critical engagement, redesign, or the explicit teaching of how modes construct meaning in specific genres. There are widely-used- instructional media in classrooms such as teacher's talk, gestures and actions when writing on a blackboard and textbooks; these have served as basic multimodal resources.

A textbook is one of the learning materials in language teaching, and it typically incorporates pictures and other visuals (Weninger, 2018). Furthermore, contemporary textbooks use a mixture of multimodal resources, including images, fonts, layouts, colours, and spatiality. In co-existent to textbooks, digital textbooks play an important part as a complement. Digital texts are often hypertextual, hyper multimodal (integrating images, language, audio, and others), and hyperlinked to other digital resources. It is suggested that textbooks incorporating both aesthetic features and functional purposes can be used to trigger the art of teaching, conduct better learning experiences and promote students' learning motivation and aesthetic experiences (Chan et al., 2012). Digital textbooks, additionally, can speed learning further to inquiry-based learning because the students are provided with intertextual links allowing them to connect their textbooks to other texts such as the internet and website.

Systemic Functional Grammar and Visual Images

The theoretical foundation of multimodal discourse analysis is derived from the Systemic Functional Linguistics (SFL) view of language as " social semiotic" (Halliday:1978). Halliday identifies "three kinds of meaning that are embodied in human language as a whole, forming the basis of the semantic organization of all natural languages" (Halliday: 1985). These metafunctions are components which operate simultaneously in the semantics of every language, namely, ideational, interpersonal, and textual metafunctions. They are defined as: the ideational metafunction, which is the resource for "the representation of experience: our experience of the world that lies about us, and also inside us, the world of our imagination. The interpersonal metafunction, which is the resource for "meaning as a form of action: the speaker or writer doing something to the listener or reader by means of language. "The textual metafunction, which is the resource for maintaining 'relevance to the context: both the preceding (and following) text, and context of the situation." (Halliday: 1985).

Furthermore, Kress & van Leeuwen (1996) suggest that the visual images must serve several communicational and representational requirements, in order to function as a full system of communication.They named representational meaning, interactive meaning and compositional meaning in correspondence with Halliday's ideational, interpersonal and textual metafunctions. Visual images involve two kinds of participants, *represented participants* (the people, the places, and things depicted in images), *and interactive participants* (the people who communicate with each other through images, the producers, and the viewers). Furthermore, the visual structure of representation can be either narrative, presenting unfolding actions and events, processes of change, transitory spatial arrangements, or conceptual, representing participants in terms of their more generalized and more or less stable and timeless essence, in terms of class or structure or meaning (Van Leeuwen, 2011)

METHODS

Firstly, the types of multimodal texts and the intersemiosis aspects are explained qualitatively concerning their role in building schema of mathematical ideas. In this case, the qualitative approach provided a thick description of mathematical discourse being examined through systemic functional approach and semiotic complementarity theories.

Research design

The rationale for using qualitative design for this research is instrumental. The researcher intends to gain insight into instructional media and classroom interaction. The analysis of multimodal texts in the instruction revealed some critical aspects, including the organization of information to deliver causal explanations, types of semiotic resources used to create meaning, and to what extent the intersemiotic complementarity created effective concept delivery. Furthermore, the results serve as consideration for mathematics teachers to develop their teaching practices and usage of instructional media.

In this study, the researcher acted as an observer in the classroom using recording devices. To engage the research participants in the activity, the researcher worked collaboratively with a class teacher to assist group activities. Also, the teacher and the researcher discussed the topics to be presented.

During class instruction, the researcher focused on observing oral presentations delivered by the teacher, types of interaction between the teacher and the students, handouts or written presentations, and other teaching aids. The analysis of multimodal texts and students' attitudes toward the instruction was conducted at every meeting. The texts and attitudes were retrieved through several instruments, including video recording, photos, field notes, and interviews. The study was conducted in a primary school. The school primarily consists of local students whose first language is Indonesian language; Mathematics lessons are delivered in Indonesian language.

