

Disciplinary knowledge and gesturing in communicative events: a comparative study between lessons using interactive whiteboards and traditional whiteboards in Mexican schools

Juan Manuel Fernández-Cárdenas^{a*} and Marcela Lucía Silveyra-De La Garza^b

^a*Faculty of Psychology, Autonomous University of Nuevo León, Monterrey, Mexico;*

^b*Comité Regional Norte de Cooperación con la UNESCO, Monterrey, Mexico*

In this study the authors have looked at the use of interactive whiteboards (IWBs) in Mexico from a linguistic anthropological perspective. Twenty lessons were video recorded to compare the use of IWBs and traditional boards in different areas of the curriculum in primary schools. Data were analysed as a set of sequenced communicative events in which participants construct knowledge together in a multimodal environment. The authors found, firstly, that teachers ask students – through the use of language and gestures – to show in sequence their understanding of the use of multimodal objects according to the goals set for the lesson and the knowledge privileged by an academic discipline. Secondly, pedagogic ideologies are an important aspect of students' socialisation into disciplinary knowledge that is embodied in communicative practices. Implications from the research include recognising the communicative competence of participants for achieving joint collective goals, as well as suggesting the design of new participation frameworks with pertinent and creative problem-solving activities for promoting knowledge construction through talk in interaction.

Keywords: communicative practice; socialisation; interactive whiteboard; disciplinary knowledge; pedagogic ideology

Introduction

Mexico has implemented an extensive placement of interactive whiteboards (IWBs) in classrooms. More than 170,000 classrooms have been equipped with this technology and the associated software *Enciclomedia* (<http://www.encyclomedia.edu.mx/index.html>), which comprises a database with digital resources corresponding to the curricular contents of the official textbooks used in fifth and sixth grade (ages 10–12) in Mexican primary schools. Consequently, there is a national debate about whether or not this technology promotes a better educational quality (Elizondo Huerta, Paredes Ochoa, & Prieto Hernández, 2006; see also Fernández-Cárdenas, 2006, 2007; Silveyra-De La Garza & Fernández-Cárdenas, 2009).

In this article we present a study that assesses the way in which these digital resources, that is, *Enciclomedia* with an interactive whiteboard, are used in lessons by teachers and students to construct disciplinary knowledge together. We do so by qualifying and comparing communicative events mediated both by traditional whiteboards (TWBs) and by IWBs using a linguistic anthropological perspective (Duranti, 1997; Duranti & Goodwin, 1992; Fernández-Cárdenas, 2008; Goodwin & Goodwin,

*Corresponding author. Email: juan.fernandezcr@uanl.edu.mx

2000; Monaghan & Goodman, 2007). This perspective focuses on social positionings, semiotic modes and participants' understandings analysed through the sequential organisation of action. Thus, cognition is situated within language practices and shaped by the cultural and material aspects of scenarios where action takes place. Culture includes historically developed tools and ideational objects (such as systems of beliefs) mediating human action in everyday and institutional contexts.

Methodologically, we employ statistical and discourse analyses to tackle two main research aims:

- to investigate how electronic resources used with IWBs mediate the construction of disciplinary knowledge between teachers and students in Mexican classrooms
- to identify differences in the knowledge construction process carried out with TWBs and IWBs.

Communicative practice

In this research we focused on comparing the communicative events and practices afforded by IWBs with the ones afforded by TWBs, to learn if and how communicative events socialise children into disciplinary knowledge.

By communicative practice we mean: (1) 'A language-mediated social activity that reflects and reproduces a community's stock of values, knowledge, and beliefs' (Kramsch & Andersen, 1999, p. 32); and (2) the interpretation of rules for social engagement and interaction in situated events (Hanks, 1996). In this respect, we consider a classroom as a scenario where multiple communicative events take place, together forming a communicative practice which involves the socialisation of students into the basic notions of academic disciplines. Thus, academic disciplines are the source of knowledge and rules of interpretation of everyday phenomena presented in classrooms.

Also, at a professional level, disciplines are constituted by communities of practice where linguistic categories and repertoires – as well as other ways of seeing, feeling and acting – are appropriated and mastered by undergraduate and graduate students in order to become professionals (Goodwin, 1997, 2003b). Professional academic disciplines are the source of academic communicative and social practices in which pupils in primary education are supposed to be socialised, even if this happens at a basic level. Moreover, teachers have to be socialised first into these practices so that they become competent at translating professional practices into school-based versions of a given academic discipline (Zeichner & Gore, 1990).

Socialisation

We refer to socialisation as the:

interactional display (covert or overt) to a novice of expected ways of feeling, thinking and acting. Social interactions themselves are sociocultural contexts and through participation children appropriate tools and knowledge gaining competence while actively engaging in social activities and dialogues. (Schieffelin & Ochs, 1986, p. 2)

For this study we focus on the use and appropriation of disciplinary knowledge in Spanish, mathematics, and natural and social sciences by means of talking, writing, touching and interacting with material and conceptual tools that have been developed in the context of professional practices in these knowledge disciplines.

Thus, we have conceptualised classroom language use in terms of communicative events in which students are being socialised into disciplinary knowledge in order to assess how language is used for this purpose. To be able to do this, we have also aimed to access the understandings of teachers and students about subject-related matters and disciplinary knowledge through participant observation and ethnographic interviews (see below).

Methodology

Data were collected from five teachers and their students ages 10–12 in three different primary schools of Monterrey, Mexico:

- School 1. Two teachers of a public primary school. Members of the UNESCO Associated Schools Project Network (ASPnet). Middle-class intake.
- School 2. Two teachers of a public primary school. Members of UNESCO ASPnet. Working-class intake.
- School 3. One teacher of a private primary school. Upper-class intake.

There were 20 visits in total, with four visits per teacher (three female and two male). The goal was to collect video records of a sample of lessons balanced in regard to social strata of students, types of schools, curricular subjects, teaching tools (TWB vs. IWB) and teacher gender. Therefore, two lessons were investigated in each of the cells of this combination of conditions as can be seen in Table 1.

