CHAPTER 13
TECHNOLOGY AND LEARNING: A MULTIMODAL APPROACH

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Introduction

The contemporary communicational landscape is increasingly theorised as global, fluid and networked (Bauman 1998; Castells 2001). A key aspect of this landscape is how forms of representation and communication feature in it, particularly the role of non-linguistic forms, and the repositioning of talk and writing.

The characteristics of new technologies contribute to the shape of contemporary communication. These includes the range of representational and communicational forms that new technologies make available (e.g. image, colour, movement, music, hyper-links, speech and writing), the new configurations of these modal forms that technology makes possible, and the new opportunities for interaction they afford. These new potentials mark what can broadly be described as a shift from print as the primary medium of dissemination towards digital media (Kress 2003). Alongside this the relationship between image and writing in educational materials (e.g. textbooks, websites and so on) appears to be changing (Jewitt 2006; Bezemer and Kress 2008). Images feature more in contemporary materials than in the recent past, and images often dominant the displays of learning resources whether these are print or digital based materials. On screen it is the case that writing is increasingly exchanged for, or brought into new relationships with, visual and other non-linguistic forms of representation on screen (Bachmair 2006). Perhaps more importantly the quality of images and their function in the representation and communication of knowledge is changing (Jewitt 2002). Images are no longer illustrative of writing on the page or screen, rather a phenomenon may now be introduced visually and new relationships between image and action, sound and speech provide new multimodal ensembles with explanatory power. In addition, digital technologies enable new relationships between production and dissemination in ways that have the potential to remake the conditions and functions of authorship and audience. Alongside these changes disciplinary boundaries and expertise have (and continue to) become increasingly blurred, reformulated or collapsed (Bauman 1998; Beck 1992).

The focus of this chapter is on how this digital multimodal landscape (that is the combination of the variety of modes in use, image, sound, animated movement and so on) affect what it means to be literate and to learn, as well as communication in the classroom more generally speaking. Against this backdrop, a fundamental question is raised for learning in the digital multimodal landscape of the classroom, that is, 'What real difference can the use of new technologies make?'. Taking a multimodal approach this chapter argues that in order to answer this question a better understanding is needed of the representational resources made available by new technologies on the one hand, and curriculum knowledge and learning on the other. With this focus in mind, the chapter addresses two questions. First, how does the use of new technologies contribute to the reshaping of curriculum knowledge? Second,

what does a change in the resources available to students mean for learning, in particular how does it reshape classroom practices that might lead to learning.

This chapter is organised into three main sections. The first section introduces the theoretical assumptions and background to multimodality. It sets out the key concepts that inform this perspective and the argument for looking beyond language. This is followed by a discussion of how the multimodal resources of new technologies reshape curriculum knowledge in Section Two. This section argues that the modal form of representation and curriculum knowledge are intimately connected and that technology is significant in shaping knowledge. Specifically it examines how knowledge is shaped through the range of modes and resources a technology makes available including animated movement and hypertext; the relationships established between these modes in new kinds of multimodal ensembles, for example, the forms of layering, connection and disconnection enabled; the capacity of new sites of display and technologies to support new forms of interaction; and the ways in which technologies can collapse and remake boundaries between space and time, for instance reconfiguring the relationship between home and school. Section Three explores what this reshaping can mean for practices that lead to learning and asks how notions of reading can be transformed by students' engagement with multimodal digital resources. The chapter concludes by drawing together key themes that have emerged across these sections and makes the case for taking a multimodal approach to understanding technology-mediated learning in the twenty-first century.

A multimodal approach

A multimodal perspective attends to all modes that are in use in a communicational event, and assumes that meanings are made (as well as distributed, interpreted and remade) through many representational and communicational resources. The classroom has always been multimodal, but new technologies are changing the range and use of modes. Despite the multimodal character of the classroom, however, language is still widely taken to be the dominant mode of communication, particularly in contexts of learning and teaching. Multimodality challenges this habitual conjunction of language and learning with the theoretical assumption and empirical evidence that meaning in the classroom is made through many representational and communicational resources not language alone. Multimodal research and pedagogic strategies attend to meaning as it is made through configurations across image, gesture, gaze, body posture, sound, writing, music, speech and so on.

Multimodality is a rather eclectic approach drawing on a range of histories and influences. The starting point for multimodality is linguistic theory in particular it builds on and extends Halliday's social semiotic theory of communication (1978) and later developments of that theory (Hodge and Kress 1988). A linguistic model was seen as adequate to investigate all modes by some academics interested in multimodal research, while others set out to expand and re-evaluate this frame of reference. This has led to the development of multimodal approaches that draw on concepts and ideas from other approaches that look beyond language (e.g. film theory, musicology, game theory). Multimodality has been influenced by cognitive and socio-cultural research, for instance Arnheim's work on visual communication and perception (1969), as well as anthropological and social research, specifically the work of Bateson (1977), Barthes (1993), Foucault (1991), Goffman (1979) and Malinowski (2006). A number of distinct (yet historically interconnected) approaches to multimodality have evolved:

multimodal social semiotics (Kress and van Leeuwen 2001; van Leeuwen 2005), Multimodal actional analysis (Scollon and Scollon 2004; Norris 2004), and Multimodal discourse analysis (O'Halloran 2005).

Strictly speaking multimodality refers to a field of application rather than a theory. A variety of disciplines and theoretical approaches have been applied to explore different aspects of the multimodal landscape. Psychological theories that look beyond language, for example, to investigate how people perceive different modes and their impact on memory (e.g. Scaife and Rogers 1996; Ainsworth 2006). Sociological and anthropological theories focus on the application of the non-verbal to examine how communities use multimodal conventions to negotiate, mark and maintain institutional roles and identities. Although the term multimodality is increasingly used to refer to a variety of perspectives that account for the non-verbal it continues to be most strongly associated with social semiotic theory (e.g. Kress and van Leeuwen 2001) and this is how the term multimodality is used in the language of description provided in this chapter.

Having introduced multimodality and the rationale for looking at all modes in the classroom the chapter now outlines the assumptions and concepts that underpin it. Multimodality makes three theoretical assumptions. Firstly, meaning making is made across a range of *modes*. Secondly, the choice of modes used to represent a curriculum concept has consequences for what is represented (as well as what can be done with the representation) due to the distinct *semiotic resources*, logics and *affordances* each mode makes available. Thirdly, it follows from both these points that all modes are partial, individual modes only realise a part of the meaning potential, and therefore attention needs to be paid to the *multimodal ensemble* and how modes interact as a part of it. The five concepts introduced below, i) semiotic resource, ii) mode, iii) modal affordance, iv) multimodal ensemble, and v) multimodal design are essential to multimodal analysis. Each of these is now discussed below. These concepts can be used to support the analysis and enhance understanding of technology as a mediating tool and how it feature in interaction – discussed later in the chapter.

i) Semiotic resource

The focus of traditional semiotics (e.g. the work of Saussure) is on how people learn the conventions of meaning making and concept of code. It conceives of semiotic systems, e.g. language, as codes, sets of rules for connecting signs and meanings. Once two or more people have mastered the same code it was thought they would be able to connect the same meanings to the same sounds or graphic patterns and hence be able to understand each other. This conception of code suggests a monolithic system cut-off from the social world and does not acknowledge how both context and people's use of signs effect meaning. It is for this reason that social semiotics rejects the concept of code in favour of the more social and contextual concept of semiotic resource with a focus on the processes of meaning making. It is concerned with people's selections from the resources available to them in a particular time and place that most aptly express the meaning they wish to make (Kress 1997). Thus, making the agency of the people making and interpreting signs central to understanding meaning. Through a focus on people design and re-design of modal resources multimodality emphasizes the dynamic character of meaning making towards an idea of change and design. In this way meanings, as well as meaning making resources are

constantly re-configured and newly re-made through the social work of the sign maker.

