

# A TEACHER'S USE OF GESTURE AND DISCOURSE AS COMMUNICATIVE STRATEGIES IN CONCLUDING A MATHEMATICAL TASK

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*An experienced teacher has been observed in dialogue with her sixth-grade pupils when summing up their solutions to a mathematical task. The pupils have worked in small groups on this task, which is related to a transposition of data (age and height) from a figure to a Cartesian diagram and to a written text. The teacher's discourse has been analysed, using the dialogical approach to communication and cognition. Analyses of gestures are based on McNeill's classification expanded by Edwards, using the concept of embodied cognition and complemented by the work of Goodwin, taking into account the contribution of the environment to the organisation of the gesture. Some communicative strategies used by the teacher have been identified, for example, questioning (who, how, why, asking for other suggestions). Pointing gestures are used, but they are not prominent. Our findings suggest that gestures are more used and connected to the teacher's explanations than to other procedures.*

## INTRODUCTION

Gesture and discourse have, for a long time, been seen as two distinct ways of conveying meaning. The tendency today is to conceive these two modalities of expression of meaning as complementary. In teaching-learning situations, gestures can be considered as carriers of meaning having the function to *locate* ideas in space, to make them visually perceived. Meanwhile, discourse has the function of *transforming/making* ideas in words. These are privileged tools used by teachers when communicating, explaining, and discussing mathematical concepts in the classroom. The aim of this paper is to focus on a teacher's communicative strategies while summing up, in dialogue with her pupils, the solutions from the pupils' small-group discussion on a mathematical task (called the diagram task), emphasising the transition between three semiotic representations: figure, diagram and written text.

This study is related to the research and developmental project, Learning Communities in Mathematics<sup>1</sup> (LCM) which was designed at the University of Agder (UiA) in Norway. The project was implemented in the period from 2004-2007, and the theoretical framework for it was presented at Cerme 4 (Cestari, Daland, Eriksen, & Jaworski, 2006). The project aimed to “create *inquiry communities* of teachers and didacticians to both develop and explore the development of mathematics teaching and learning” (Jaworski, Fuglestad, Bjuland, Breiteig, Goodchild, & Grevholm, 2007, p. 7).

Inspired by ideas and discussions at workshops in the LCM project, the experienced teacher in focus (about 35 years in service, spring 2005) organised workshops in the

classroom with her pupils during one lesson a week. It is in such a workshop context that the diagram task was used in the classroom with the following structure in three parts: 1. Introduction of activities (00:00-04:28), 2. Working in groups of two and three (04:28-13:47), and 3. Summing up with the whole class (13:47-18:47). In Bjuland, Cestari and Borgersen (2008c) we identified the teacher's communicative strategies while presenting the task in a dialogue with her pupils (part 1). The teacher used both speech and gestures when focusing on the transition from the two different semiotic representations, figure and diagram. More specifically, she posed open *questions* while simultaneously "*pointing* to the diagram followed by a gradually decreasing *circular sliding* between the diagram and the picture" (op. cit., p. 190).

We were also concerned with the difficulties the pupils met in the solution process. One group (two girls) made incorrect suggestions without being attuned to each other, and they had difficulties in focusing on two dimensions in the diagram. The teacher visited the girls twice during the solution process (part 2). She posed different questions (yes-no, open, specific) in order to help them to express their difficulties. The teacher gave verbal explanations simultaneously with using gestures like *pointing* and *circular slidings* to make connections between figure and diagram (Bjuland et al., 2008c).

After having reported from the first two parts of the work on the diagram task, we are now concerned with the way the teacher sums up and concludes the mathematical activity (part 3). This paper addresses the following research question: What kinds of communicative strategies does an experienced teacher use in her dialogues with sixth-grade pupils, while summing up the pupils' solutions to a task that involves moving between different semiotic representations? In Bjuland et al. (2008c), we have illustrated that gesture and speech are natural mediating devices when this teacher introduced the diagram task and when she visited the girls' group. It is therefore important to ask how gestures are used in connection with speech in part 3.