Table 1. Sampling scheme for data collection.

Teacher	History		Geography		Science	
	IWB	TWB	IWB	TWB	IWB	TWB
1. Public school. Male	2 lessons	2 lessons				
2. Public school. Male			2 lessons	2 lessons		
3. Public school. Female					2 lessons	2 lessons
4. Public school. Female						
5. Private school. Female						

Teacher	Maths		Spanish	
	IWB	TWB	IWB	TWB
1. Public school. Male				
2. Public school. Male				
3. Public school. Female				
4. Public school. Female	2 lessons	2 lessons		
5. Private school. Female			2 lessons	2 lessons

Analysis of results

We collected the following data:

- 20 video-recorded lessons in history, geography, science, mathematics, and Spanish (10 TWB lessons; 10 IWB lessons)
- 40 fieldnotes; two observers per visit
- nine interviews: five teacher interviews and four focus groups with students. The interviews were carried out with teachers involved, following an ethnographic perspective. That is, we showed them the video-recorded communicative events and our analysis to find out about their own perspective on these data.

All video recordings were transcribed following Edwards and Mercer's (1987) transcript conventions. Each turn was numbered and all non-verbal actions were also registered. Following the approach of ethnography of communication (Fernández-Cárdenas, 2008; Hymes, 1972; Rojas-Drummond, Mazón, Fernández, & Wegerif, 2006) all the observed and recorded lessons were codified into communicative situations, events, and acts (see Figure 1).

We observed different types of communicative situations, such as:

- individual activities
- small-group activities
- whole-class interactive activities
- game activities
- expository activity
- recap activities.

Similarly, within communicative situations we found communicative events, such as:

- textbook exercise
- questions and answers in pairs
- collective reading
- memory game
- plenary.

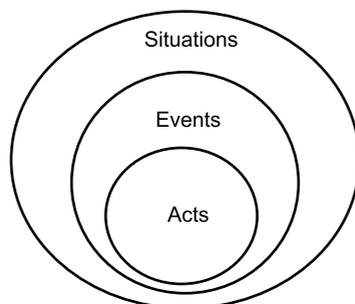


Figure 1. Communicative situations, events and acts.

Finally, within events, the communicative acts were:

- individual or collective plenary
- copying or providing opinions
- listening to or asking about vocabulary.

Over 20 hours of recorded lessons provided the following codified results. First, our sample of recorded lessons accounts for a very similar percentage of the use of total time in the different communicative situations codified, and for the two modalities investigated: almost 50% for each of the use of IWBs and the TWBs. Second, the activity with the biggest frequency and time spent in each modality was ‘whole-class interactive activity’, as can be seen in Table 2.

In order to analyse the quality of communicative acts and events between these two modalities, the transcribed events were codified in terms of Initiation-Response-Feedback (IRFs), following Sinclair and Coulthard’s (1975) theory of discourse analysis. This is because it has been argued that the quality of knowledge construction in a given event is related to the existence of sequenced spirals of turns I-R-F/I-R-F/I-R-F... (see Rojas-Drummond, 2000).

The findings in Table 3 show that the IWB modality has fewer IRF spirals, more Initiation-Response (IR) chains, and more Non-Immediately Sequential Turns (NISTs) than the TWB modality. These differences are statistically significant. The parallel lines in the initial two segments of Figure 2 and the similarity of the pattern in subsequent segments illustrate the consistency *within* the individual teachers’ styles and the different types of sequences and tools. In other words, the way a teacher uses traditional whiteboards has a direct impact on the way s/he uses the IWB.

Table 2. Time percentage for situations.

Situation	TWB	IWB
Individual activity	9%	5%
Small-group activity	5%	4%
Whole-class interactive activity	10%	16%
Game activity (competition)	8%	–
Expository activity	10%	8%
Recap activity	8%	13%
Change of goal	2%	2%
TOTAL	52%	48%

Table 3. Initiation-Response-Feedback spirals (IRF), Initiation-Response chains (IR) and Non-Immediately Sequential Turns (NISTs) in TWB and IWB.

Tool	IRF Spirals	IR Chains	Non-Immediately Sequential Turns	TOTAL
TWB	741 turns	210	135	1086
IWB	591	350	290	1231

Note. Chi square = 99.74; $p < .0001$.

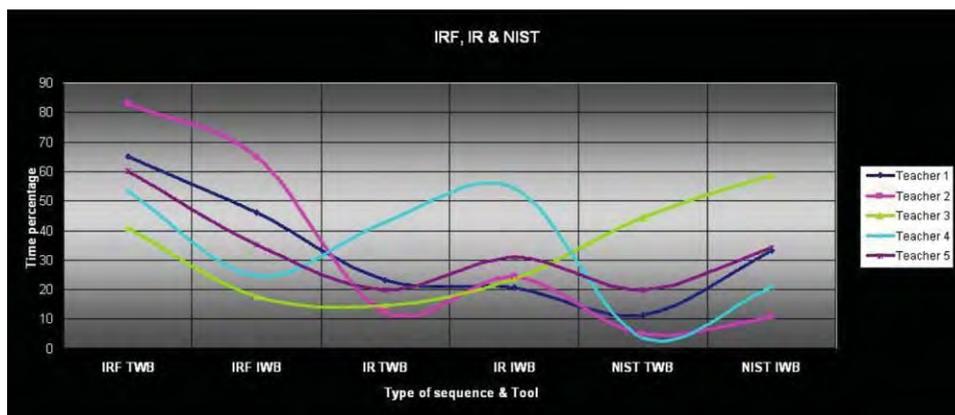


Figure 2. Time percentage for type of sequence and tool (TWB and IWB) for each teacher.

Table 4. Regression analyses comparing TWB versus IWB for all teachers.

IRF TWB predicts IRF IWB	F = 81.043 Sig. = .003
IR TWB predicts IR IWB	F = 12.086 Sig. = .040
NIST TWB predicts NIST IWB	F = 25.825 Sig. = .015

This was statistically tested with regression analyses for IRFs, IRs, and NISTs. In all cases the use of traditional boards predicts the way IWBs are used, as can be seen in Table 4.