Research has been conducted to produce descriptive inventories of the semiotic resources and the 'grammar-like' organizing principles that govern modes, as well as the cultural, historical and social references that underpin these. Considerable work has been undertaken on mapping the resources for visual representation and communication, a significant contribution being Kress and van Leeuwen's *Reading Images* (1996). This and other studies provide a systematic and comprehensive account of the way in which people's use of image, space, sound, gesture, gaze, clothes, arrows and layout can communicate meaning (Kress and van Leeuwen 2001; van Leeuwen 1999, 2005; Kress 2003).

As well as focusing on the semiotic resources of individual modes research has been conducted on the ways in which modes interact in a text or communicative event. The work of Kress *et al* (2001, 2005), for instance, maps the inter-semiotic relations between the use of image, movement, gesture, and gaze by students and teachers in the Science and English classroom. This work shows that how modes feature in the classroom is dependant on the communicative practices, histories and demands of curriculum subjects. How students interact with and make sense of multimodal ensembles in the context of technology mediated learning has been the focus of a wide range of research. Hampel and Hauck (2006) have examined online language learning environments to show how the use of different facilities (e.g. video, audio chat, MSN texting) shape learning. Burn and Parker (2003) have used multimodal theory to analyse and teach digital video editing in the media classroom, and others have examined the multimodal global mediascapes of children (Marsh 2005). Jewitt (2002, 2006) has investigated how the configuration of modes in computer applications used by students in the English, Maths and Science classroom is implicated in the practices of reading, interpretation and constructing knowledge as well as the opportunities to perform 'being a learner'. Pelletier's study of young people making computer games (2005) takes a multimodal approach to analyse young people's games with relation to the performitivity of identity. The potential to work across space and time that is offered by new technologies have been examined by Leander and colleagues (2007, 2006) to reveal how activities circulate, connect and disconnect the time and space of the classroom and out of school. In addition the emergence of hyper-text as a mode and its significance for how impact on how children work with meaning on screen has been explored (Zammitt 2007). These studies highlight the role of the medium of a technology in what semiotic resources are made available for the work of representation and communication.

ii) Mode

From a multimodal perspective mode is used to refer to these organized sets of semiotic resources for meaning making which are broadly understood to be the effect of the work of culture and social usage. Multimodal studies of semiotic resources make the point that modes are constantly transformed by their users in response to the communicative needs of society, as a consequence new modes are always being created and existing modes transformed. Therefore, what can be considered a mode is always contingent as the resources for making meaning are fluid rather than static. Over time these resources come to display regularities through the ways in which people use them. It follows therefore that the more a set of resources has been used in

the social life of a particular community the more fully and finely articulated it will have become. Gesture, as a mode has been articulated to form systems of meaning in many different communities to realise particular kinds of functions: semaphore, sign languages for the hearing impaired, conducting music, hand-movements in dance, and so on. Gesture is not a fixed mode, rather the possibilities of gesture are socially shaped by the demands of the communities that use it.

iii) Modal affordance

Modal affordance is a way of thinking about what it is possible to express and represent easily with a mode.[1] Multimodality approaches affordance as a complex concept connected to the material *and* the cultural, social historical use of a mode. On the one hand, how a mode has been used, what it has been repeatedly used to mean and do, and the social conventions that inform its use in context shapes its affordance. Where a mode 'comes from' in its history of cultural work, its provenance and its materiality becomes a part of its affordance. On the other hand, that is not the whole story; the affordance of a mode is also material and physical environment. Image, in the form of graphic marks on a two-dimensional surface offers different potentials for the expression and representation of meaning than those offered by the affordances of speech in the form of sounds over time. Each mode possesses a specific logic and provides different communicational and representational potentials. The sounds of speech for instance happen in time, and this sequence in time shapes what can be done with (speech) sounds. The logic of sequence in time is unavoidable for speech: one sound has to be uttered after another, one word after another, one syntactic and textual element after another. This sequence is an affordance: it produces the possibilities for putting things first or last, or somewhere else in a sequence. The mode of speech can therefore be said to be governed by the logic of time. (Still) images are governed by the logic of space and simultaneity.

In addition, the semiotic resources of a mode come to be shaped through specific histories as do the way people use them. The assertion that all modes are partial, including the linguistic modes of writing and speech, stems from the logic of modes. This introduces the notion of the multimodal ensemble as an important concept.

iv) Multimodal ensemble

The meaning of any message is understood as distributed across all of these modes, although not necessarily evenly (e.g. Kress *et al*. 2001; Kress *et al*. 2005). Given the distinct semiotic resources, materiality and logic of each mode both social and material, it follows that aspects of meaning are carried in different ways by modes. Any one mode in an ensemble is therefore only ever carrying a part of the message only: each mode is partial in relation to the whole of the meaning (and this is also the case for speech and writing).

[1] The term *affordances* originated in the work of Gibson (1977). It was later taken up by Norman in relation to design (1988). For multimodality, affordance is not a matter of perception – as it is for Gibson. Norman's view of affordance considers the material and social aspects of design, in a way that I find more useful. For me, neither Gibson nor Norman's notion of affordances adequately acknowledge the extent to which tools (conceptual and material tools/objects) are shaped by people's use of them in specific social situations.

This interplay takes different forms. At times the meaning realised by two modes can be equivalent, at others they may be complementary. Alternatively each mode may refer to quite different aspects of meaning and be contradictory, caught in a struggle for meaning (Lemke 1998). When the relationship between modes as they are orchestrated in an interaction or text is one of tension between the aspects of meaning, this tension can itself be meaningful. For instance such clashes of meaning across modes in a text can provide a means to encourage reflection and critique or signal a conflict, perhaps between scientific and everyday views of a phenomena or an acceptable and unacceptable discourse. A study of the visual and verbal discourses of masculinity realised in sexual health promotion leaflets targeted at young men is an example of the later (Jewitt 1999). The writing in the leaflets presented a view of men as prepared to take responsibility in their relationships while the images told a completely different story (discourse) of men as irresponsible, sexually predatory, and incompetent.