The participants of this study consisted of eleven students in the fifth grade. The researcher collaborated with the teacher who taught the fifth grade. The observation of Mathematics instruction was conducted within three meetings. Additionally, the observation was only focused on meetings, which cover an introduction of a new topic. Rehearsal and assessment activities were excluded from the observation.

Research Instruments

In order to get the required data, the researcher developed some instruments, including interviews, observation sheets, and field notes. The other instrument is videotaping, and digital cameras. First, a preliminary study was obtained through interviews with teachers. The observation sheet, the primary instrument of this study, is set up by the researcher to obtain facts and information about the teacher and the student's general activity during the instruction. Specifically, the observation sheet has been a valuable instrument for learning data about the types of multimodal texts used by the teacher and how they are incorporated to deliver causal explanation discourse. Second, a field note is assigned to assist the primary instrument. It enables the researcher to record detailed descriptions of real places and events as they occur naturally (Stringer, 2004). The field notes were written during the observation. Finally, videotaping and photos were subsequently taken to get actual data about the discourse used in the instruction.

Data Collection Procedures

A number of procedures were implemented during this study: preparation, piloting preliminary study, executing classroom observation, analyzing data, and reporting. The researcher interviewed the headmaster and teaching staff related to the overall activities in teaching mathematics and the students' academic performance across different levels. Through this stage, the researcher collected information about which level of mathematical instruction appeared to be the most challenging to teach. Finally, a class was chosen to be observed for several meetings. The researcher attended the class instruction for several meetings, using video recording and a camera to gain authentic discourse and teach media performance. The researcher also made use of field notes to capture details.

Data Analysis

In terms of qualitative data analysis, classroom discourse was transcribed; coding schemes were developed to analyze and classify the multimodal texts used in the instruction as well as the literature to codify the data. Coded segments were be extracted and put together to form themes. Subsequently, analysis structure was conducted based on the systemic functional linguistics (SFL) through metafunctions standpoint proposed by Halliday (1978). The metafunctions were used as the basis to analyze the data including classroom interaction, learning media and text type. In essence, the analysis begins with the ideational metafunction, followed by the interpersonal and textual metafunction.

Textual metafunction describes the meaning of complete layout of instructional activities, how the relationship between modes is outlined, and how the modes work together to create meaning. Analytical elements include information value, salience, and framing. The analysis of the interpersonal meaning examines how instructional media and activities build relations to the receiver through choices made among semiotic resources, such as angle, distance, perspective, volume, font size, and interaction. Finally, ideational meaning focuses on how different modes are used to convey interpretations of the world and can be both narratives, with events and actions, and conceptual (Kress and van Leeuwen, 2006)

Ethical Issues

This study considers some ethical aspects, namely, the amount of shared information, relationships, data collection methods, anonymity, handling the collected data, ownership of the data, sensitive information (Dornyei, 2007). Other ethics issues are legal context and the researcher's integrity (Dornyei, 2007). In order to obtain legal permission to conduct the study, the researcher fulfilled the documents and all the requirements from the university.

FINDINGS AND DISCUSSION

Multimodal Discourse in Mathematics Instruction

To analyze causal discourse in Mathematics instruction the researcher transcribed the class verbal interaction. The interaction involved several participants namely the teacher, the students, and the fellow researcher. The causal discourse observation was divided into four sections in which each section described a specific stage of instructional activities; the sections included introduction to topic, concept and skill building.

