

# Teaching and learning in the science classroom

## The methodological challenges of research

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Studies of classrooms confirm them to be arenas of great complexity. By investigating the relationship between teaching and pupils' opportunities for learning, the studies in this volume contribute to the empirical base of didactics as a science of teaching; this essay's contribution is a methodological discussion of possible approaches to research timescales. Research results from the tradition of science education, and more specifically teaching and learning about biological evolution, are used here to develop a research approach to empirical materials that considers the many timescales of classroom interaction.<sup>1</sup> The essay takes two questions that are critical to professional teachers as its starting points, namely how to reach moments of joint understanding, and how to achieve subject-matter progression in the classroom.

The science education research tradition has had much to say about the difficulties associated with teaching and learning specific science topics. The topic of biological evolution includes teaching and learning about concepts that involve several biological organisational levels and long-term perspectives, such as the development of life, biological adaptation, and biodiversity (for example, Skolverket 2011). The description of the development of life on Earth involves

long time spans, in which rates of survival and reproduction explain evolutionary changes over many generations. Biological adaptation refers to how survival in a specific environment is promoted by an increase in certain heritable trait frequencies of a population (Rector et al. 2013). Biodiversity refers to biological variation on various organisational levels, including genetics and species populations. Research has shown these concepts are demanding to understand, teach, and learn (for an overview see Smith 2010b). Additionally, for some teachers and pupils and in some religious contexts, evolution is perceived as a controversial topic (Smith 2010a). All these aspects present teachers and learners with certain challenges, as the empirical examples presented here will show.

Some of the documented difficulties in the area of biological evolution are connected to the many biological organisational levels that concepts in this area involve. Biology teachers have to develop strategies for how to move between referring to an individual organism and explanations on the level of the population of species in their communications with pupils. The introduction of the genetic level is critical, for it allows the teacher to differentiate between the different levels of biological organisation. The analysis in this essay identifies the precise moment when the genetic level is introduced for the first time in a teaching sequence about evolution. This moment occurs when one pupil asks a question during a whole-class discussion, and it is possible to study the details of the teacher's response both on the spot and in the following lesson. This essay therefore describes a significant turning point in the investigated lesson sequence.

The essay explores communication in a classroom where pupils take an active role in the teaching and learning. This context is perhaps not the most common for discussions about classrooms as arenas for communication. In past research, teachers' ways of asking questions have traditionally been an object of study (Mehan 1979; Sinclair & Coulthard 1975). However, these ways of asking questions are also distinct patterns, which from a methodological perspective it is feasible for research to focus on—these patterns may be easily observed in recordings of short episodes of classroom communication. The results from that research tradition illuminate

the dominant position of teachers in the classroom, as well as pupils' restricted opportunities to contribute and talk, which has implications both for teaching practice and for teacher education and professional development.

An issue that is less investigated is how talk in the classroom develops and how communicative patterns are constructed over several lessons. This is true for the didactic tradition in science education (see Duschl et al. 2011) but also for research about classroom communication. How do science teachers and pupils attain those moments of mutual understanding? How is topic progression achieved? How do teachers ensure continuity in the classroom communication with only one or two lessons per week for a given group of pupils? To answer such questions, research approaches need to be developed that capture and analyse what happens both in short episodes and over longer periods of time in the classroom.

The reported case study demonstrates an approach based on open, incomplete, and unfinalised units of analysis (Matusov 2007). This means studying moments and patterns of communication in one classroom is an analysis of a combination of short episodes, classroom activities, individual lessons, and the full sequence of lessons in a curricular unit. The aim here is to describe one research approach and to use it to investigate how subject-matter progression is achieved in one particular classroom. Although the approach is developed in the context of teaching biological evolution, it can be applied to the study of other curricular topics too.

### Knowledge of classroom interaction and its consequences for research methodology

Starting from a broad perspective, teaching and learning activities can be understood on several timescales (Lemke 2000 & 2001). This recognises that whatever the research focuses—parts of lessons, lessons, school days, curricular units, semesters, academic years—the teaching and learning activities take place in various spaces inside the walls of the classroom, with each space contributing to the communicated meaning (Hipkiss, in this volume). Inside the

classroom, teacher and pupils participate on different terms, and by using different strategies the teacher acts as a coordinator of the communication (Cazden 2001).