Multimodality, in this way, foregrounds the question of what to attend to so that what to 'make meaningful' becomes amplified with significance regarding curriculum design and learning.

v) Multimodal design

Multimodality approaches communication as a process in which people make choices from a network of alternatives: selecting one semiotic resource (meaning potential) over another (Halliday 1978). People (as they are socially situated and constrained) make meanings by selecting from, adapting, and remaking, the range of representational and communicational resources available to them in a specific time and place. Flewitt's (2006) multimodal study of preschool classroom interaction demonstrates the strong link between the communicative demands of a context and the modes in use. Flewitt's research draws on data from ethnographic video case studies of young children communicating at home and in a preschool playgroup. By focusing on all modes of communication (talk, gesture, movement, gaze and so on) she is able to scrutinize young children's multifunctional uses of different modalities in meaning making. She shows that a young child's silence in school contrasts with the child's talkative character at home. Through detailed analysis she shows how the multimodal features of home serve to scaffold and enable talk, while those of school strip the child of this modal resource. Flewitt's (2006: 47) 'analysis of children's uses of different semiotic modes as intentional, socially organized activity in the construction of meaning' argues against 'pathologizing the absence of talk'. This work as well as other studies offers a different account of classroom language by locating the analysis of classroom talk in the broader context of children's total multimodal resources within a multimodal ensemble.

The concept of mode, semiotic resource, modal affordance and multimodal ensemble are analytical tools that enable the complexity of multimodal design and meaning making to be broken down, cracked open, and examined. Section Two of this chapter uses these concepts to turn a multimodal lens on technology and how it reconfigures the conditions for the articulation of knowledge in the school classroom. It argues that changes in the mediating tools used in the classroom remediate the interaction between the learner and the object of study (Bolter and Grusin 1998). It is important for learning to understand the specific ways in which different technologies and

applications work as *mediating tools* (Säljö, 1999). Much of the attention given to technology in the classroom has been on what goes on *around* the screen: in particular the different kinds of talk between learners. However, the semiotic resources of technologies effect the potential for new practices of reading, producing and disseminating texts. How a technology contributes to learning obviously depends on how it is used: a technology is not inherently good or bad. Nonetheless, the medium used to distribute a text demands its technical re-coding and is therefore itself part of making meaning. As Kress and van Leeuwen (1996: 233) state:

> Technology enters fundamentally into the semiotic process: through the kinds of meaning which it facilitates or favours, and through the differential access to the means of productions and reception which it provides.

The following section applies the assumptions and concepts outlined here to address the question of how the use of new technologies in the classroom[2] contributes to the curriculum knowledge.

Shapes of curriculum knowledge

Representation has a central role in mediating knowledge, identity, communication and cognition. It follows therefore that decisions made by curriculum resource designers, teachers, and students in the classroom concerning how school knowledge is represented and communicated are significant for learning. The choice of modes, for example, whether to combine image or writing to represent a curriculum concept shapes how it is constructed, what people can know about it and the processes through which they can know themselves in relation to it. Just as discourse analysis of classroom talk shows the significance of how teachers use language, for instance in the school science classroom (see Mortimer and Scott 2003), multimodal research in school science shows the significance of image, action, and artifacts for learning (Kress *et al*. 2001; Lemke 1998; Scott and Jewitt 2003).

Take the example of a lesson on plant cells, the teacher needs to decide whether and when to represent a plant cell through writing, a static image, a three-dimensional plastic model or an animated digital diagram. Will it be represented in colour or black and white? Will the style (orientation) of the image be naturalistic, or a cartoon, or a scientific technical representation? A visual representation requires the shape of elements, their relative size, as well as the spatial relations between them to be represented. It also requires decisions about what elements will be included and excluded from the representation of a cell. If the teacher uses an animation further decisions will need to be made about what aspects of the representation students will be enabled to manipulate and interact with and which will be fixed or automated. Students were involved in many of the above decisions when they were instructed to make three-dimensional models of a plant cell, in a school science classroom observed as part of a research project on multimodal teaching and learning (Kress *et al*. 2001). Students had to decide whether to incorporate movement in their models,

[2] The majority of the multimodal research that I have undertaken has been conducted in the core subject classrooms of Inner London state schools populated by students from low socio-economic families and from diverse religious, ethnic and racial backgrounds. In the main it is these classrooms that I am thinking of when I talk of the classroom.

and if so how and what to make move. Most did not incorporate movement but those that did, chose to make the nucleus move (e.g. using a stone that rolled slowly around the box in a surveying motion). Thus giving the nucleus more potential for salience than the other elements. The choice of the mode made different aspects of the concept of cell available to students in the classroom (Jewitt 2006). A choice which is central to the epistemological shaping of knowledge and ideological design. What can be done and thought with image, writing, or action differs (due to the associated semiotic resources and modal affordance) in ways that are significant for learning. The majority of the time more than one representation will be used in a classroom. The sequence of these and the work of connecting them therefore becomes an important matter for design and learning. In this regard, the longstanding focus on language as the principal, if not sole medium of instruction, can at best offer a very partial view of the work of communicating in the classroom.

The language of description provided by multimodal theory enables the exploration of how curriculum knowledge is organized, classified, represented and communicated. This serves to highlight the significance of representation for how knowledge is placed within and connected to the world. The five concepts introduced in the previous section (i.e. semiotic resources, mode, modal affordance, multimodal ensemble and design) provide the starting point for a multimodal approach to technology-mediated learning. These concepts can be applied to examine i) the range of modes that a technology makes available, ii) the multimodal ensembles which these modes are organized into, iii) the affordances of the site of display provided by a technology, iv) the capacity for interaction it offers and v) the facilities for connecting different locations and users. These are outlined and illustrated in this section.

i) Range of modes
The facilities of digital technologies have enabled a range of modes, image, sound and movement, to enter the classroom in new and significant ways.

The Interactive Whiteboard (IWB) provides an illustrative example of the way in which technologies change the resources available in the classroom. A key aspect of IWBs is their capacity to harness a wider range of multimodal resources in order to facilitate pupil learning (Kennewell and Beauchamp2007). The IWB, like computers, can enable the classroom to be connected with the Internet. A recent study of IWBs (Moss *et al.* 2007) showed the degree to which Teachers remade the resources on the Internet in their learning materials for IWBs and other digital technologies in the classroom varies. Some teachers downloaded ready-made teaching materials for use in the classroom. Others made their own multimodal learning resources using PowerPoint or Flipchart to organize downloaded images, audio files, and video files. While other teachers incorporated websites from a wide range of origins via hyperlinks into their learning materials, such as, holiday websites to explore persuasive language (and image) use or Nasa film archives in school science. Each of these professional practices used the IWB as a digital hub bringing a range of modal resources into the classroom.

A study of the use of IWBs in Secondary Schools in London (Moss *et al*. 2007) showed that IWB technologies enabled a wide range of multimodal texts to be easily displayed and manipulated in the classroom. In one classroom, for instance, the

teacher used the application Geometer Sketchpad to teach about exterior and interior angles in a mathematics class. The use of color in the application was significant in the visual construction of these two angles with reference to the Mathematics curriculum. For each corresponding interior and exterior angle, the application used the same colour hue, with a paler shade to represent the exterior angle. This use of colour created a link between the two categories of angles (interior and exterior). Colours from across the spectrum were used to represent each of the interior angles in a shape. On the click of a button each of the coloured segments that represented each of the interior angles simultaneously migrated across the screen to fill a small circle. This movement demonstrated the rule that the sum of the interior angles in any shape always amount to 360 degrees. The use of colour and movement was central in the construction of the concept of interior and exterior angles and their relationship to one another. Teacher and students could manipulate a shape on the screen by dragging its sides with an electronic pen. This movement demonstrated that as a shape changed the individual angles changed but the sum of the angles remained the same. In this way the use of colour and movement in Geometer Sketchpad combined with the IWB as a site of display and its capacity for interaction drew on a multimodal ensemble of image, colour, and movement to construct the curriculum concept of angles as something fluid yet bound by principle.