## **THEORETICAL FRAMEWORK**

Gestures and discourses are fundamental modalities in the interpretation of communicative strategies used by teachers in the classroom. According to Roth (2001), teachers employ many gestural resources crucial for understanding a concept. So, pupils need to attend to both their teachers' speech and their gestures in order to access information presented in a lesson. In Bjuland et al. (2008b), we have revealed how the multimodal components of expression, speech, gesture, and written inscriptions develop synchronically. These major components of the objectification process (Radford, 2003) have stimulated the pupils to come up with a solution. We have in our work mostly observed deictic gestures. These are defined by Mc Neill as "pointing movements, which are prototypically performed with the pointing finger" (1992, p. 80). This kind of gestures has an important function of locating in space the referent of the discussion. Likewise, Edwards (2005) reported that almost all gestures produced in the solution of a problem, related to fractions, by prospective teachers

were deictic. According to Edwards (2009), they constitute a particular modality of embodied cognition.

In this paper we take a complementary approach, inspired by the work of Goodwin (2003), and include the analysis of the structure of the task. He has introduced the concept of *symbiotic gesture* when investigating how gesture is related to the physical, semiotic, social and cultural components of the context where it is embedded. An example provided by Goodwin (op. cit.) refers to archaeological analysis related to patterns of earth. He explains that the finger of the archaeologist pointing to the ground shows the graphic structure in the dirt, and, at the same time, that structure provides the context, the place, for the precise movement of the gesture. Another example of a football player is a classic one: if taken in isolation, it is not evident what he is doing. However, if the player is placed in the context of the game, the meaning emerges naturally. According to Goodwin (op. cit.), the nature of embodied practices which promote the competence to act as a member of a community is basically interactive. So, instead of taking as an analytical focus the gesture and discourse by themselves, we include the object which gestures are referring to as part of the analysis. We include as well the activity where this object is inserted in a sequential organisation, taking into account contributions from participants assuming different roles at different moments in the lesson. We illustrate how the teacher makes use of these components in the dialogues with her pupils.

## METHOD

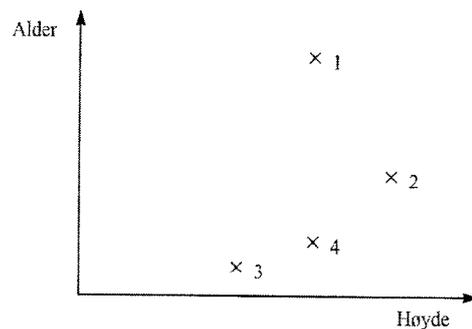
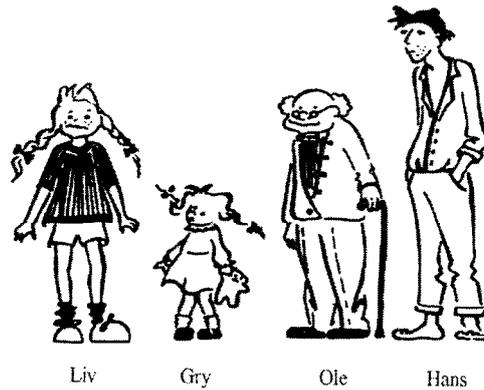
For analysing the discourses we have used a dialogical approach to communication and cognition (Bjuland, 2002; Cestari, 1997; Linell, 1998; Marková & Foppa, 1990) in order to identify an experienced teacher's communicative strategies used in the dialogue with her pupils. In this approach, there are some important principles: the *sequentiality*, *joint construction*, and *act-activity interdependency* (Linell, 1998). As far as the *sequential organisation* of discourse is concerned, "each constituent action, contribution or sequence, gets significant parts of its meaning from the position in a sequence. That means that one can never fully understand an utterance or an extract, if taken out of the sequence which provides its context" (op. cit., p. 85). In this case we have to take into account how a particular utterance is related to the *previous* utterance as well as to the *subsequent* one. The teacher's gestures are identified within a theoretical framework that considers cognition as an embodied phenomenon (Edwards, 2009) and as an interactional process (Goodwin, 2003). Further details about this multimodal approach can be found in Borgersen, Cestari, and Bjuland (in press) and in Bjuland et al. (2008b).