In summary, the tool (TWB or IWB) affects the way lessons are conducted, and this is statistically demonstrated with the results of the chi-square contingency test in Table 3. This is also true for all individual teachers, as shown in the regression analysis in Table 4. In each case, the use of IWBs is statistically different to the use of traditional boards in relation to IRFs, IRs and NISTs.

But why is there a difference between the sequential organisation of turns due to the use of TWBs versus IWBs? We aim to answer this question by analysing qualitatively the transcripts of all communicative events when teachers are using IWBs. In this article, we only present a selection of these events, namely those categorised as ‘whole-class IWB interactive activity’. The events are followed by a discussion based on our findings and on the approach chosen for the analysis: linguistic anthropology.

Communicative events

Transcript 1. Story machine

In this transcript (see Figure 3) the teacher uses the IWB to help her fifth-graders (ages 10–11) create a story. The students interact with an electronic roulette to take turns to come to the front of the class and also interact with a story machine on the IWB which triggers initial phrases for the beginning, development, and end of a story.

TURN	I-R-F	PARTICIPANT	TRANSCRIPT
1	I	TEACHER	Javier / please come // to spin the roulette and raffle the student that is going to go next / it's this (<i>teacher points out to the students roulette icon</i>)
2	I		(<i>Javier clicks the roulette icon with his finger and a window pops up with the name "Vania"</i>)
3	R	TEACHER	"Valeria" (<i>reading from screen</i>) (<i>Teacher clicks on the Story Machine icon</i>) Now pull down the lever to see what comes out
4	I		(<i>Valeria pulls down the slot machine lever and a screen pops up with the phrase "One night he found..."</i>)
5	R	VANIA	"One night [he found]" (<i>reading from screen</i>)
6	I	STUDENT	[and we
7	I	STUDENT	[and we write five lines teacher?
8	R/I	TEACHER	Five lines and we write (<i>teacher moves her hand as if she were counting lines in the air</i>) "One night he found..."
9	I	STUDENT	This way teacher?
10	R/I	TEACHER	Aha (<i>Teacher waits for the children to write on their notebooks "One night he found..."</i>) // Up to here, are we ok? / are you already imagining your story?
11	R	STUDENT	[No
12	R	STUDENT	[Yes
13	I	TEACHER	About the transparent boy?
14	R	STUDENTS	No
15	R	STUDENT	More or less
16	I	TEACHER	No?
			.
			.
			.
23	I	TEACHER	(<i>The teacher clicks an icon to finish the game and a screen pops up with the three phrases the slot machine had provided to create a story</i>) We read // "Write the title of your story" we are going to put it on top but we need to put it at the end / when we've finished / our story / and here we have the parts that we were writing (<i>She reads "Write the title of your story" from the screen and moves her hand as if she was designating a place for the title in the air</i>) "Once upon a time there was a boy that was transparent because..." / and you also left the lines like here, right? (<i>The teacher points out the phrases from the screen</i>) "Every time he arrived to a new place..." and you...
24	I	STUDENT	Teacher / can the story be imaginary?
25	R/I	TEACHER	Of course / why do you think it needs to be imaginary?
26	R	STUDENT	Because there is no invisible boy
27	F	TEACHER	Because there is no invisible boy / that we know about, right? / Although he might be sitting there // couldn't he?

Figure 3. Transcript 1.

The roulette randomly assigns turns to students, and the story machine pops up phrases which scaffold the creation of stories. With this input, the IWB acts as if it were an informed participant in the interaction; thus distributing knowledge and authority among teacher and students (see turns 2 and 4). The story machine is also quite useful for socialising disciplinary knowledge about genres, such as tales and fables, and it promotes creativity among students while they identify the different parts of a story. The turn-taking structure is also a productive mix of mostly NIST and IR chains and has only one feedback turn at the end of the event in turn 27. This turn is particularly relevant as it provides an assessment for the students' previous turns (24 and 26) clarifying the creative nature of the task (i.e. 25. 'Of course, why do you think it needs to be imaginary?' 27. 'Because there is no invisible boy').

Transcript 2. Consecutive numbers

While using *Enciclopedia* the teacher presents the students (see Figure 4) with an interactive activity about consecutive numbers. In this exercise a calculator is presented along with a given number. The students' objective is to type two consecutive numbers whose sum would be the given number; if the numbers are correct the IWB shows 'Very good', and if it is incorrect they have to try again.

Both the teacher and class use the big calculator projected on the IWB as a shared visual reference. In this example, children are socialised into the basic notions of mathematical sequences, which are the basis of the understanding of vectors and other graphics. The structure of the event is a mixture of NIST, IR chains and IRF spirals. Each of these turn-taking sequences is productive for exploring the use of the calculator, for assessing together the responses to the mathematical puzzles presented by students, and for verifying the children's understanding of the nature of consecutive numbers.

Transcript 3. History of Mexico

The teacher shows three fragments of a famous Mexican historical soap opera called *La Antorcha Encendida* ('The Lighted Torch'). After watching these fragments he recaps with the students the importance of appreciating the struggle Mexican heroes went through (see Figure 5).

The use of the IWB as a cinema or widescreen TV to show the soap opera helps children get excited and enthusiastic about Mexican history. The event has a clear IR chain structure and with this the teacher recontextualises the information presented, making links between everyday knowledge (i.e. popular celebration) and disciplinary knowledge (i.e. historical facts). Also, teacher and students co-construct new historical interpretations (see turns 11 to 15) as part of this recontextualising process.

Qualitative analysis

Looking in more detail at the transcripts of the selected events presented here, as a sample of linguistic and interactional features that are also common to the rest of our data, the following findings emerged.