The technologised space of the classroom raises the question of what can usefully be displayed in this space, what modes could be used, what could be done with and in this space, and for what pedagogic purposes. Towards addressing this question this chapter briefly explores how the semiotic features of image, movement and sound on screen contribute to curriculum knowledge. The examples that support this discussion are drawn from a range of research but focus primarily on two illustrative examples from the author's research in secondary schools. The first draws on video and observational data from a series of five English lessons with a Year 10 class (students aged 14 –15 years) at an Inner-London Secondary School working with a CD-ROM version of Steinbeck's novel *Of Mice and Men*. The second focuses on video and observational data from a science lesson with a Year 7 class (students aged 11 –12 years) at an Inner-London Secondary School working with a CD-ROM *Multimedia Science School* to learn about particle theory.

Image

The 21st century is marked by a plethora of imaging and visual technologies and in contemporary western society everyday life is saturated with the images that these technologies make available (Virilio 1994). Images are part of our cultural history and everyday life but this period in time is marked by an increased potential for active use of the visual. For instance, images have started to replace words for some young people using MSN, with the use of picture dialogues (Leander 2007). The move of novels and textbooks from the medium of the book to the screen has also been accompanied by an implosion of images and increasingly the backwash of technology has impacted on the re-visualisation of the printed textbook. In teacher made learning materials the use of images is prevalent, particularly in teacher made digital materials. For instance, the use of images taken from the Internet to discuss character via visual symbolism in Macbeth, or a visual biography of Steinbeck made through photographs, maps, and images from film and stage productions of his plays.

Visual representations are claimed to make some concepts more easily accessible and learning 'easier' (Ligorio 2001), to be effective in highlighting overall patterns and trends (Clark and Mayer 2003), to demonstrate complex notions, depict spatial relations and create mood and immediacy. Similarly, colour has been found to be a potentially powerful tool to direct and maintain attention, interest and motivation, and to increase retention of learning materials. There continues, however, to be much debate about the role of visual representations in learning.

Multimodality seeks to describe and understand the specific modal affordances and semiotic resources the visual contributes to a multimodal ensemble as it is socially situated, and the impact of this on meaning making and learning. The spatial logics and simultaneity of image are part of the affordances of image. Analytical dimensions that inform this work include whether the image is realised as a narrative or a conceptual classification, the designed position of the viewer (through the use of distance, contact and angles), the modality of reality (i.e. naturalistic, abstract or scientific orientation) and the composition of an image.

Movement

Teachers especially science teachers have always animated models and artefacts to demonstrate concepts and processes. For instance, the use of a wobbly crystal model to show the action of particles in a solid, ping pong balls on string whirled around to represent orbits, models made of coloured balls and bulbs to represent the solar system. While the use of gesture, action and movement is central to the science classroom the extent to which these modes are included in analysis of teaching and learning is another matter. All that said, movement is a modal resource made available in the classroom by new technologies in new ways.

An illustrative example of how on screen movement can be used as a resource for constructing curriculum entities is offered by the use of gaze and movement in the CR-ROM version of Steinbeck's novel *Of Mice and Men*. The scene shows the novel's main characters George and Lennie sat talking by a fire. The character George is represented as possessing physical qualities that are associated with calmness and stability. He is shown as still, his gaze is steady, and his posture relaxed, his body stretched out. His leaning in toward the character Lennie and his close spatial distance serve to realise an intimate engagement. George's soft rolling gesture is slow and gentle, a sign of control and ease. In contrast the springing, lunging movement, gaze, and 'prodding' gestures of Lennie represent him as unsettled, volatile, and unaware of danger (epitomised by his leaning across the fire). The posture of Lennie, his legs pulled tight into his body, is a closed tight one and signals the tension of the character. It is also suggestive of a childishness or insecurity. His jerky gestures are fast and forceful and indicate both his strength, and his lack of control. In contrast to George's steady gaze, Lennie's gaze at George is shown wavering and darts around towards the woods, his gaze is unclear, and unfocused a multimodal sign of his lack of concentration. These multimodal representations produce George as a rational adult character and the emotional child-like character of Lennie – who literally 'can't sit still'. This multimodal construction of the characters shapes the viewer's relationship to the characters and understanding of their relationship and Steinbeck's written text. A new representation of the two characters that reworked the original novel with significant implications for how it is read in a contemporary context.

The semiotic resources of movement have a number of roles for learning. Movement can be used to display changes over time or to simulate experiences, as well as to show environments that it is not possible to experience (Laurel 1990). Movement in simulation programs can provide students with access to complex phenomena, the opportunity to observe the unobservable and to manipulate models and concepts. For example in the application *Interactive Physics* students can build a pulley system that can be 'run' and the conditions of gravity can be altered, for example to see how the system would operate with zero gravity. *Multimedia Science School* provides an animation of which shows the speed and spatial arrangement of particles in different states of matter (Jewitt 2006). Transforming the curriculum focus from the static representation of discrete states to the dynamic representation of the transformation between states. The potential of animated micro-worlds to demonstrate the differences between everyday understandings of movement and those acceptable to physics in different ways than other technologies has also been shown (Säljö 1999).

Google Earth, a GIS (Geographical Information System) application that is used by teachers in the geography classroom to promote spatial awareness skills is another example of how new technologies bring the resources of movement into the classroom (Briebach, 2007). Google Earth provides high quality digital ariel photography of the world linked to a variety of geo referenced data. A key dynamic feature of Google Earth is the 'fly to' tool that enables the user to visually move from one location on the globe to another, and to zoom in and out of a location. As the teacher opens the application Google Earth, usually on an IWB, a globe image of the world is displayed. If the teacher or student then types in the postcode of the school in the 'fly to' window and click on the search icon, the image of the globe spins as the viewer position moves slowly towards the globe, down through the strata sphere to the county, flying down towards the city, and finally hovering over the specified locale. This involves students in visually and spatially locating themselves and their local neighbourhood in a national and global context – from a position outside of their experience of the world, making the familiar strange. It also provides zoom and navigational tools to investigate and remake the area, for example through visual place markers, and the mapping of routes and trails. In short, movement contributes to the way in which curriculum knowledge is shaped, as well as what is to be learnt and the practices of learning.

