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# Modes and meaning in the classroom – The role of different semiotic resources to convey meaning in science classrooms

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ABSTRACT

This study is framed within social semiotic perspectives on multimodality, and it has a twofold aim. The primary aim is to analyze the ways in which teachers draw on different semiotic resources when introducing a new scientific concept in secondary school science classrooms, and to link the results to modal affordance. A secondary aim is to try out parallel analyses of different modes in multimodal meaning making using the ideational meta-function of the SFL framework. Analyses are based on instructional episodes when chemistry teachers introduced the atom as a scientific phenomenon. The main focus of the analyses is on processes used in different modes and how these depict the atom as either static or dynamic. The framework proved fruitful, and analyses revealed important patterns as to what aspects of the atom were given through what mode(s), something which could partly be linked to modal affordance. The results are discussed in relation to its implications for research and education.



## 1. Introduction

Over the last decades, the role of language in meaning making has been emphasized by numerous scholars (Halliday & Martin, 1993; Lemke, 1990; Norris & Phillips, 2003; Schleppegrell, 2004; Shanahan & Shanahan, 2008; Wellington & Osborne, 2001). However, multimodality is ubiquitous in all communication, and a specialized use of modes for representation (e.g. writing, speech, gesture, and image) is central in every content area (e.g. Danielsson & Selander, 2014, 2016; Kress et al., 2005; Kress, Jewitt, Ogborn, & Tsatsarelis, 2001).

In this article, *mode* is defined as a meaning-making resource system which is shaped and developed over time in a community. Examples of modes are speech, writing, gesture, and image. *Multimodality* deals with representations or communicative events involving more than one mode, for instance a drawing consisting of both image and writing, or spoken words combined with gestures (see, Jewitt, 2009a, for definitions and further discussions of these concepts). Meaning making in science classrooms, which is the focus of the present study, has repeatedly been described as highly multimodal, involving action, speech, writing, subject specific symbols, graphs, and diagrams, et cetera (e.g. Axelsson & Danielsson, 2012; Jakobson et al., forthcoming; Kress et al., 2001; Lemke, 1998; Simpson & Walsh, 2010; Tang, Tan, & Yeo, 2011).

Lemke's (1998) case study, focusing on one student in secondary school during a single day in physics and chemistry classrooms is elucidating as to the complex demands for students to "juggle" between and integrate, for instance, verbal, chemical-symbolic, and visual–graphical symbolic systems for different aspects of scientific content. Yet, Lemke claims that the same information needs to be accessible through as many types of media or channels as possible, not only since exactly the same content cannot be expressed through any mode, but also since there needs to be a level of redundancy in the learning situation. Another example is the study by Tang and colleagues (Tang et al., 2011), where ninth-grade physics students were followed during a teaching and learning cycle on the concept of work-energy. Here students' understanding of multiple representations in different modes was focused. The students had difficulties in constructing a scientific understanding of the content, something which was discussed in regard to differences in the categorical, quantitative, and spatial meanings of the representations. The findings in both these studies gave rise to reflections about the importance of meta-discussions in classrooms as to *how* content is expressed.

Since each representation of a concept (in the form of a gesture, an image, words, etc.) has its specific potential for meaning making (see *affordance*, below), certain aspects will be toned down while others will be emphasized depending on the representation used. Thus, to be able to "juggle" with representations, or to make meaning from the teacher's juggling, is a demanding task for the novice, who is about to learn something new.

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Regarding the role of multiple representations in knowledge building in science, Tang and colleagues (Tang, Delgado, & Moje, 2014) have noted two main foci. Firstly, research on *multiple representations* concerning how multiple representations of scientific concepts in classroom practices affect students' understanding; secondly, research on *multimodality* dealing with students' understanding of scientific concepts through the simultaneous use of various modes within and across representations. The present study can be seen as yet another alternative, through its focus on the ways in which various semiotic resources used for describing a specific scientific concept convey different meanings of the particular concept; in this case, the extent to which one curricular entity in the science classroom, namely the atom, is represented as dynamic or static in teacher introductions of the concept.

A key notion for the study is that of *affordance* (Gibson, 1977; van Leeuwen, 2005; Kress, 2010), here defined as the 'meaning potential' (van Leeuwen, 2005) or 'potentials and limitations' of modes (e.g. Kress, 2010:84). This notion relates to the fact that different modes, as they are realized in social contexts, are governed by different logics. Examples are speech, which is governed by the logic of time (speech sounds happen across time) and image, which is governed by the logic of space, with still images also being governed by the logic of simultaneity, and moving images by the logic of time. This is one reason why speech is regarded as especially apt for describing temporal aspects, or issues of cause and effect. Images, on the other hand, are considered to be more apt for spatial properties, such as size and relative position between parts and wholes.