TURN	I-R-F	PARTICIPANT	TRANSCRIPT
	R		(Aaron types 20 + 13)
15	I	TEACHER	[What is he missing? // what is he missing? // let's see / check what he's typed // twenty plus thirteen (teacher points at the numbers) // what has he missed? // let's see, Aaron?
16	R	AARON	That they are not consecutive (teacher points to a student)
17	F/I	TEACHER	That they are not consecutive / what did we say 'consecutive' was?
18	R	STUDENTS	(classroom noise)
19	I	TEACHER	What is 'consecutive'?
20	R	STUDENTS	That they follow
21	F/I	TEACHER	That they follow, right? / that one follows the other / and twenty doesn't follow thirteen / and thirteen doesn't follow twenty / who has these numbers in the calculator already?
22	I	STUDENTS	Me, me, me
23	I	TEACHER	Let's see, Valeria // which are they? // [to Aaron] you type them, just let Valeria tell you which ones are they // Valeria, which ones are they?
24	R	VALERIA	Thirteen plus twenty
25	I	TEACHER	Which?
26	R	VALERIA	Thirteen plus twenty
27	F	TEACHER	Yes, but remember that they have to be con-se-cu-tives / con-se-cu-tives / let's see
28	I	STUDENTS	Me, me, me
29	I	TEACHER	Annie
30	R	ANNIE	Hum, hum, thirty / plus / three
31	F	TEACHER	They have to be con-se-cu-tives / that follow / that follows
32	I	STUDENTS	Me, me, me
33	I	TEACHER	Let's see
34	R	STUDENT	Fifteen plus eighteen
35	F/I	TEACHER	Fifteen plus eighteen / but, does fifteen follow eighteen or eighteen follow fifteen?
36	R	STUDENTS	No:o.
37	I	TEACHER	Let's see consecutives
38	R	STUDENT	Thirty one plus two
39	F/I	TEACHER	Thirty one, plus? / two / Are they consecutives, thirty one plus two?
40	R	STUDENTS	No:o.
41	I	TEACHER	Thirty / two follows thirty one?
42	R	STUDENTS	No:o.
43	F/I	TEACHER	No , we haven't understood what consecutive is / let's see
44	R	STUDENT	Ten plus twenty three?
45	I	TEACHER	Ten plus twenty three, are they consecutives?
46	R	STUDENTS	No:o.
47	F/I	TEACHER	They are not consecutives // ten doesn't follow twenty three // let's see Aaron, tell me first
			(Aaron thinks again with his fist on his chin)
48	I	TEACHER	Let's see, Aaron?
49	R	AARON	Sixteen plus seventeen
50	F	TEACHER	Exactly / sixteen plus seventeen // are they consecutives? sixteen plus seventeen? seventeen follows / sixteen
			(Aaron types 16 + 17 in the IWB. The IWB shows "Very Good!")
51	F	TEACHER	There you are / right? That is consecutive

Figure 4. Transcript 2.

TURN	I-R-F	PARTICIPANT	TRANSCRIPT
			(Video projection)
			(Students applause)
1	I	TEACHER	So // I hope you understood a bit better this part / remember that the history [of Mexico] is very extensive / I think the history [of Mexico] is very extensive, we have to analyse / part / each part of what it is happening (Teacher shows with his hands 'the parts') // alright?
2	R	STUDENTS	Ye:es
3	I	TEACHER	Does anyone have a / does anyone have a comment?
4	R	STUDENT	No
5	I	TEACHER	How did you like it? Did you understand it a little more? Did you understand it a little more?
6	R	STUDENTS	Ye:es
7	I	TEACHER	Yes? / is it clearer why is it important to celebrate, yes, our Independence?
8	R	STUDENTS	Yes
9	I	TEACHER	(Teacher moves his hand as ringing a bell) Is it clear why don Miguel Hidalgo or why all the people nowadays celebrate ringing the bell and shouting / Viva Viva! (Teacher moves his hands as celebrating with fireworks) And everybody applauds and there are fireworks and everything / but obviously this is a representation of something (Teacher points at the screen where the video was projected)
10	R	STUDENTS	(...)
11	I	TEACHER	I think that it was not so cheerful / [it is] something / how can we say it? Something...
12	R	STUDENT	...serious
13	F/I	TEACHER	Serious, something very important or maybe of great tension, of a lot of nervousness, and fear too
14	R	STUDENT	Of terror
15	I	TEACHER	Of courage / so I think that it's important to get to know history little by little ...

Figure 5. Transcript 3.

Role of IWBs

In the events, the IWB mediates the knowledge-construction process, as it was used with: a) interactive presentations (i.e. for calculating the formula for the area of the triangle); b) interactive exercises (i.e. using a calculator to understand consecutive numbers); c) cinema or widescreen TV (i.e. watching a historical soap opera); d) simulations (i.e. using a 'story machine'). In all cases, pupils and teacher used IWBs as a common visual reference to discuss and to point at and to make gestures as part of different interactive frameworks (Goodwin, 2003a, 2003b), which were sequentially co-constructed and used for negotiating meaning moment by moment. In general, our findings agree with Hennessy and Deane (2007) about the use of IWBs as a shared visual framework, providing 'a dynamic and manipulable object of joint reference offering new forms of support for intersubjectivity' (p. 2).

Turn structure

The sequence of turns was productive in nearly all its formats and instances, that is, IRF spirals verified children's knowledge; IR chains were relevant to present information and to nominate options; NISTs were frequent when participants explored the IWB functions, and when interpreting the software use.

By analysing the sequential organisation of turns, it is also possible to identify that participants use language to achieve joint goals and that they do it effectively so that tasks are completed in a set of sequenced communicative acts, events and situations. In this respect, we would argue that language use is not only shaped by the material and 'ideal objects' presented in the analysed settings, but also that interaction is goal-oriented (Leontiev, 1978/2000; Wertsch, 1998). Interventions are being assessed continually as appropriate (i.e. 'we haven't understood what consecutive is') as well as relevant (i.e. 'of course/why do you think it needs to be imaginary?'); they also tend to reflect economy (i.e. 'this way teacher?') in the way participants pursue different goals. In sum, participants are aware of what Grice (1975) called the 'maxims of the cooperative principle in conversational implicature' (p. 45); that is, the maxims of quantity, quality, relation and manner.