Speech, sound and music

Music and spoken dialogue are features of many online novels, web-based resources and CD-ROMS and these contribute in important way to the shaping of curriculum entities. Sound, music and speech may introduce new resources to the reader, for example using music in filmic ways to set the emotional tenor of a story, or to make salient a particular emotional moment. The move from page to screen brings with it the potential to make the characters speak the dialogue of a novel. The different voices 'given' to the characters of a novel are a part of their multimodal transformation. In the novel as a CD-Rom version of Steinbeck's *Of Mice and Men*, for example, the main characters George and Lennie are reshaped through the use of voice. George is represented as speaking in a soft, slow, clear tone and pitch- each word is distinct and he speaks in a smooth level tone. His voice sounds relaxed, full, and unwavering. In contrast, the voice of Lennie is quick and stuttering. His voice is breathless, his words are shortened, words run together and become mixed-up. He

talks loudly and the words 'shake' as they stumble out of his mouth. This audio re-presentation of the characters is the result of choices from a range of aural possibilities, choices that carry meaning. The slow rhythm, normative level, and evenness of George's voice combine to form a sign of calmness and stability. The fast and faltering quality of Lennie's voice signals the meaning of instability and lack of control: the exaggerated stutter serves to remove any sense of clarity. This emphasises the contrast between the two characters. It marks Lennie's lack of control and his potentially dangerous nature from 'the moment he opens his mouth' - making his future silence potent and sinister. All of this adds up to a less sympathetic view of Lennie than the one offered in the original novel and places the relationship of the characters Lennie and George in a context of control and power rather than of friendship.

In the same CD-ROM, the guide is placed in the role of storyteller and he presents a range of information. Bindy's narrative interludes offer the reader of the 'Novel as CD-ROM' an alternative view of the original novel. The guide introduces the need to move *beyond* the text, to understand the author, the social context of the novel (this personifies the traditional notion of a guide.) He also introduces the need to move *through* the text to get at its meaning, its themes, and how it extends other texts. He suggests practices to the reader like book marking the text as they read, making notes, and so on. In this way the character guide Bindy structures and presents the content of the Novel as CD-ROM for the reader. The heavy country accent of the guide Bindy echoes that of the main character George's voice. Through the mode of voice this mutually establishes the character Bindy as authentic and the character George as authoritative.

Increasingly many technologies and applications used in the classroom provide facilities for learners to record and import audio files of their own voice, music etc. Some applications to support language learning and reading, for instance, have the facility for students to record their speech for feedback – either automated feedback or by a tutor at a later date. The Playground Project (Hoyles *et al*. 2002) and Making Games Project (Pelletier 2005) investigated the potential of game programming tools for learning. In both projects students were able to upload audio files (of their speech, sound effects, or music) to the games that they made. The students made use of sound as a resource to create mood, tension, warning, indicate character and so on. Sound can also be used to communicate information about things that happen, or dynamic changes for example liquid reaching the top of a glass, or to show events in space (e.g. the use of footsteps or the volume of a voice to indicate distance) (Mountford and Gaver 1990).

Writing

New technologies emphasise the visual potential of writing, as well its more conventional uses. This re visualising of writing brings forth new configurations of image and writing on screen through the resources of font, bold, italic, colour, and layout (Bolter 1998; Jewitt 2002, 2005). Increasingly writing may serve a labelling and naming function. While the multimodal action rolls on, writing is used to name a character or indicate its status, specify a narrative point, or identify a decision. For example, the decision of when and what to represent in writing and/or speech can shape the construction of character and narrative. Writing and speech can be used to give voice and expression to some characters (in a text, in a game, or elements in an

animation) and not others. Students move through an application by using the characters' access to speech as a multimodal clue to their potential to help solve puzzles and tasks. A character's access to language indicates (can be read as a part of) their value—that is, their value in achieving the object of a task, to collect resources to move through to the next level of a task or game. A multimodal semiotic analysis of students play with the game *Kingdom Hearts* (Jewitt 2005), for example, shows that some characters have the potential to speak, some respond by written text bubbles when approached by the player/avatar, and others have no language potential at all. The characters that have the most modes of communication are the key to game success.

At times, writing on screen becomes fully visual, that is the content of the writing is almost consumed by its form. Writing 'becomes image' when it is either too big or too small to relate to the practice of reading. For instance, the tiny scrawl of printed words may retreat to a textured pattern of lines and is redefined as a visual representation on screen. When writing moves about the screen, interacting in rhythm with other modes for example, the linguistic meaning of what is written is often illegible and transformed (Jewitt 2002).

Returning to the illustrative example of the *Of Mice and Men* CD-ROM, the visual dominates the screen taking up more than half of the space in over three-quarters of incidents. This de-facto dominance serves to de-centre writing. Writing is displayed on the screen framed within a white block; this block is placed over an image that fills the screen. The positions of the blocks of writing over a series of three screens using the same image serve to change what is seen of the image. In one sequence of screens as the written dialogue expresses the anger of the main character the white block of text obliterates character that he is angry with, as his anger subsides and the two are reunited in the written narrative the block of text is gradually repositioned to reveal the character. In this sense the writing as a block has a visual role beyond the content of what is written. This contributes to the construction of the narrative of the relationships between the two main characters.

The amount of writing per screen is greatly reduced when compared to the page of the novel. A page consists of three or four paragraphs, whereas each CD-ROM screen consists of one paragraph. This restructuring breaks up the narrative and disconnects ideas that previously ran across one page to fragment the narrative across screens. This reorganisation serves to chunk up information and curriculum concepts. Moss *et a.l* (2007) noted a similar modularisation and restructuring of curriculum content and classroom time with relation to the design and use of IWB learning materials across the curriculum. That research shows that IWBs as compared with non-interactive whiteboards or blackboards, reduced the amount of data on a board, increased the amount of image and increased the number of screens. This spreads information acrosss screens, increasing pace, and reducing the amount of time a screen is shown in the classroom, all of which impacts on the shapes of school knowledge.

Image, movement, gaze and gesture, sound, music and speech, and writing are rarely alone on screen. Rather they are brought together in multimodal ensembles in which each contributes. The role of new technologies in shaping these multimodal ensembles is discussed in the following section.

ii) Multimodal ensembles

The range of modes new technologies bring into the classroom are configured into multimodal ensembles in ways that reshape what is to be learnt and the practices of learning. The multimodal transformation of the characters in the Of Mice and Men CD-ROM, for example, repositioned the characters George and Lennie who are polarised by the contrast in their appearance, clothes, voice, gesture, composition and editing. In this case the modes work together to realise an equivalent meaning. This multimodal reshaping presents a new set of motivations for character and narrative as well as emphasising particular characters and moments of the story. Through the visual arrangement of image and writing on the screens of the Novel as CD-ROM some of the characters were literally given appearance and voice. As a result they appeared in the repetition of moments in video excerpts embedded at the beginning of each chapter of the novel, still image, and writing. The pace and thematic emphasis of the structure of the Novel as CD-ROM is transformed by the placement (and repetition) of what are effectively concluding moments at the start of each chapter via the video clips. It reshapes the characters, their relations and motivations, and the overall narrative. It also works to reorganise the 'novel as book' to 'novel as CD-ROM' and to fragment, rupture, and reconfigure the narrative. It fills in the descriptions of the characters. In some respects then, the multimodal ensemble does much of the imaginative work demanded of the students as they read the book. The multimodal transformation of *Of Mice and Men* to the CD-ROM offers the students several readings of the novel and provides them with different tools to think with in their engagement with the entity character that reflect the demands of the curriculum (a point returned to later in this chapter).