Among the strategies used by teachers is IRE dialogue—teacher Initiation, pupil Response, teacher Evaluation—or follow-up (Mehan 1979; Sinclair & Coulthard 1975; Wells & Arauz 2006). In the teaching of the science subjects, IRE dialogue is prevalent (Lemke 1990; Mortimer & Scott 2003), and science teachers seem to have particular difficulties in establishing alternative patterns of communication (Scott et al. 2006). From a research perspective, the frequent use of IRE dialogue in the classroom raises questions about alternative interpretations (see, for example, Lee 2007), as well as the possibility of communicative patterns over other timescales—patterns over several lessons may still exist even if they are difficult to detect, after all. This suggests that focusing too much on IRE patterns might be misleading, and that the functions of IRE dialogue in the classroom might not yet be fully understood.

For the researcher, a range of possibilities exists for investigating how the communication in the classroom proceeds. This includes examining the structure and chronology of the teaching (for example, lessons), and delimitations and sequentialities constructed by the participants (certain activities or projects). Take the example of Ball and Wells (2009), who focus on one teacher's annual project with pupils in Year 4, building vehicles. They conclude that the absence of follow-up moves by the teacher increased over the years, as well as the proportion of 'unsolicited "offers" of information' by the pupils (2009, 378). A second example is Engle (2006) who investigates the framing of time in a four-month-long unit in Year 5, with 34 sessions (1.5 hours each) about endangered species, a study which illuminates how one teacher's frequent use of references to previous and future sessions frames the unit as part of various open, on-going activities and the pupils' participation in these activities. A third possibility is exemplified by Aguiar et al. (2010), who investigate pupils' 'wonderment questions' during lesson sequences about thermal physics and energy transformation in Year 7. That study shows how the character of pupils' questions requires the teacher to adopt different strategies,

which has an impact on how the teaching develops. These three studies share an interest in various timescales for classroom teaching and learning, although they identify separate units of analysis as being relevant to their particular object of study, to wit changing patterns of communication in an annual project, interactional framing of classroom activities lasting four months, and developing patterns of classroom communication over a sequence of lessons.

Mercer (2008) writes of a lack of methodological guidance for studying the development of talk in the classroom. He claims that the temporal context of classroom talk includes historical and dynamic aspects, mostly related to the institutional and cultural context, but also to the individual speakers' historical and future relations, leaving it contingent on the emerging conversation (Mercer 2008, 44). For research, the methodological challenge is capturing how knowledge resources become jointly constructed in the communication—the idea of a dialogic trajectory. One conclusion of Mercer's is that there is a need to conceptualise how different levels of human activity are linked.

Ludvigsen et al. (2010) discuss the concept of time and its analytical potential in understanding learning by looking at intersecting trajectories of participation. In order to better understand the use of, for example, books and computers, Ludvigsen et al. find it useful to establish how the timescales of longer processes have an influence on much shorter timescales. The suggestion is a combination of perspectives: a vertical in-depth analysis of moment-to-moment interactions and longitudinal timescales using a horizontal perspective.

In addition to the dimension of time that describes the continuous flow of events, Molenaar (2014) suggests the relative arrangement of multiple events as another dimension of time. She stresses that the interval varies according to the phenomena under study, and therefore that artificial divisions into units of time have large implications for research results. As an alternative to defining units of analysis, a methodology based on open, incomplete, and unfinished units of analysis has been suggested (Matusov 2007). This could potentially be used to capture, identify, and distinguish details of phenomena such as those Molenaar (2014) refers to as

reoccurring patterns of interaction (for example, cyclic working processes), non-reoccurring patterns (learning how to read), or irregular interaction changes (building collaborations from chaotic interaction). Topical progression can be understood as an established pattern of classroom communication, and therefore in this essay a more open and undefined unit of analysis is thought better suited to the study.

### Moments and patterns in eleven lessons about evolution

By looking at one research approach to a unit about evolution in biology in Year 9, it is possible to gauge how subject-matter progression is achieved in this particular classroom. An early decision in the project was to focus on the teaching of a curricular unit about evolution. This made it possible to start with unfinalised units of analysis (Matusov 2007) and to study various phenomena that appeared within the delimitation of the sequence of lessons.