Socialisation and practice

Through different types of interaction and language use, participants showed their understanding of the situations, the tools being used, the roles taken, and the disciplinary knowledge at stake. Of course, the data show that teachers have a major responsibility in the flow of the activity, showing their interest in the students' understanding of the activity as a whole. Mercer (1995) called this the 'guided construction of knowledge' and we identified this process by looking in detail at the sequential organisation of turns and the use of deictic terms with visual references within a communicative event.

Children were also active in interpreting what was going on in a situation when they were participating in communicative events. As a sign of this we identify children taking, in some cases, the Initiation turn when they were using the IWB, such as in turn 24 in Transcript 1 (see p. 180). Also, there are events of overlapping turn-by-turn co-construction of knowledge such as in turns 11–15 in Transcript 3. Similarly, there are many instances where children do not want to sit down and continue standing, such as Aaron raising his hand till he manages to get the answer in turn 49 in Transcript 2.

The socialised disciplinary knowledge included geometric notions; mathematical sequences; narrative written genres; Egyptian historical narratives; natural selection, adaptation, and variability in the evolution of species; geography and maps; and the nature of the solar system. Communicative practice also included a pedagogic ideology of the academic discipline and how to teach it (Ball & McDiarmid, 1990), which we can see through the following ethnographic interview commentaries:

The Spanish teacher expressed the view that her subject is important as it helps students learn how to write, understand the use of a word in a particular context, and 'be able to communicate appropriately, have the necessary resources to write ..., express themselves in public ... as well as searching and selecting information'. (Teacher 5)

The mathematics teacher finds her subject relevant because it helps the student face everyday challenges through the understanding of underlying abstract concepts in

geometry, randomisation and prediction, and calculations in situated problems. She also finds that mathematics is useful to learn how to reason together, and to understand and propose possible solutions to problems depending on the context. (Teacher 4)

The history teacher explains that it is important that pupils understand this subject in order to learn not only historical facts and dates, but also to identify what are the historical consequences ‘for my life’ of events such as the struggle for votes for women, the development of democracy, etc. Nowadays people are not as they used to be and a historian’s major agenda/goal is to uncover the myths that in many cases surround events and heroes in order to reveal ‘the person’. In many cases we are the ones who create the myth. (Teacher 1)

Multimodal orchestration and gesturing

Teachers socialised children into disciplinary categories and meanings through the use of graphical simulations, audiovisual and film sequences, oral language in use and, predominantly, gestures. Communicative practice then showed the efforts of teachers in orchestrating all the different semiotic resources necessary for socialising children into disciplinary knowledge (Jewitt & Kress, 2003; Jewitt, Moss, & Cardini, 2007; Twiner, Coffin, Littleton, & Whitelock, 2010, this issue). In particular we would suggest that communicative practice mediated with IWBs included gestures as the main orchestration strategy to organise talk, electronic resources displayed on the IWB, and participation from the students in a coherent whole. Here we would like to highlight how participants intentionally used their bodies and hands to make statements about what was going on in the situation: for example, a) a teacher representing ‘consecutive’ with her hands; b) a teacher ringing the bell and throwing fireworks in relation to Mexico’s Independence Day; c) a teacher signing lines in a notebook; d) a student showing how he takes time to ‘think’, and even in a more playful sense; e) a student waving at the ‘transparent boy’ that might have been seated in the classroom (see Figures 6 to 11). It is as if participants were constructing objects in the surrounding space with their hands and bodies and invoking concepts and categories with these objects to make sense of their intentions in the course of interaction (i.e. see also Goodwin, 2007; Núñez, 2004). We would suggest that these ‘objects’ have different and sometimes simultaneous existence within the flow of the class (i.e. the word ‘consecutive’ is written and is looked up in a dictionary, is spoken and signed with hands by the teacher, and as a category is implicitly invoked when numbers are keyed by students in the calculator).

Teachers were aware of different semiotic modes involved in communicative events, including for example:

- the use of the digital resources of IWBs
- the way they talked
- the way they gestured.

In relation to the IWB, this is exemplified by the following extracts from our observation and interview data:

Teacher 5 mentioned that she thinks that the unfolding screen, the reflector, the digital markers, and the virtual keyboard makes the lesson quite interactive and uses the screen as a wide visual frame of reference.



Figure 6. Teacher explaining what 'consecutive' is with her hands while saying 'That follows, that follows'. Photo: Juan Manuel Fernández-Cárdenas, 2007.



Figure 7. Teacher moves his hand as if ringing a bell. Photo: Juan Manuel Fernández-Cárdenas, 2007.



Figure 8. Teacher directs her gaze and orients her body to the student's roulette icon and the student's hand. Photo: Juan Manuel Fernández-Cárdenas, 2007.



Figure 9. Teacher moves her hand as if she were counting lines in the air. Photo: Juan Manuel Fernández-Cárdenas, 2007.



Figure 10. Aaron thinks with his fist in his chin. Photo: Juan Manuel Fernández-Cárdenas, 2007.

Teacher 4 highlights the apparently big effect it has on learning – ‘when they come in front of the class and touch the screen it is fabulous. They never forget what they came to do. They might forget what I said. Twenty or 30 might hear what I said, but if another 10 do not listen to what I say and come to use the IWB they will never forget the experience ..., and especially if they made a mistake ... I choose children with difficulties to come in front of the class and try to press the right keys to solve the problem’.

This last testimony is also interesting as it has been argued that IWBs provide opportunities for experimenting with alternatives to solve a problem in a given



Figure 11. Girl waves her hand to say hi to the ‘invisible boy’. Photo: Juan Manuel Fernández-Cárdenas, 2007.

discipline and to learn together about the possible mistakes (Gillen, Kleine Staarman, Littleton, Mercer, & Twiner, 2007).

Regarding talk, Teacher 4 mentioned in the ethnographic interviews:

In this event she did not want to tell the children the right answer. Instead she wanted the students to discover the meaning of ‘consecutive’ in a mathematics context, so that despite being repetitive ‘I had to make them understand without giving them the right answer’. She shows her belief in discovery learning when she mentions during the interview that she believes that when a student discovers something, then she learns it.