Changes in image and writing relations are illustrated by the way in which particles and states of matter (solid, liquid and gas) are represented in the contemporary school science classroom. Particles and states of matter are represented in the majority of School Science textbooks either in the form of diagrams or in the form of photographic images. The diagrams –a set of three line drawings each of which show the changing space between particles in a solid, liquid and a gas - visually classify the three states of matter in terms of their arrangement, density and spacing of particles. While the photographs represent everyday examples of states of matter in a realistic form: an ice cube on a saucer, a glass of water, and steam coming from the spout of a kettle. The representation of this curriculum concept is radically reshaped by the capacity of new technology to depict movement and therefore show processes of change in *Multimedia Science School*, that is, the transformation of one state to another rather than discrete states.

The interface of *Multimedia Science School* draws on the modes of writing, image, movement, and their arrangement on screen. The way that these modes are organised visually (designed) on the screen serves to create two distinct areas of the screen: a 'frame' and a 'central screen within the screen'. These two areas of the screen attend to quite distinct kinds of activity. The frame attends to scientific classification and labelling and presents the means by which scientific phenomena such as states of matter can be explored. The screen within the screen attends to the empirical world that is to be the subject of scientific investigation that is made visible on the screen: for example, the representation of an ice-cube melting to become a liquid. These two aspects of school science – scientific language and theory and the empirical world, are marked through the visual composition of the screen, as well as modally. The frame

relies on the mode of writing and the visual resources of layout and composition while the 'screen-within a screen' relies on the modes of image and movement. Both employ the mode of colour; however they do so in quite different ways and as a consequence each contributes differently to the construction of the entities of the science curriculum, and to learning more generally.

The colours used in the frame are muted, dark, and flat and use several shades of grey, locating it within the coding orientation of 'scientific-ness'. The range of colours used in the central screen stand in stark contrast to the dull monotone of the frame. In the central screen colour is used to construct a hyper-scientific realism where how things are in the 'natural' everyday world is echoed and filtered through the lens of scientific-ness - in which water is blue and ice is pale – but bluer and paler than in a naturalistic representation. The 'screen within the screen' uses saturated colours and a range of different hues. The central screen is a multimodal space without written elements. Further in contrast to the persistence and stability of the frame, the central screen is a place of change and movement. In summary, the empirical world displayed in the central screen mediates and provides the evidence that fills-in the scientific concepts realised linguistically in the frame, in this case 'states of matter'. This example illustrates that image and word have specific roles in shaping the construction of the curriculum concept of particles.

In learning environments that use avatars (games, second life, some simulations), the modal resources of image, movement, sound and speech all combine in the multimodal ensemble of the body on screen. The design of the self via these modes is the complex rendering of a range of modes into a multimodal sign.

Hypertext embeds writing, image and other modes into web-like patterns in significant ways. It can be understood as a mode (an emergent mode) that acts as a kind of digital glue within a multimodal ensemble. Hypertext has the potential to realise new interactions between word, image and sound and connect disparate sites and resources through inter-semiotic hyperlinks (Lemke 2002). It is often the case that images on the Internet enter into co-operative relations with words in which images function as characters that link screens. Such structures in interactive texts are 'modelled on, and can themselves provide models for, social cohesion and interactivity' (van Leeuwen 1999: 119). The design of hyper links and routes create relations and continuity or discontinuity between elements (Lemke 2002). For instance, the use of hyperlinks changes the narrative structure of the novel *Of Mice and Men* (Steinbeck 1937) in significant ways. The novel as CD-ROM includes hyperlinks to factual definitions of slang words in the text and hyperlinks to a map and historical information on the location of the novel. These links create new connections that go beyond the novel and produce different epistemological layers of knowledge of fact and fiction. This has consequences both for curriculum knowledge and the imaginative work or students.

Similarly, in the illustrative example of *Multimedia Science School* a Hide Particles and View Particles button is displayed on frame panel. This button is the means by which students can switch the displayed appearance of the sequence in the central screen thus enabling the students to choose between two different sequences in the central screen. Selecting the Hide Particles viewing option displays an everyday view of the transformation of states of matter – the image of an ice cube in a beaker. Here

the focus is on what is and how things are in the world of the everyday. The focus is on the change in shape, texture and movement from one state to another. By contrast, the option View Particles displays a view beyond and beneath the everyday, a scientific view in which the focus is on explanation on 'how things actually are' – this shows the same image and includes an overlay of animated particles in the ice cube. These multimodal representations and the facilities of the technology enable the students to move between two accounts of states of matter- the everyday and the scientific. The potential to move between these two representations produces a tension between the two views in which each representation visually explains the other. This structure demand different things of the students, on the one hand, classification and on the other observation of patterns and the connection of their everyday experiences with scientific theories of phenomena (this is returned to in the third section of the paper).

The structural links between screens can take a number of forms. Among others these can be index-like lists, nested structures, tree structures, or semantic links (linking for example, a car with transport: the link 'is' 'kind of'). Other semiotic potentials combine to make meaning through elements such as direction and distance from the home page, what is linked to what, and the contrast between the styles of different pages. It follows then that analysing the structure of an interface is one way to bring the ideology, hidden agenda or curriculum of an application into the 'open' (Zammit 2007). In this way, hypertext creates new resources for meaning making (Luke 2003; Lemke 2002).The way in which screens of information can be linked, their *hypermodality* contributes to the meaning potential of an application. As Lemke comments, 'It is not simply that we juxtapose image, text, and sound; we design multiple interconnections among them, both potential and explicit.' (Lemke 2002: 300). The connections and disconnections that are realised by hyperlinks impact on how school knowledge is constructed by students.

The visual sharing of objects and links across screens enables students to pursue textual and thematic issues that contribute to the shaping of curriculum concepts. In this way, shared objects visually indicate the relationships between elements and characters. In other words, meaning is constructed from the juxtaposition of different texts, and events that unfold across and among various media. In the case of the *Of Mice and Men CD-Rom*, the shared image of a hand-addressed envelope associated with the characters George and Curly's wife visually introduces the suggestion of a relationship between them. This is echoed in the songs sung by these two characters (audio files within the CD) which although sung separately are presented as a duet via the shared tune, musical style, lyrics and tone (a duet separated by time and space). The visual and aural re-shaping of character introduces a heterosexual romantic strand into the narrative that realises both the vulnerable femininity of Curly's Wife and the heterosexuality of the character George (two characteristics not realised in the novel). It also suggests a glimmer of hope (and escapism) that stands in stark contrast to the bleak and relentless loneliness and realism of the original novel.

The use of hypertext links in Google Earth and other GIS applications offer the facility to produce visual layers of content. In turn this offers the potential to see change and analyse events over time. For instance, maps of an area from different times can be layered over one another to build a semi-transparent layer that makes visible consistency and change. Layers can be built to visualize census and other

survey data, mapped to enable the comparison and analysis of patterns. Thus transforming numerical data into visual data. The facilities of digital technologies to hyperlink elements and build layers, provides new resources and dimensions for the realisation of multimodal ensembles.