The dialogues presented in this paper are situated in a particular instructional context where the teacher, in dialogue with her pupils, sums up the mathematical solutions (part 3). In our analysis, we focus on the teacher's speech and gestures embodied and situated in the lesson. Part 3 of the selected 19-minutes video clip has been transcribed line by line, and we have divided the transcribed material into numbered

utterances/turns. “An utterance lasts as long as a speaker holds the floor” (op. cit., p. 281). The gestures are described in italics inside brackets [ ] within the utterances/turns where they occurred.

### The task

The following task was given to the pupils: Write down which person corresponds to each of the points in the diagram (the Norwegian words *alder* and *høyde* mean age and height respectively).



Liv corresponds to point .....

Gry corresponds to point .....

Ole corresponds to point .....

Hans corresponds to point .....

In earlier papers (Bjuland et al., 2008a; Bjuland et al., 2008b) we presented a detailed analysis of the proposed task, emphasising the characteristics of the three mathematical representations *figure*, *diagram* and *written text* respectively. Here, we only present the task as a background for understanding the dialogue between the teacher and her pupils while summing up the mathematical solutions. The teacher-pupil dialogues therefore focus particularly on the third representation (written text), including questions asking for the number in the diagram corresponding to every person in the figure.

## SUMMING UP IN THE CLASSROOM

The plenary discussion (part 3) could be summarised in one ongoing episode, consisting of five thematic sequences:

Sequence	Communicative Strategies	Time	Turns
1. The location of Ole – explanation	Open question: Who is number one, two, three and four respectively? Two how-questions, trigger pupil explanation. The answer is visualised on the overhead projector. One further how-question, and the pupil repeats his explanation. Question asking for other suggestions. The teacher uses gestures by pointing to point 1, 2, 3 and 4 on the transparency.	1.13 min	162–172a
2. The location of Gry – explanation and justification	Open question: What about the other points? How-question – triggers an explanation. The answer is visualised on the overhead. Why-question related to the two variables, height and age. Gestures are not identified.	0.43 min	172b–179
3. The location of Hans – explanation and justification	Open question: Other answers? The answer is visualised on the overhead. How-question – triggers an explanation. Question asking for other suggestions in combination with gestures, pointing to point 1. Why could Hans not be point 1?	1.21 min	180–200a
4. The location of Liv – explanation and justification	Question directed to a pupil, Do you have the last solution? The answer is visualised on the overhead. How-question – triggers an explanation. One further question, Was it just a guess or should it be like this? Gestures are not identified.	0.40 min	200b–206a
5. Teacher summing up	Do all of you agree with these answers? Other solutions? Give praise to the pupils. Focus on the unusual – height at the horizontal axis. Recapitulation of the two dimensions, height and age. Gestures are not identified.	0.54 min	206b

Table 1: Plenary discussion after the small-group work

In our analysis we have focused on the first sequence of the dialogue since it illustrates how the teacher initiates the discussion. We have also chosen an extract from the third sequence since this dialogue shows how the teacher focuses on the pupils' argumentation, emphasising the connection between the two dimensions, height and age in the diagram. This third sequence also shows how one of the pupils

(from the group with the two girls) that seemed to have most difficulties in understanding the task (Bjuland et al., 2008a; Bjuland et al., 2008b) responds to one of the teacher's questions, giving us some impressions of her understanding of the problem at this moment.