The concept building was found to be the most resourceful process where the teacher allowed the students to identify and comprehend some key elements of mathematical operation symbols. These symbols operated to explain about the value of numbers, the concept of addition, subtraction, multiplication, and square and square root operation. It was found that each symbol was explained in conjugation with the sample questions. First, the teacher started the lesson by giving the students a question about the previous lesson, later followed by modeling square root operation. The teacher then asked the students to memorize some basic quadratic and root numbers followed by some root operation questions, 100, 121, 25. Finally, the teacher introduced the concept of basic math symbols:

Table 1. Basic math symbols

Basic symbol	**Symbol Name**	**Meaning**
=	Equal sign	Equal to
<	Strict inequality	Less than
>	Strict inequality	Greater than
a^{b}	Power	exponent
$\sqrt{a}$	Square root	Square root
+	addition	To add
-	subtraction	To subtract
:	division	To divide
x	multiplication	To multiply

The follow up activities were modeling activities led by the teacher in collaboration with the students. The students were asked voluntarily to solve a mathematical problem written on the blackboard and guided to find the answer in front of their peers with the teacher's guidance. First, the teacher wrote the follow up math exercises on the blackboard, she explained the exercise instructions to the students including the steps to find the answer.

The causal discourse was identified by the classroom discourse with major tag questions with variation of tones. The following is the sample summary of the causal discourse performed by the teachers.

Table 2. Concept building activities' transcription (translated version)

Performer	Cue phrase	Tone
teacher	How much is it?	interrogative
	Times this	imperative
	Divide this	imperative
	How much is the result?	interrogative
	And then how much is this?	interrogative
	Add this	imperative
	and how much?	interrogative
	What is the result?	interrogative
	Later please compare which one is bigger and which one is lesser	imperative
Student	-	-

After a while, the teacher and the students collaboratively did the exercise on the blackboard. Each student also received personal assistance to solve the math problem. During this time the teacher received responses from the students in terms of confirmations. The confirmation statements varied from declarative and interrogative statements.

Table 3. Rehearsal activities' transcription (translated version)

Performer	**Phrases/ clauses**	**Clause types**
teacher	It is not equal	declarative
	Yes this is correct. This needs equal sign.	declarative
	Continue!	

	Which one is bigger 14 or 13?	interrogative
	So, how much is this √676?	Interrogative
student	Mam, why 13 is bigger than 14?	interrogative
	It is 26	declarative
	What page is that mam?	Interrogative

The final skill building session was delivered by the fellow researcher about how to get exponential operation with numbers ending in 5 (five). The fellow researcher explained the way to solve the problem step by step and finally they came to the result of 5^2, 15^2, 25^2, 35^2, 45^2, 55^2, 65^2, 75^2, 85^2, 95^2.

Table 4. Supplement lesson from fellow researcher (translated version)

Performer	**Phrases/ clauses**	**Clause types**
teacher	Ok, do you know how to calculate exponential operation without having you're the help from your finger?	interrogative
	Please come forward and you can choose the item	imperative
	5^2 equals to ten, is it right or wrong?	interrogative
	Now let me show you how to solve the exponential operation with the following figures: 5^2, 15^2, 25^2, 35^2, 45^2, 55^2, 65^2, 75^2, 85^2, 95^2.	declarative
	Since all the numbers ended with 5 so you put the result of 5^2 which is 25 in the last two digits for the rest of all numbers and then you multiply the first number with the following number and put the result in front of 25.	imperative
Student	Let me try number one	declarative
	No, it is wrong, it should be….	declarative