The key point made here is that a multimodal ensemble realises meaning potential through the configuration of modes within it. The decision to foreground one mode over another, to arrange modes in a relationship of equivalence, complementary tasks, or in tension is itself an important aspect of meaning making and the shaping of school knowledge.

iii) Sites of display

The book page, the newspaper, the advertising billboard, television, the computer screen, the Interactive whiteboard (IWB) and the mobile phone screen can all be understood as sites of display. These sites of display have different social histories that are embedded in their design and continue to impinge on people's use of them. In the contemporary communicational landscape screens, the page and other displays are being remade by people's use of technologies, collapsing and converging and becoming new, for instance, the online newspaper (Knox 2007), the online book, the digital photograph frame, and the phone as television. Screens shrink and flex to fit in our pockets, while architects and artists transform public space into enormous screens for information display and the creation of interactive popular culture. The screen and what appears on it are new and yet fundamentally connected with the present and past (Gere, 2006). That is the screen and the page are in an ongoing dialogue with both shaped and re-made by the notion of the other. There are screens that look page-like as well as pages that look screen-like (e.g. Dorling Kingsley books) (Moss 2003).

Many learning and teaching materials for computers and IWBs (both commercial and teacher made) continue to be informed by print based design principles (Moss *et al*. 2007). Indeed it has been argued that the textbook or worksheet has tended to migrate onto the screen in many classrooms. The IWB is an example of a technology that fits the spatial and pedagogic logic (the histories) of the classroom so easily that it enables teachers to continue their practices *seemingly* unchanged. However, teaching with an IWB affectswhat is taught and how it is taught even when the teacher continues to work with it as a non-interactive board. Take for instance the example of a Maths or English teacher that writes directly onto the white board, without using image or connecting to the Internet. The screen size of the IWB combined with the ability to save and return to a screen serves to break up curriculum content and pedagogic narratives into smaller sized chunks than the traditional white or black board. In the process the narrative of a problem to be solved over the time of a lesson disappears from the sight and control of the student.

The way in which the site of display features in the classroom reshapes the work demanded of the learner and the experience of learning. One aspect of this is the capacity an application or technological hardware offers for interaction and dissemination and connection – both of which are discussed in more detail in the two following sub-sections.

iv) Interaction

Teachers' use of the resources for interaction that a technology offers is crucial for

learning. Once in the classroom new technologies and the multimodal resources that these release into the classroom can be manipulated, resized, annotated, or reorganized. Returning to the example of IWBs as an instance of a technology that is common in the classroom, the following example illustrates the potential for interaction to shape curriculum knowledge.

This capacity for interaction can lead to the recreation of new kinds of inter-textual layers and authorship. The creation of new texts is illustrated by the following example from Moss *et al* (2007). A student in a school English lesson made a poster using pen and paper. The poster was scanned by the teacher and displayed on the IWB. During a whole class discussion the teacher acted as a scribe for the students' comments and annotated the digital poster. The poster was then saved as a digital file. In this moment the layers of activity across the original poster transformed it from an individual student's poster, not to a teacher's poster, but to a collective classroom poster. This opened up the space of the IWB from a teacher space to a classroom space in a way that a non-interactive white board could not enable.

An illustrative episode of interaction is from a mathematics lesson on algebra and factorisation in which the teacher used a learning resource she had made provides another example of how the capacity to manipulate elements on the screen can contribute to the shaping of school knowledge and classroom practices[3]. The screen showed the black outline of a square divided into sections and two sets of shapes: a yellow square and a series of four differently coloured shapes (two brown rectangles of the same size, and two other different sized and coloured squares). When arranged these sets of shapes filled the yellow square and outline. Another slide consisted of a series of algebraic equations to be solved. Students then suggested and showed (through the manipulation of the shapes using an interactive slate) alternative arrangements of the four shapes within the square. In this example, the students used image, colour, and movement to explore factorisation through their manipulation of the different shapes and visually checking the fit between the series of shapes and the large yellow square. The whole class teaching was designed to enhance and create spaces for interactive work. Discussion and extended dialogue were opened up by the teachers' use of the IWB. The teacher used peripherals (slates) with the IWB. This positioned her at the back of the classroom and enhanced techniques for student participation and control over their own learning. The teaching focused on the process used to find the area of the yellow square in the text displayed on the IWB. Different students controlled the IWB text using a slate passed from one desk to the other to try and find out the area of the square. The contents of the text were used as open-ended prompts and as resources for exploring the processes of factorisation. The teacher intervened with comments, and the students suggested ways of solving the problem. The teacher summarised what they had learnt by asking questions to pupils and indicating the formula behind that process. When summarising the teacher referred to the insights that different pupils had made. The teacher encouraged students' spoken and physical participation and pupils were active in the lessons. The board was used to display students processes of thinking and ideas rather than what they had done or correct answers. Answers were realised through discussion and student participation

[3] This was prepared using the Promethan package ActivStudio flipchart. The example is taken from the data set of the Moss *et al* 2007 evaluation of IWB use in secondary schools in London.

in the lesson. The capacity of the application design of materials and the IWB hardware enabled the teacher and students together to shape the construction of knowledge in the classroom.

This lesson was marked by the display of texts for annotation, manipulation and collective discussion and a move away from using IWB features such as drag and drop, hide and reveal which tend to focus on prepared content to be revealed. As a result there was less use of the IWB for direct mapping and transmission of information into student exercise books through copying the contents of the board and more creation of opportunities for talk supported by technology-enabled manipulation of elements on the board. In short the text design was 'left open' for completion by the action of the students.

v) Dissemination and connection

One outcome of new technologies providing new opportunities for children and young people to engage in publication and dissemination. Sites and applications (such as wikis, blogs, myspace, forums, facebook, and flickr) create spaces for publication that are highly multimodal and breakdown some of the distinctions between producer or audience (Unsworth *et al* 2005). Online fan fiction forums, such as HarryPotter FanFiction, offer an illustrative example of these roles. This site enables children to move between a variety of pratices and identity categories. Including that of writer, reviewer or editor of other fans' stories, writing mentor - involved in coaching other writers, adding paragraphs and offering suggestions, summary writer - writing summaries for stories posted on the site, illustrator - making graphic art for others' stories, critic - rating and commenting on posted stories, or a collaborative writer working as a member of a team. It opens up new spaces for identity play and for reflection on notions of audience and process that are important for learning and the construction of knowledge.

The use of new technologies can impact on the connections of knowledge and practices of learners across different spaces and times (Leander 2007; Nespor 1994; Deleuze 1989). For example it can be used in ways that collapse and remake the boundaries and spaces between home and school. The Homework project (Kerawalla *et al* 2007) , for example, developed educational software for Tablet PCs that children used at home and school to promote and support communication between learners and teachers in both home and school learning contexts. The technology enabled the students to work in the school in groups or alone or later with their family, in the kitchen, in the car, or elsewhere. The facility of technology to newly connect spaces works to make different connections of time and practices. Knowledge circulates across time differently in online spaces, with archiving, complex rhythms of asynchronous and synchronos tasks and multiple tasks merging across what Leander (2007) has called 'economies of rhythm'. The school timetable would require a reimagining of the school to fully engage with this potential. The comparison of the types of activities that the children undertake on computers at home and at the school demonstrates how the different local contexts of these settings acted to mediate different types of computer use (Kerawalla and Crook 2002; Leander 2007). Myartspace is an interactive project that uses mobile phones to 'collect' artefacts in museums and galleries to produce individual websites for pupils. Children can collect photographs, drawings, writing and audio commentaries as well as museum and gallery objects and these can be manipulated, organized and annotated to produce

personalized ‘galleries’ of a museum or gallery exhibition. This works to create connections across time and space (as well as experiences) and enable narratives to be circulated, shared, reused, and further transformed. In this way new technologies can offer ways of manipulating information in ways that significantly re-shape knowledge and learning.