Finally, related to gesturing while using the IWB, we have:

I make a lot of signs, I change the tone of my voice, I highlight, I induce them to get to where I want them to without telling them what is the result that I want; it is an induction, both with the way I move my hands, and the way I change the tone of my voice, that is how I highlight many things. I’ve been doing it for 30 years. (Teacher 4)

Teacher 1 mentions that ‘body talks [so] I move my hands when I talk; nobody teaches us to talk and to move our hands in a particular way; except in oratory where there are special movements for this type of talk – the faces I make, change a lot of the meaning of a phrase; I move my hands a lot while I talk, I am very passionate and I feel this is my way ... everything I feel I express it with my hands, it is something natural and this also applies to the way I move my body and walk through the class’.

These last three testimonies again invoke pedagogic ideologies of ‘learning by discovery’ and ‘passion’ implemented through gestures.

Miller and Averis (in press) argue that IWBs stimulate the use of gestures and that this can be used strategically to improve teachers’ effectiveness in knowledge construction. We would also like to suggest that gesturing and pointing help negotiate meaning through the sequential organisation of interactive frameworks. That is, teachers and students negotiate moment by moment what is going on by drawing on the semiotic resources available on the screen, but also by orienting their bodies towards each other, by talking in interaction, and predominantly by pointing accordingly within the situated activity that is taking place.

This also has implications for the assessment of the quality of talk and turn taking. For instance, Smith, Hardman, and Higgins (2006) in a very detailed study found that ‘lessons which used IWBs had significantly more open questions, answers from pupils and evaluation’ (p. 12) which led to a faster pace of interaction in these lessons. They also reported that ‘answers during IWB lessons are therefore frequent, but briefer than answers given in non-IWB lessons’ (p. 12). We also found this effect in our data, both in relationship to initial open questions and briefer responses from pupils. We would suggest that the pace of articulation of joint interactive frameworks increases with the speed of the electronic flow of images, words and other digital semiotic resources used with the IWBs. That is, we would suggest that in the division of labour for the construction of meaning, participants tend to point more and to talk less because of the rich and rapidly shared resources they have available to show their understanding of the situation, and also because gesture sometimes is used as a supplementary mode for showing understanding of conceptual relations ahead of verbal ability (i.e. Goldin-Meadow, 1999; Goldin-Meadow & Singer, 2003).

Discussion

We have investigated the attributes of IWBs in contrast to traditional boards for socially constructing knowledge across the curriculum. For this purpose, we first analysed a sample of communicative events corresponding to ‘whole-class interaction’ in terms of the structure of the sequence of turns. We found that IWB use invoked fewer Initiation-Response-Feedback spirals, more IR chains and also more Non-Immediately Sequential Turns. Moreover, we found that this effect was consistent amongst all participating teachers in that the way traditional boards are used predicts the use of IWBs by the same individual.

These results are consistent with what Somekh et al. (2007) found in relation to the time it takes for ICT to genuinely transform teachers’ educational practice. Similarly, Moss et al. (2007) suggests there is ‘a continuum in which new technologies initially support, then extend and finally transform pedagogy as teachers gradually find out what the technology can do’ (p. 6). The teachers who participated in our study had about two years of experience with the IWB, so that there was transference of practice between teaching with a TWB and an IWB. Teachers also have an ideology or belief system about the academic discipline they teach and they demonstrate their beliefs by the way they talk about it in class. In this same way they extend their beliefs about learning to their use of IWBs (for example, by discovery) and to the importance they give to using and touching the board to solve a problem (for example, for the less skilled pupils in front of the class). Certainly, pedagogic ideologies about academic disciplines take time to change. Change is not only subject to the teachers’ use of technology, but also, we would argue, to the way they participate in constructing knowledge practices with other professionals and researchers in the academic field, and to the quality of versions of these practices adapted to basic education through continuing teacher development.

In summary, IWBs are tools that are part of situated activity systems (Fernández-Cárdenas, 2008; Goodwin, 1997; Säljö, 1995) with affordances and constraints (Albrechtsen, Andersen, Bødker, & Pejtersen, 2001; Gibson, 1979; Greeno, 1994; Kennewell, 2001). Situated activity systems are a configuration of material and conceptual tools as well as social rules, which are used by participants to sequentially negotiate situated meaning in the course of interaction in order to achieve collective goals. In this respect:

- In contrast to TWBs, IWBs afford the ‘design’ of more multimodal communicative practices to socialise children into disciplinary knowledge. Children and teachers can touch, point, and make gestures related to digital and material objects. In contrast to opaque and static representations in TWBs, digital objects are dynamic, colourful, and simulate complex activities in human everyday and institutional contexts.
- The investigated situated activity systems in this study were too close to traditional classroom rules, activities, and constraints. Our data highlight how close TWBs and IWBs are to pedagogic practices. Pedagogic ideologies remain static despite the change of artefacts, so that the update of these belief systems in teachers is a key and fundamental issue for more creative practices; for instance, moving from a pedagogy based on learning by discovery to a pedagogy based on the access, appropriation and mastery of sociohistorical tools. Communicative practice reflects ideology.

- Socialisation is constrained by the restricted access of one IWB per class, so that not all the children can eventually interact directly with the screen. New and more creative activities need to be designed so that the majority of children can have an opportunity within the same lesson. Alternatively, the situated activity system can benefit by incorporating and merging the use of mobile devices such as laptops, PDAs and smartphones.
- Socialisation of disciplinary knowledge is also constrained by the limited access teachers have to the professional practices of the disciplines they teach. Thus, socialisation can be improved by promoting continuous professional development courses in close relation to the work of researchers and other professionals in their fields. Also, activity systems in schools can be enriched by directly involving other types of participants such as researchers, professionals, university students and parents who might want to share their expertise in their respective fields.
- We suggest that if participation is goal oriented, perhaps it would be more productive to design problem-solving activities where problems and disciplinary solutions are pertinent and creative, in a sociohistorical sense, for promoting knowledge construction and discussion amongst all participants with questions such as: How relevant is this knowledge for solving that problem? How was this problem solved by other scientists and professionals? How relevant is this problem for my actual circumstances? (For example, see Gutiérrez, 2008; Gutiérrez, Baquedano-López, & Tejada, 1999.)