The teacher who volunteered for the project, who was well known to the group of 23 pupils, planned the eleven lessons independently from the research team. The pupils were 15 years old and in their final term of Swedish compulsory school. It was decided that the teacher's and pupils' informed consent to participate should be combined with information for the pupils' legal guardians, and that those pupils who chose not to participate would be placed out of shot when filming the classroom. When reporting results, the names of individual pupils and teachers were anonymised and pictures from the data were processed to protect the privacy of the informants.

The eleven lessons were 50 minutes long and distributed over a period of four weeks. Four video cameras were used to capture the detail of what happened during the lessons: one was focused on the teacher, two on two pupil groups, and one provided an overview of the classroom. The video cameras gave multiple perspectives on what was going on in the classroom and were a highly valuable resource. Everything the teacher said was recorded using a wireless microphone, and the recording transcribed. The talk in two pupil

groups was transcribed in part, primarily when the pupils were working on particular tasks. In total, 38 hours of video recordings were collected.

The theoretical framing in dialogical theories of communication (Linell 2009) provided analytical tools and perspectives on classroom communication. Dialogical theories include a number of theoretical and epistemological assumptions about the human mind and human action, in which relations and dynamics are fundamental: 'But dynamics in situations and traditions—contextedness on different timescales—is assumed to be an essential property of human activities, rather than just products of irrelevant variations' (Linell 2009, 432). This implies a perspective that views human activity as constantly changing and constituted by reflexivity. One consequence of using this framework in research is the nature of the presented results. Research, for example, may establish and represent how participants construct relations between space and time, such as between previous activities and on-going activities in the classroom. When applied to the study of classrooms, this means viewing teaching as being primarily a communicative activity, which allows the multiple timescales of teaching and learning to be taken into consideration. The respective positions and contributions of teachers and pupils are studied as equally legitimate communicative projects (189–90). Three theoretical principles guided the current analysis: the principles of joint construction, sequentiality, and act–activity interdependence (187). The principle of joint construction states that meaning is jointly constructed in the interaction between participants; the principle of sequentiality implies that every utterance is understood by establishing the position of this utterance in the sequence of actions. In the analysis, this is taken into account by identifying responsive and projective properties of the particular utterance, for example how it is in part a response to a previous contribution and at the same time points towards a particular response. The principle of act–activity interdependence implies that a particular conversation is understood as the realisation of a communicative activity distributed over larger timescales.

The video recordings were watched several times, and evolving

topics, on-going activities, and specific discussions were documented. By combining different units of analysis, three separate studies were developed. The first involved mapping the activities and ways of participation offered to pupils in the classroom. The second study involved identifying instances where the meaning of frequently used specific words and themes were jointly constructed, and assembling them into collections to be analysed for possible patterns in specific situations. The third study involved investigating how the teacher and pupils in their communication linked the eleven lessons together into a curricular unit about evolution.

Three episodes are used here to illustrate the approach as a whole. Taken from lessons 5 and 6, they shed light on some of the processes involved when a genetic explanation is introduced in the sequence of lessons about biological evolution. The episodes represent reoccurring and non-reoccurring patterns or irregular interaction changes (Molenaar 2014), in relation to the progression of topics in the classroom communication as a whole. The three episodes took place in the same classroom, which was equipped with a fume cupboard and sinks, tables arranged for groups of pupils, a teacher's desk, and a whiteboard on one of the walls. Episode 1 is whole-class teaching, and episodes 2 and 3 are from interaction in small-group activities. The three episodes are presented chronologically.

### *Episode 1 (Lesson 5)*

The teacher stands in front of the class, making notes on the whiteboard about adaptation in relation to three explanatory models of the evolution of life on Earth: creationism, Lamarckism, and Darwinism. A central topic is the survival and extinction of species.

Lesson 5 [18.00–18.51]

Teacher: But Darwinism says that there isn't so much that can be done [about it]—some are adapted from the start, and they made it.

Pupil: But that's what I find so tricky, when you say it like that, because then it ends up as if it is the same thing as crea...creationism.

Teacher: As creationism.

Pupil: But if we say it like this, yes, some are—some are like this from the start—then it's a mixture.

Teacher: Yes, yes, and I get it, I get it [pupil]. We will talk about that pretty soon—about mutations and the variation of traits, because it is clear that from the start maybe we don't have such large variations of traits... But then we have to start talking about the first life on earth, and the first life on earth is not one little single-celled organism, but it is in many places at the same time. But I understand that it [that way of expressing things] fools you into thinking that everything was decided from the start.