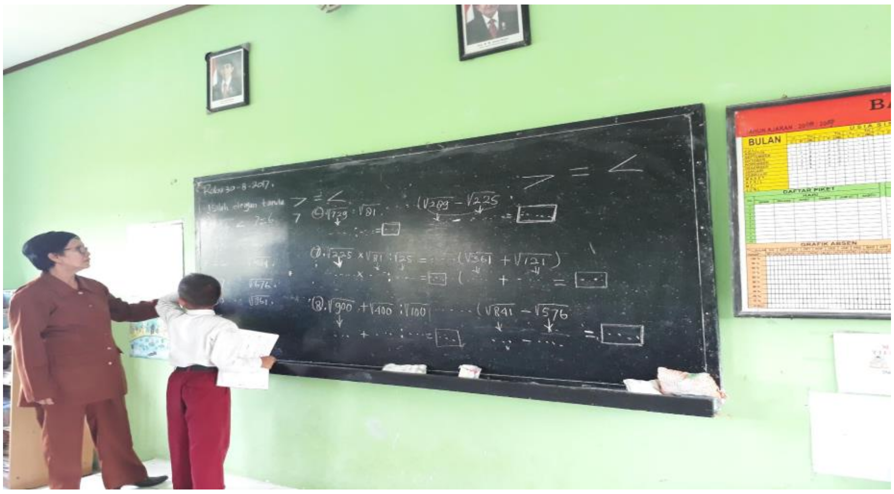
During the exchange of communication there were a number of social semiotics used to express causal discourse. Spoken language expressions served as the major causal discourse. Each type of clause functions to stimulate a certain response. From the data, the majority of spoken language by the teacher was interrogative. Interrogative tone by the teacher was used to invite student's responses in terms of questions or confirmations while other types of clauses used by the teacher such as imperative and declarative were used to indicate instruction or suggestion. From the observation it was also found that interrogative clause usage outperformed the other types when it came to concept building. Furthermore, to indicate cause and effect relationship to explain mathematical concept adverb clause connectors were most employed such as 'now', 'later','since' and 'then'. The word 'and' was excessively spoken and served as conjunction or ordering steps. The teacher also used reference words in considerable numbers to indicate causality such as 'this', 'that', 'there', and 'here'. On the other hand, in general, there were limited student's response throughout the teacher's explanation. Most of the student's responses were declarative. This tone was used to express their agreement and disagreement to options given by the teacher. Another type of clause type was interrogative which was rarely used unless the students asked for technical problems not specifically about the mathematical concept.

Ideational, Interpersonal and Textual Meaning

In figure 1, the interpretation of ideational meaning includes the main characters, the activities, and the circumstances. The characters can be seen from the two participants standing in front of the blackboard while solving mathematical operations. The teacher was depicted with a strong posture with an oblique position that indicated power and authority while the student was facing toward the blackboard while fully being responsible to finish the task. Reflecting on the teacher's and the student's hand and face gesture, the dialogue process apparently occurred one way, that the teacher gave an instruction and suggestion whereas the students received the information and proceeded as instructed. The circumstances can be indicated by the blackboard, uniforms, information panel, a small book cabinet and two photographs and a glimpse of light reflected through the blackboard. This can tell that the instruction occurred in formal ways in daylight. Also, through the circumstance, we found that there were a limited number of teaching aids being used for interactive processes.

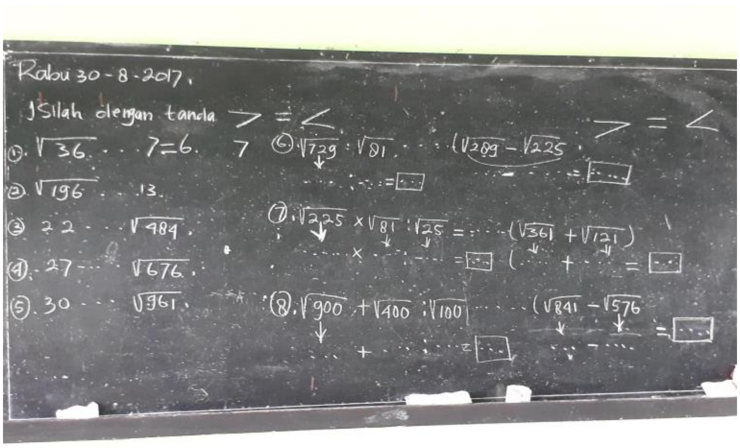
Meanwhile, interpersonal meaning was shown by the distance where the teacher and the student were standing to each other. The teacher stood beside the students and the blackboard to allow spaces for the students to comprehend the mathematical questions while she also provided clear directions. This gesture indicated nurture and scaffolding which gave the students ample opportunities to explore the problems.