In summary, within the actual characteristics of the studied activity systems, we suggest that teachers need to be creative and aware of their resources within this process, and perhaps more importantly, to be sensitive to engaging students in the conversation. This particularly provides opportunities for children to show their understanding of the situation, and work from there to advance in the appropriation and mastery of disciplinary knowledge and categories. We argue that knowledge is constructed between participants, mediated by tools, and with multiple semiotic resources. In this respect interaction is sequential and assessed continually by participants in terms of the type of social positions taken, the goals being pursued in the activity, and the knowledge that is considered relevant in a given discipline. Participants strive to be competent in the communicative events in which they participate so that goals are jointly achieved. Pedagogical change should not only come from a desire to transform their communicative efforts, but also from a careful design of more creative and meaningful activities and goals to be achieved.

Acknowledgements

This research was sponsored by the North Regional Committee for Cooperation with UNESCO and the State Government of Nuevo León, Mexico. We would like to thank the academic suggestions made by Charles Goodwin to improve this manuscript. Similarly, we appreciate the assistance of Joana Kennington in the revision of the academic linguistic style. In all cases, the opinions expressed in this article are the responsibility of the authors.

Notes on contributors

Juan Manuel Fernández-Cárdenas holds a PhD in Language and Education from The Open University in the United Kingdom. He works as a full-time researcher and lecturer at the

Faculty of Psychology of the Autonomous University of Nuevo León in Monterrey, Mexico. His main research areas include the study of the relationship between language, cognition, and culture in educational communities of practice.

Marcela Lucía Silveyra-De La Garza obtained a Bachelor's degree in Educational Sciences from the University of Monterrey, Mexico. Until October 2009 she worked as a research fellow in the North Regional Committee for Cooperation with UNESCO. Her publications focus on the affordances and constraints of educational practices associated with ICT tools.

References

- Albrechtsen, H., Andersen, H.H.K., Bødker, S., & Pejtersen, A.M. (2001). *Affordances in activity theory and cognitive systems engineering* (pp. 38). Roskilde, Denmark: Risø National Laboratory.
- Ball, D.L., & McDiarmid, G.W. (1990). The subject matter preparation of teachers. In W.R. Houston (Ed.), *Handbook of research on teacher education: A project of the Association of Teacher Educators* (pp. 437–449). New York: Macmillan.
- Duranti, A. (1997). *Linguistic anthropology*. New York: Cambridge University Press.
- Duranti, A., & Goodwin, C. (Eds.). (1992). *Rethinking context: Language as an interactive phenomenon*. New York: Cambridge University Press.
- Edwards, D., & Mercer, N. (1987). *Common knowledge: The development of understanding in the classroom*. London: Methuen and Co.
- Elizondo Huerta, A., Paredes Ochoa, F.J., & Prieto Hernández, A.M. (2006). Enciclomedia. Un programa a debate. [Debate temático]. *Revista Mexicana de Investigación Educativa*, 11(28), 209–224.
- Fernández-Cárdenas, J.M. (2006). *The mediation of interactive white board in education: The perspective of different agents in Mexico*. Senderos II, North Regional Committee for Cooperation with UNESCO. Retrieved from <http://www.comitenorte.org.mx/documento/604200691042/senderos2.pdf>.
- Fernández-Cárdenas, J.M. (2007). La educación en ciudadanía para la sociedad del conocimiento: Una aproximación sociocultural [Citizenship education for the knowledge society: A socio-cultural approach]. In C. Carrión (Ed.), *Educación para una Sociedad del Conocimiento [Education for the knowledge society]* (pp. 47–84). Monterrey, Mexico: Trillas.
- Fernández-Cárdenas, J.M. (2008). The situated aspect of creativity in communicative events: How do children design web pages together? *Thinking Skills and Creativity*, 3(3), 203–216.
- Gibson, J.J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.
- Gillen, J., Kleine Staarman, J., Littleton, K., Mercer, N., & Twiner, A. (2007). A 'learning revolution'? Investigating pedagogic practice around interactive whiteboards in British primary classrooms. *Learning, Media and Technology*, 32(3), 243–256.
- Goldin-Meadow, S. (1999). The role of gesture in communication and thinking. *Trends in Cognitive Sciences*, 3(11), 419–429.
- Goldin-Meadow, S., & Singer, M.A. (2003). From children's hands to adults' ears: Gesture's role in the learning process. *Developmental Psychology*, 39(3), 509–520.
- Goodwin, C. (1997). The blackness of black: Color categories as situated practice. In L.B. Resnick, R. Säljö, C. Pontecorvo, & B. Burge (Eds.), *Discourse, tools, and reasoning* (pp. 111–140). Berlin: Springer-Verlag.
- Goodwin, C. (2003a). Conversational frameworks for the accomplishment of meaning in aphasia. In C. Goodwin (Ed.), *Conversation and brain damage* (pp. 90–116). New York: Oxford University Press.
- Goodwin, C. (2003b). Pointing as situated practice. In S. Kita (Ed.), *Pointing: Where language, culture, and cognition meet* (pp. 217–241). Mahwah, New Jersey: Lawrence Erlbaum.
- Goodwin, C. (2007). Environmentally coupled gestures. In S.D. Duncan, J. Cassell, & E.T. Levy (Eds.), *Gesture and the dynamic dimension of language* (pp. 195–212). Amsterdam: John Benjamins.
- Goodwin, M.H., & Goodwin, C. (2000). Emotion within situated activity. In A. Duranti (Ed.), *Linguistic anthropology: A reader* (pp. 239–257). Malden, Massachusetts: Blackwell.