One pupil objects to the teacher's statement in response to what the teacher has just said: 'some are adapted from the start, and they made it'. The pupil says 'that's what I find so tricky, when you say it like that', indicating that similar expressions have been heard on other occasions. Although the pupil's utterance does not take the form of a question, it requires the teacher to explain further. The pupil then repeats 'some are like this from the start' and points to how this makes it hard to differentiate between the three models written on the board. The teacher agrees that the message is unclear saying: 'yes, yes, and I get it, I get it'. The repeated phrase is a strong confirmation that the objection is reasonable at this point. The teacher actually suggests that the current lesson will clarify the perceived difficulty by introducing a genetic explanation.

The topic for discussion—survival and extinction of species—is addressed in four of the eleven lessons. In the final lesson, it is the teacher who brings it up, asking why certain bacteria survive—a question that requires pupils to combine several concepts to provide an explanation (reproduction rate, survival rate, population of species, mutations, and hereditary traits). Following this topical trajectory, Episode 1 marks a point where the discussion about causes for species' survival and extinction for the first time is transposed across biological organisational levels, from the population of a species to the genetic level of hereditary traits. The conversation indicates that the teacher and the pupil have a common goal: to talk about how the three models explain the survival and extinction of

species and identify the key differences between them. Analytically, a shared communicative project is established among several of the pupils, if not all (see Episode 2), and distributed over the lessons in this unit. Even though the teacher had already planned to introduce the genetic level, it is the objection made by the pupil that provides the teacher with an opportunity to explicitly introduce the genetic level to the class. The conversation represents a moment of mutual understanding and becomes a resource or common point of reference in the subsequent classroom communication. The analysis shows that the contribution made by the pupil in Episode 1 has a significant role for how the topic of survival and extinction of species develops over the lessons in this classroom.

### *Episode 2 (Lesson 6)*

A small-group activity is initiated. The teacher writes a question on the whiteboard: Will a mutation in a muscle cell be transferred to any children? There is a short pause and then one of three pupils sitting in a row by one table addresses the question. One after another, the pupils claim not to know the answer. After a few exchanges, one of the pupils turns to look at the screen of a laptop placed on the table; the other two pupils remain quiet. For ten seconds all three pupils are silent and the teacher approaches them.

Lesson 6 [20.16–20.36]

Teacher: What do you think?

Pupil 1: I have no idea

Pupil 2: Something has to be transferred

Teacher: Then you have to return to sex education: why? What is needed? Use your knowledge: what is necessary for a new individual?

The teacher, in approaching the silent group and asking what they think, is in response to the question written on the board, and to the apparent silence of the members of the group. It encourages the pupils to respond and elaborate on their thinking, while not necessarily requiring a correct answer. The first pupil repeats the

claim not to know the answer and the second pupil contributes a conclusion that something ought to be transferred to the children. The word 'transferred', which is part of the question on the board, is repeated, and by using the word 'something' this pupil indirectly requests a clarification from the teacher. Then the teacher suggests that knowledge about sex education may be useful and asks several quick questions about how traits are transferred between generations. In the initial conversation between the pupils in the group, they demonstrate not-knowing positions: one by one, they claim not to know the answer. What the teacher does when approaching the group is to show that knowledge resources are available. The teacher thereby indicates that their not-knowing position may be an orientation, and possibly a consequence of a reluctance to work with the task.

Analysing pupil participation over the eleven lessons gives an insight into how activity roles are distributed on a larger timescale. This shows that the not-knowing position is a pattern of interaction that recurs in the classroom, together with a contrasting pattern where pupils take a knowing position. The ten seconds of silence in Episode 2 is part of the wider pattern. The two positions—knowing and not-knowing—have an impact on the communication and the different opportunities for learning that pupils are provided with by participating in the communication. Analytically, Episode 2 indicates that at this stage this group of pupils does not share the communicative project initiated by the teacher: to give an answer to the key question about genetic inheritance written on the whiteboard. The not-knowing position is problematic for the progression of the teaching, and requires the teacher to develop communicative strategies. In this particular classroom, the teacher organises small-group activities, which enables her to leave her position at the front of the classroom, approaching and giving support to groups of pupils.