These sequences show the direction of the mathematical discussion between the teacher and her pupils, from a discussion of the location of Ole to the location of Gry and so on. This is based on the pupils' responses to the questions posed by their teacher.

### The location of Ole

The dialogue below illustrates the first utterances in the teacher-pupil discussion of the mathematical solutions which have resulted from the collaborative small-group work. The teacher (Tea) initiates the dialogue, inviting her pupils of both sexes to be attentive to the task:

- 162 Tea: Girls and boys [*Turns on the overhead projector*]. What I wonder about, what I actually wonder about, where are the different persons? Who is number one? [*Points at point 1, diagram*], who is two? [*Points at point 2, diagram*], who is three? [*Points at point 3, diagram*], and who is four? [*Points at point 4, diagram*] Per?
- 163 Per: We think Ole is one.
- 164 Tea: Ole is number one. How can you be sure of that? How did you think that out?
- 165 Per: Since he's oldest, and then he is tallest [Hans] (...).
- 166 Tea: Yes.
- 167 Per: [Ole is] as tall as Liv.
- 168 Tea: Okay. But Ole he's then number one. Can you write it on [the transparency], so we know it? [Per goes to the overhead projector and writes "1" on the transparency] ... Ole is number one. [Per gives the pen/Indian ink to his teacher and goes down to his seat] But what did you think when you found out that Ole was number one?
- 169 Per: Since, when he is [oldest]
- 170 Tea: [Ssss]
- 171 Per: and then he is on the picture, then he is as tall as Liv. No one else is as old as him [Ole].
- 172 Tea: Okay. Mm. Did anyone think differently? Since he is oldest, okay.

The teacher initiates the discussion by using the same open questions as she did when she presented the task before the collaborative small-group work (Bjuland et al., 2008c). However, her gestures are a bit different. In Bjuland (op. cit.) we observed that she focused on the transition from the figure to the Cartesian coordinate diagram by making four consecutive *pointings* to the diagram with a gradually decreasing *circular sliding* between the diagram and the figure. The interplay between the teacher's gesture and her questions seemed to be a mediating device in her

presentation, showing the relationship between figure and diagram. She is here using the four *pointing gestures* to the diagram in connection with her questions without moving between the two representations (162). We observe from the dialogue that the teacher's use of gestures in part 3 is far less prominent than in the presentation of the task (part 1) and in her small-group dialogue (part 2) with the two girls (Bjuland et al., 2008b). This indicates that the teacher uses more gestures in connection with her explanations to the pupils than in relation to pupils' explanations. In the dialogue between the teacher and the pupil Per (162-172), he comes up with the group solution for Ole as a candidate for point 1 (163). This response guides the direction of the discussion, showing that the teacher-pupil dialogue begins to focus on one of the extreme locations. The two questions from the teacher (164) stimulate Per to give an explanation (165) by making a comparison between Hans and Ole related to both age and height and a comparison of Liv and Ole related to their same height (167).

After having been concerned with the third representation (*written text*), showing the written solution on the transparency, the teacher poses a third how-question (168), provoking Per to repeat his explanation (169), (171). The teacher invites the pupils to make other suggestions (172), but she does not wait for a response. It seems that the teacher has observed that her pupils are satisfied with the solution putting Ole at point 1.

### The location of Hans

The dialogue below contains a particular extract from the third sequence.

- 194 Tea: But you [singular you], what did you [plural you] think when you found out that Hans should be number two?
- 195 Odd: We thought that he was tall, and he [Hans] was much younger than Ole.
- 196 Tea: Mm. Yes, so therefore he should be there. Is there anyone else that thought about it? [Silence, 6. sec.] Leo, what did you think?
- 197 Leo: Eeh, no I (...)
- 198 Tea: Eeh, yes, Is there anyone else that thought about it? Let's see, Hans is number two. He had to be there. Why couldn't Hans be there [Points at point 1, diagram] Why couldn't Hans be there, Eli?[The teacher chose Eli among several pupils who raised their hands]
- 199 Eli: Since he, or if Ole, he is the oldest and then couldn't he [Hans], since he [Hans] is the youngest [of these two].
- 200a Tea: Mm. Yes.