Figure 1. Teacher-student Collaboration



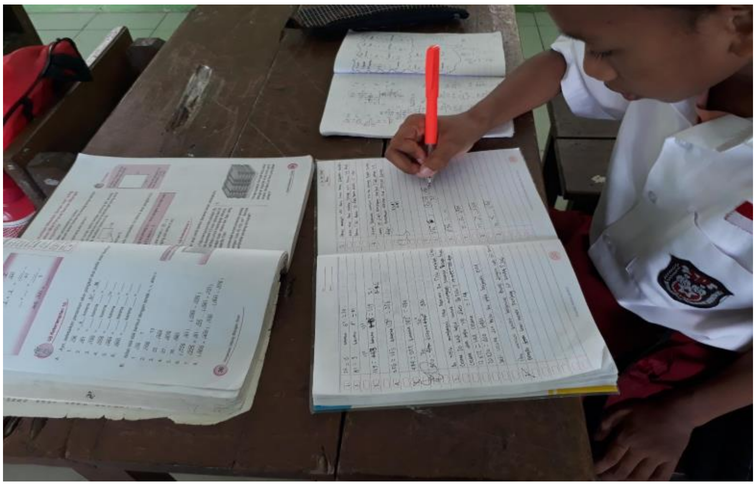
Furthermore, in terms of textual meaning, the mathematical concept of equality and inequality of value was depicted by written symbols in the blackboard as the information value, salience was performed through allocation of textboxes and brackets, and framing led the students to follow the reading pathway. Framing consisted of two different divisions. First, the board was divided into several sections of columns, the left and the right ones. Second, there was a dash line throughout the blackboard to contain all written symbols to cover up the whole concept. In the upper left column the teacher wrote the day and the date as the information value while to indicate the salience of mathematical problems that needed to be solved by the students, brackets for ordering numbers and dots within the textbox were used. Moreover, to show the result of the square root and where to locate the result, an arrow was used to show causality relation. In overall, the teacher used top-bottom flow of reading to interpret the maths-question while left to right reading direction to get the overall result of equality and inequality operation.

Figure 2. Blackboard



In addition to the multimodal texts used in this classroom, the textbook and the notebook functioned as a complement to the teacher's explanation**.** Even though the textbook provided more semiotic resources such as language, symbols, figures, colors, and images, these received minimal scaffolding in which the students only focused on pages, the instruction statement and numbering of mathematical questions. The same way as using the notebook, there was no specific instruction from the teacher on how to translate math concepts explained in the blackboard to relate with the student's textbook.

Figure 3. Textbook and Note Book



From the presented figures above the types of multimodal texts used in the instructional activities were only limited to a blackboard, textbooks and notebooks. The existing multimodal texts were a combination of language, symbols, numbers, shapes, and images. However, there was only one multimodal text, the blackboard, used for the whole instructional activities especially to transfer the concept of equality and inequality. Unfortunately, there were no other supplementary teaching aids that could engage the students for interactive processes.

CONCLUSION

To support the whole concept transfer, it appeared the teacher's direct instruction, which primarily relied on spoken resources, supplemented the student's cognition process. This evidently has been shown through symbols such as dots and arrows as well as the adverbial phrases of causality given by the teachers to stimulate the student's comprehension, recall, and retention. Most expressions made by the teachers were almost in the form of interrogative clauses and phrases, but only few contained cohesive devices expressing the relationship of causes and effects. The most common cohesive device used was 'and'. Meanwhile, to keep the students engaged in the lesson the teacher quite often used references such as *this, that, there, and here*. These reference words were used to describe the circumstances underlying the teacher's explanation. The situation, where the teacher made use of reference and asked questions to the students, apparently reflected semiotic complementarity. The teacher's explanation was supplemented by the mathematical symbols, shapes, and numbers written on the blackboard. They might offer limited meaning to the students if the interactive process did not follow. The result of this research might contribute to teaching Math using multimodality.

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