In the attempt to understand how topical progression is achieved in the classroom, the teachers' query constructions before the small-group activities are analysed with regard to what kind of answers they are looking for. This shows that in lessons 1, 5 and 8, the teacher asks 'What is your view on why—' or either/or questions. In lessons

6, 7 and 11, the increasing complexity is represented by questions such as 'How will it be affected by—?' and 'What happens if—?' In Lesson 11, questions such as 'Why do we get—?' and 'Why do some—?' are used by the teacher. These last questions are found to be requests for causal explanations of sequences of events. This illuminates how the small-group activities manifest an increasing complexity over the course of the sequence of lessons with a more specialised vocabulary expected from pupils in the later part of the sequence. Analytically, the teacher's query constructions provide a distributed perspective on the principle of sequentiality. The questions and small-group activities indicate the teacher's strategy for achieving topical progression in the unit. She co-ordinates her teaching by listening and talking to the pupils. When talking with groups of pupils, the teacher identifies and responds to pupils' difficulties either during the small-group activity or in one of the upcoming lessons. Compared to Episode 1, Episode 2 does not easily transform into a moment of mutual understanding, although the pupils' responses provide the teacher with important information.

### *Episode 3 (Lesson 6)*

The teacher leans with both arms on a table where three pupils are sitting. The pupils are working with questions from a textbook. The page is open at a couple of pictures, and one question asks whether the particular traits shown will be inherited by any offspring.

Lesson 6 [42.31–42.51]

Pupil: The white moose.

Teacher: Will it have white offspring, okay, why?

Pupil: Greatest chance.

Teacher: Why?

Pupil: Cause.

Teacher: Can you explain why?

Pupil: Cause it's not become white during its life, it has not been painted or anything.

Teacher: If you in fact had that trait.

Pupil: [nods]

Teacher: In one's cells, is that what you are saying [pupil]?

Pupil: [nods]

Episode 3 illustrates a well-known question–answer, teacher–pupil type of dialogue, in which the teacher asks the pupil to explain something. The teacher is not satisfied with the short answer first given by the pupil, and asks three why questions in short order. Then the pupil makes a contribution that the teacher accepts: in this case the pupil suggests some causes for white fur colour and rejects the possibility of them being heritable traits. Analytically, the well-known feedback pattern (IRE) facilitates a common content orientation in the communication, a prerequisite for establishing shared communicative projects. The pupil's response shows an understanding of what might count as an acceptable response to the teacher's question and provides the teacher with important information. This can be seen in the way the teacher immediately uses the response and develops an explanation for the contrasting case: white fur colour as a heritable trait. Explanations for natural phenomena have a central position in the sciences, and in this classroom pupils develop their skills in providing explanations for various phenomena. The question–answer dialogue creates a moment of mutual understanding about how to explain physical attributes by distinguishing between acquired and genetic traits.

Lesson 6 marks the half-way point in the unit. In the next lesson (Lesson 7), the teacher leads a whole-class review of the main study question. Seen from this sequential perspective, the pupil in Episode 3 contributes information that is useful to the teacher in the planning of the next lesson.

### *Summary*

The three episodes illustrate aspects identified as significant in relation to the achieved topical progression. They provide an insight into some of the processes involved when the genetic level is introduced when teaching biological evolution in this particular classroom.

Episode 1 is from whole-class teaching and is an example of one pupil's objection about details in the teacher's way of expressing herself. This is not a criticism, but a contribution to the construction of mutual understanding about the survival and extinction of species in the evolution of life. Episode 3 is from a small-group activity, and exemplifies a question–answer dialogue in which the teacher is provided with information about how the pupil distinguishes acquired from genetic traits. The two episodes capture communicative strategies used by the teacher for handling some of the demanding aspects of this topic discussed in the literature (Smith 2010b): the multiple biological organisational levels involved and the long-term perspectives. Episode 2 is also from a small-group activity, and is an example of how activity roles are distributed in the classroom and how the teacher handles the challenge of teaching pupils who take a not-knowing position. There are many possible reasons as to why they take this position, for example talking about sexual reproduction in this context possibly evokes reluctance among some pupils. By including several timescales in the analysis, the understanding of what goes on in the three episodes is expanded to include the relation between individual conversations and the topical progression achieved over the sequence of lessons.