- Greeno, J.G. (1994). Gibson's affordances. *Psychological Review*, 101(2), 336–342.
- Grice, H.P. (1975). Logic and conversation. In P. Cole & J.L. Morgan (Eds.), *Syntax and semantics. Volume III: Speech acts* (pp. 41–58). New York: Academic Press.
- Gutiérrez, K. (2008). Developing a sociocritical literacy in the third space. *Reading Research Quarterly*, 43(2), 148–164. DOI:10.1598/RRQ.43.2.3
- Gutiérrez, K., Baquedano-López, P., & Tejada, C. (1999). Rethinking diversity: Hybridity and hybrid language practices in the third space. *Mind, Culture and Activity*, 6(4), 286–303.
- Hanks, W.F. (1996). *Language and communicative practice*. Boulder, Colorado: Westview Press.
- Hennessy, S., & Deaney, R. (2007). *Exploring teacher mediation of subject learning with ICT*. Final report to Economic and Social Research Council (ref. RES-000-23-0825). Cambridge: University of Cambridge.
- Hymes, D. (1972). Models of interaction in language and social life. In J.J. Gumperz & D. Hymes (Eds.), *Directions in sociolinguistics: The ethnography of communication* (pp. 35–71). London: Basil Blackwell.
- Jewitt, C., & Kress, G. (2003). A multimodal approach to research in education. In S. Goodman, T. Lillis, J. Maybin, & N. Mercer (Eds.), *Language, literacy and education: A reader* (pp. 277–292). Stoke-on-Trent, UK: Trentham Books.
- Jewitt, C., Moss, G., & Cardini, A. (2007). Pace, interactivity and multimodality in teachers' design of texts for interactive whiteboards in the secondary school classroom. *Learning, Media and Technology*, 32(3), 303–317.
- Kennewell, S. (2001). Using affordances and constraints to evaluate the use of information and communications technology in teaching and learning. *Technology, Pedagogy and Education*, 10, 101–116.
- Kramsch, C., & Andersen, R.W. (1999). Teaching text and context through multimedia. *Language Learning & Technology*, 2(2), 31–42.
- Leontiev, A.N. (1978/2000). *Activity, consciousness, and personality*. Retrieved from Marxists Internet Archive: <http://www.marxists.org/archive/leontev/works/1978/index.htm>.
- Mercer, N. (1995). *The guided construction of knowledge: Talk amongst teachers and learners*. Clevedon, UK: Multilingual Matters.
- Miller, D., & Averis, D. (in press). Gesture and the use of interactive whiteboard: Work in progress in secondary mathematics teaching. University of Keele.
- Monaghan, L., & Goodman, J.E. (Eds.). (2007). *A cultural approach to interpersonal communication*. Malden, Massachusetts: Blackwell.
- Moss, G., Jewitt, C., Levaïç, R., Armstrong, V., Cardini, A., & Castle, F. (2007). *The interactive whiteboards, pedagogy and pupil performance evaluation: An evaluation of the Schools Whiteboard Expansion (SWE) project: London Challenge*. London: Department for Education and Skills.
- Núñez, R. (2004). Do real numbers really move? Language, thought, and gesture: The embodied cognitive foundations of mathematics. In F. Iida, R. Pfeifer, L. Steels, & Y. Kuniyoshi (Eds.), *Embodied artificial intelligence* (pp. 54–73). Berlin: Springer-Verlag.
- Rojas-Drummond, S. (2000). Guided participation, discourse and the construction of knowledge in Mexican classrooms. In H. Cowie & G. van der Aalsvort (Eds.), *Social interaction in learning and instruction* (pp. 193–213). Oxford: Pergamon.
- Rojas-Drummond, S., Mazón, N., Fernández, M., & Wegerif, R. (2006). Explicit reasoning, creativity and co-construction in primary school children's collaborative activities. *Thinking Skills and Creativity* 1, 84–94.
- Säljö, R. (1995). Mental and physical artifacts in cognitive practices. In P. Reimann & H. Spada (Eds.), *Learning in humans and machines: Towards an interdisciplinary learning science* (pp. 83–96). Oxford: Pergamon.
- Schieffelin, B.B., & Ochs, E. (Eds.). (1986). *Language socialization across cultures*. New York: Cambridge University Press.
- Silveyra-De La Garza, M.L., & Fernández-Cárdenas, J.M. (2009). La multimodalidad y las interacciones dentro del aula en distintas áreas del curriculum educativo mexicano: Un estudio comparativo con diferentes herramientas tecnológicas [Multimodality and classroom interactions in different areas of the Mexican curriculum: A comparative study with different technological tools]. In J.M. Fernández-Cárdenas (Ed.), *Conferencia Internacional en Tecnología e Innovación Educativa REDIIEN'07 [International conference in*

- technology and educational innovation REDIEN'07]* (pp. 411–428). Monterrey, Mexico: Red de Investigación e Innovación en Educación del Noreste de México (REDIEN).
- Sinclair, J.M., & Coulthard, M. (1975). *Towards an analysis of discourse: The English used by teachers and pupils*. London: Oxford University Press.
- Smith, F., Hardman, F., & Higgins, S. (2006). The impact of interactive whiteboards on teacher–pupil interaction in the National Literacy and National Numeracy Strategies. *British Educational Research Journal*, 32(3), 443–457.
- Somekh, B., Underwood, J., Convery, A., Dillon, G., Jarvis, J., Lewin, C., et al. (2007). *Evaluation of the ICT Test Bed project*. Coventry, UK: Becta.
- Twiner, A., Coffin, C., Littleton, K., & Whitelock, D. (2010). Multimodality, orchestration and participation in the context of classroom use of the interactive whiteboard: A discussion. *Technology, Pedagogy and Education*, 19, 211–223.
- Wertsch, J.V. (1998). *Mind as action*. New York: Oxford University Press.
- Zeichner, K., & Gore, J. (1990). Teacher socialization. In W.R. Houston (Ed.), *Handbook of research on teacher education: A project of the Association of Teacher Educators* (pp. 329–348). New York: Macmillan.