In the second sequence of the episode, one of the girls chooses Gry at another extreme location in point 3 and gives an explanation for the location of Gry (see Table 1). One of the boys has responded to the teacher's open question and told the class that Hans corresponds to point 2, the third extreme location. This answer has also been visualised on the transparency.

In the continuation of the dialogue, the teacher poses a question that stimulates the pupils to explain how they come up with this particular location for Hans (194). The pupils were not only to produce an answer, but they are also challenged to explain their thinking. Odd's response, starting with *we*, (195) shows that he explains the group's thinking. In his explanation Odd is concerned with the two variables, age and height, making a comparison between Ole and Hans. Since they have already discussed the location of Ole (first sequence), it is natural for Odd to explain how his group has discovered the relationship between the placement of Hans and Ole respectively.

After having evaluated this response, the teacher goes on to pose another question that provokes other suggestions (196). The pause indicates that the teacher allows a waiting time of six seconds, giving the pupils opportunities for individual considerations. Since the pupils do not respond to this initiative, the teacher repeats her question and directs it to the individual pupil, Leo (197). His response and the teacher's next question (198) show that the pupils do not have other suggestions. They seem to be convinced that Hans corresponds to point 2. We might wonder why the teacher is so focused on bringing other suggestions into the dialogue. One possible explanation could be that she wants to focus on possible misconceptions. The teacher seems to be aware of how complex it could be for pupils to realise how the two variables, height and age, are connected in the Cartesian coordinate system. By focusing on point 1 as a possible location for Hans, the teacher also triggers the visual misconception: the tallest person corresponds to the point, located highest in the diagram. In connection with this question she also uses gestures to make the pupils aware of the possible location of Hans at point 1. In the analysis of the dialogue of the two girls (Bjuland et al., 2008b), we identified this misconception.

When the teacher poses the challenging why-question twice, provoking the pupils to consider the wrong location of Hans, the pupil Eli (pupil 4 from our girl group) responds to the teacher's initiative (199). Eli makes a comparison of Hans and Ole due to their ages. In one respect, it is possible to argue that Eli is still just focusing on one dimension, the variable of age. However, if we situate the response in this particular context based on the teacher's way of posing the question and also the teacher's evaluation of the response (200), it seems as if Eli has given a proper explanation and developed her understanding from the group work.

## CONCLUDING REMARKS

Through the analysis of dialogues from the teacher-pupil discussion of group solutions on the diagram task, we have identified the teacher's communicative strategies. Her use of *questioning* (who, how, why, other suggestions) is the most prominent strategy. The analysis has also revealed that her use of gestures is more restricted in part 3 compared to gestures used in connection with her explanations while presenting the task and in a small-group dialogue with the two girls (Bjuland et al., 2008c). We could wonder why this restriction happens in part 3. When the teacher

plays the role as a *presenter* (part 1) and as a *supervisor* (part 2), she uses gestures as a mediating device in combination with verbal explanations. In part 3 she uses mainly gestures, pointing to the diagram without circular slidings between representations, to initiate the discussion. Here (in part 3) the teacher plays the role as a *coordinator*, opening the floor for the pupils to write their answers. The teacher-pupil discussion focuses on the mathematical representation, *written text*, in which the pupils show their group solutions on the transparency, making explanations and justifications.

Concerning the contribution of the environment, supported by the concept of *symbiotic gestures* (Goodwin, 2003) we have observed that the nature of the task is influencing the different pointing gestures. It is indeed the pupils' responses that guide the direction of the mathematical discussion. Gestures and discourses are conceived as *meaning translators* between different mathematical and pedagogical ideas used by the teacher as communicative strategies.

## NOTE

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