### Multiple timescales in a science of teaching

The previous section describes one research approach for investigating how pupils' contributions to the classroom communication influence the topical progression achieved in a curricular unit. The investigation shows some patterns of communication over the sequence of lessons, and some communicative strategies in short episodes of a conversation. In this classroom, the combination of the progression in query constructions and providing many chances for pupils to participate and have discussions in small groups, creates a classroom organisation with rich opportunities for the teacher to interact and catch up with individuals and groups of pupils. The small-group situations have at least two things in common. Firstly, the contexts in which pupils are asked to explain and reason about

a problem strategically chosen in relation to the topic of biological evolution. Secondly, these discussions are characterised by their informality. This is shown in the teacher's and pupils' posture, tone of voice, and interactions, as for example in Episode 3 when the teacher is leaning on the pupils' table in a relaxed position.

For the whole class, Episode 1 shows how the contribution of one pupil drives communication forward and enables the teacher to move the topic of conversation from addressing adaptation at the level of individual organisms to include the genetic level and explanations at the level of the population of species. This occasion marks the end of a longer discussion in Lesson 5, where pupils' difficulties in previous lessons are openly addressed. Looking at the sequence as a whole, it seems this particular discussion represents an irregular interaction change (Molenaar 2014)—a kind of turning point—in the sequence of lessons. In this way, the combination of several units of analysis provides insight into communicative strategies used in the achieved topical progression, with lessons 5 and 6 representing a phase of transposing the topic from the level of individual organisms to the genetic level. The essay shows how the achieved topical progression includes regular changes in terms of reoccurring and non-reoccurring patterns, as well as irregular changes in the classroom. These findings contribute to our understanding, not only about the teaching and learning of evolution, but also of how patterns of classroom communication are constructed over several lessons.

The didactical consequences from this study concern how, as a teacher, to take notice of the short conversations with pupils and their possible contribution to the whole of the teaching. The many scientific concepts included in the science subjects demands a continuous evaluation and exploration by science teachers of the ways these are addressed in classroom communication. For the professional teacher, this is part of their everyday work. Paying close attention to the pupils and their difficulties, and using their contributions to develop the future teaching, are skills a teacher develops. This does not mean that there are simple strategies for how to do this. What this essay attempts to show is teaching as a complex communicative activity. In the preparation for this activity, the teacher mobilizes

knowledge about the content, knowledge about pupils' learning about the content in general, and knowledge about the particular group of pupils. By paying close attention to the communication in the classroom during teaching, the teacher may recognise potentials for change and consider how to develop the teaching on different timescales. The research presented here does not attempt to prescribe particular teaching practices, but illuminates details and gives an overview of some communicative strategies that are found in this example of the teaching of biological evolution. The essay provides an opportunity for individual and collegial reflections by teachers, in the firm conviction that the development and evaluation of best teaching practices is primarily a task for the teaching profession.

This essay includes a methodological discussion of the approaches to timescales in research, and illustrates a possible research approach to empirical material that touches on the many timescales of classroom interaction. It has previously been indicated that multiple-scale video analysis has the potential to significantly contribute to the understanding of how content is taught and learnt (Klette 2007), and this essay constitutes one such example. In order to better understand the continuous flow of events characterising classroom teaching and learning activities (Lemke 2000; Ludvigsen et al. 2010; Mercer 2008; Molenaar 2014) new research approaches are called for.

This volume offers a spectrum of research approaches, and the present essay embraces an empirical and analytical perspective on didactics. It indicates the need for a coherent science of teaching based on empirical and analytical studies, a science of teaching that does not necessarily impose answers to the questions of how (as well as why, to whom, when, and where) teaching ought to be conducted. In relation to the didactical triangle, this essay does not explore the relations between teacher, content, and pupil. For the lesson sequence studied, the interaction in the classroom can be described in terms of movement in all directions within an area inside the didactical triangle. The focus in this essay is, however, not primarily on the teacher, nor the pupil, nor the content itself, neither is it on one of the relations represented by the sides of the triangle. What the three episodes are supposed to illustrate to the reader are situations in

which all three relations are significant for the continuation of the sequence of lessons. One way of illustrating this could perhaps be to add a dimension to the triangle, turning the triangle into a prism with an apex representing time. This would add a fourth dimension to the classic didactical triad: the potential for change.

## Note

- 1 For further details of the project, see Rocksén 2015. The data used for illustration has previously been published elsewhere, where details about methods and analytical procedures can be found (Rocksén 2016 & 2017; Rocksén & Olander 2017). The writing of this essay was financially supported by the Swedish Research Council (dnr 349–2006–146) through the Linnaeus Centre for Research on Learning, Interaction and Mediated Communication in Contemporary Society.

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