Also, aspects such as valued modes (see Jewitt, 2009b or Kress, 2009 for discussions) need to be taken into consideration. In schools, writing has long been valued, and the mode which students normally are supposed to use when their learning is assessed, that is, for their learning to be recognized (Kress, 2010; Kress & Selander, 2012). The present study uses data from a larger project (see Data, below). One finding in that project was that teachers' multimodal board notes appeared to be highly valued in the classroom practices. What was written in the students' notebooks was considered decidedly important for passing the final written assessment of the course, and with few exceptions these notes were direct transformations of the teachers' board-notes. Thus, information given through other resources, such as speech or gestures, was generally disregarded (Danielsson, 2011a).

The primary aim of the present study is to reveal patterns in chemistry classrooms regarding what aspects of a specific scientific phenomenon (in this case, the atom) is given through what mode, or combinations of modes in *multimodal ensembles* (e.g. Jewitt, 2009b; Kress et al., 2001), and to link these results to the notion of affordance. The main focus is whether the atom is depicted as static or dynamic through the different modes. A secondary aim is to contribute with methodological insights regarding multimodal analyses, by using the ideational meta-function in *systemic functional grammar* (Halliday & Matthiessen, 2004) for parallel analyses of different modes (see below). With this twofold perspective, the present study can contribute with theoretical and analytical insights as well as knowledge with relevance for classroom practices.

To accommodate for these aims, the study is theoretically and methodologically framed within *social semiotics* (Halliday, 1978), and specifically on multimodality (van Leeuwen, 2005; Jewitt, 2009a; Kress, 2010). A key notion in social semiotics is that semiotic choice both reflects and shapes content. Furthermore, choice of semiotic resource or mode for representation is seen as a result of social, cultural and situational factors in the context in which the communication takes place, including participants and available modes and resources. Hence, from such perspectives, learning something new is intrinsically interwoven with ways of expressing that knowledge through different semiotic choices.

Studies within social semiotics are connected to Halliday's *systemic functional grammar* (SFG) (Halliday & Matthiessen, 2004), the theoretical foundation of *systemic functional linguistics* (SFL); the latter term is often used for applications of the SFG system on communication in different modes, such as speech, writing, images, and gestures.

Social-semiotic theory rests on three meta-functions: the *ideational* (representing meanings about actions, states and events in the world), the *interpersonal* (representing meanings about the social relations of those engaged in the communication) and the *textual* meta-function (representing the communicative channel and textual organization). These meta-functions reflect different aspects of meaning making (see Halliday & Matthiessen, 2004, for a thorough presentation of the framework). The analyses in the present study are done in relation to the *ideational* meta-function (sometimes also referred to as *experiential* meaning), that is, the field of communication, or what content is in focus in the communicative situation.

A foundation of the ideational meta-function is the *transitivity system* in SFG (see Halliday & Matthiessen, 2004:302, for a model). Transitivity analyses involve three major features in a clause, namely the type of *process* (i.e. that something *happens, is said, is* or *is perceived*: 'the electrons *move* in a high speed'), what *participants* are involved in the process (i.e. *who*/*what* does/is/says/owns *what*, etc.: '*the electrons* move in a high speed'), and the *circumstances* around the process (*where*, *how*, *when*, etc., the participant did/thought/said: 'the electrons move *in a high speed*').

This article focuses on process types in the various resources for meaning making that teachers use when introducing the atom as a phenomenon (see Section 4). Previously, ideational analyses connected to different disciplines have mainly been performed on writing (e.g. Halliday & Martin, 1993; Schleppegrell, 2004). When the SFL framework has been used for other modes, such as images (Kress & van Leeuwen, 2006; Martin & Rose, 2008), other aspects of the ideational meta-function have been highlighted. In their ideational analysis of images in scientific texts, Martin and Rose focus on aspects such as whether the scientific phenomenon is an entity or an activity or if the categories are explicit or implicit. Even though Martin and Rose (just like Unsworth, e.g. 2001) discuss relations between image and writing, the type of detailed analyses to compare modes which is performed in the present study, are scarce. Here Martinec's (2004) model for gesture analyses, is interesting from a methodological point of view. In his data, Martinec analyzed both gestures and linguistic choice with respect to experiential meaning (the *ideational* meta-function), and found that process types were often the same in both modes. The fact that Martinec analyzed gestures and verbal language as equivalent is relevant for the present study. However, in the present study, a number of modes (speech, writing, images, gestures, etc.), at times appearing in multimodal ensembles, are analyzed through the same framework, not only speech and gesture (cf. Martinec, 2004), or writing in connection to images (cf. Martin & Rose, 2008; Unsworth, 2001).

### 1.1. The atomic model

Since the atomic model is in focus for they study, some comments on the nature of the atom need to be given for the sake of clarity for readers who might not be familiar with this subject content.

At the beginning of the 20th century, Niels Bohr presented his model of the atom, a model which is widely used even today, not the least in schools. A typical image of the model is the third from