These potentials to connect and disseminate content (and practices) make new demands on students, both in relation to how knowledge is represented and communicated and how those representations circulate and are mobilized across times and spaces (Nespor 1994). The layout arrangement of modes on screen draws on structural resources such as hyperlink which can itself be understood as an emergent modal form (Zammitt 2007) and the digital body or avatar which brings image, action, sound, movement, time and space into relations on screen in new ways. Indeed is it possible with the changing notions of time and space that the screen makes possible to think of time itself as a modal resource? The connections across the display sites and spaces of the classroom and beyond also introduce new kinds of textual spaces in the classroom for meaning making.

The technical facilities and multimodal resources that new (and old) technologies make available have to be activated by teachers and students, as well as the social and political demands of the curriculum and the school. The illustrative examples presented thus far highlight the importance of understanding how knowledge is shaped through the teacher’s choice of one mode over another, and the consequent constraints and possibilities those choices introduce. (Choices that are constrained by the institutional social web that teachers are firmly situated within.) In this way the representation of curriculum knowledge can be viewed as a process of pedagogic multimodal design, of the matching of target knowledges with particular modal affordances. In this process meanings are made and remade (designed) when representations are enlivened in the classroom, and again when students engage with them for the purposes of making their own meanings in lesson practices.

This section of the paper has outlined how curriculum knowledge is shaped, disseminated, and remade through the semiotic resources, multimodal ensembles, and facilities that new technologies can make available in the classroom. The question of what all this can mean for practices in the classroom that might lead to learning is the focus of the next section.

Multimodal learning

This section draws on the ideas and concepts discussed in section one and two to focus on multimodality and learning. It examines the ways in which semiotic resources, the modes made available, modal affordances, and the ways in which these are arranged into multimodal ensembles effect the practices that students engage in. When students use multimodal computer applications they are engaged with a range of modes, semiotic resources as shaped by the tools they are working with. Students point, gesture, gaze at the screen, they move the mouse (or joystick), click on icons and, sometimes (but not always) they talk. Adopting a multimodal approach is beneficial when examining how students construct meaning and other practices that may lead onto learning.

In a study of students' use of game design to learn about the character and construction of rules in mathematics (Hoyles *et al*. 2002), multimodal analysis showed that the students' use of representations offered a way to investigate their learning (Jewitt 2003). The following example focuses on two students designing a computer game. Their game revolved around 'a little figure that will be caught by an alien' – this was how their written description of the game had been explained in written form. The students choose an image of an alien and an image of Jupiter for the game background. They needed to find a form for the 'little figure'. The work of the students was to select from a range of semiotic resources to express the meanings that they wanted to make. The students used visual difference, size, and movement to represent the little figure as weak in comparison with the alien. They decided on a small flying dog with a rocket strapped on its back. The students' choice of a dog - a familiar pet on planet earth, rather than a small alien emphasised the little figure's difference to the alien. It also gave the little figure an outsider status that further highlighted its potential weakness. It is easy to change the size of an image in Toontalk - the decision to keep the dog small and the alien big added to their visual construction of the dog as vulnerable. The students programme the dog with limited movement: it can only move sideways. This adds to the weakness of the little dog in the game. The students chose the most apt signifiers from the available semiotic resources of image and movement to express the vulnerability and strength of the characters in their game. This example illustrates the process of learning is intricately wrapped up in the agency of the sign maker, the concept of sign, and the technology and modal resources that are available.

There is an extensive literature on learning and what learning is continues to be a matter of debate among parents, educational practitioners and academics (e.g. psychologists, sociologists, etc). This chapter sets out to contribute to this debate by providing an account of how the design of the multimodal resources of computer applications might re-organise or re-mediate the practices of students. In particular it discusses how students' texts can be understood as semiotic signs of learning, and the semiotic work of interpretation in the multimodal environment of the classroom. In particular, the role of hyperlinks and layering structures, entry points and reading paths, and the design of learner positions in this process.

Signs of learning

A multimodal perspective focuses on external representations and the processes of meaning making realised through interaction. It argues that the modes that are available to people in the social world are therefore crucial for learning because the semiotic resources in the social worlds that people live in are fundamentally connected to mind, ways of thinking and making meaning (Halliday 1978). From this perspective there is then a need to move beyond the traditional focus on language to re-think internalisation as multimodal. The external material signs that students (and teachers) make can be understood as embodying (in some way) the patterned exchanges and interactions that they emerged from. This leads to the interpretation of student's material expressions as one kind of 'evidence' of their thinking and learning. From this perspective *all* modes contribute to learning. This moves away from seeing the 'repetition' of meaning across more than one mode as a matter of redundancy towards an understanding of 'repetition' as reinforcement, emphasis and foregrounding.

Multimodality approaches learning as a process whereby external representations are worked with and appropriated by a person (or community) and made sense of in relation to their present and previous experience – this builds on neo-Vygotskian ideas of learning (Daniels 2001; Mortimer and Scott 2003). Through this process meanings are re-made by people. This moves away from the view of learning as a process involving the acquisition and accumulation of *given* semiotic meanings (or codes). From this perspective there is a fundamental connection between what might be described as *external* and *inner* signs thus highlighting the importance of semiotic resources for learning. Multimodality provides a language of description to better understand these signs, their semiotic features, affordances and meaning potentials.

Exactly how people process different modes of information is a matter of continuing debate (Dubois and Vial 2000), although there is a generally agreement that different forms of external representation affect human cognition differently (Jehng *et al.* 2000; Tricot *et al* 2000). External cognition sets out to theorize the nature of the relationship and interaction between cognitive processes and external representations (Scaife and Rogers 1996). The focus is on the specific properties of external structures in terms of their differential cognitive benefits and disadvantages, that is the cognitive affect of representations. Theories of external cognition approach internal and external representations as acting in a complex cyclical process integrating people's existing knowledge over time. A number of cognitive dimensions of representation have been theorized as central to the process of learning, for example, drawing on cognitive load theory which suggests the need to integrate and minimize the number of simultaneous representations to avoid redundancy, 'cognitive offloading' and 'cognitive effort' and the contiguity principle (Clark and Mayer 2003) which suggests the need for integrating textual explanations into graphic elements.

The cognitive affect of these continues to be debated (Clark and Mayer 2003). Ainsworth (2006) argues that the effectiveness of multiple representations depends on its purpose and that to benefit from multiple representations learners must understand the relations between them. She identifies several factors that are key to the design of effective multiple multimodal representations including the number of representation, the distribution of information across these, the representational system, sequence, and support for the translation between representations. In this way external cognition and socio-cultural theories of mediation more generally provide useful resources for multimodality to connect with dimensions of cognitive processing for learning.

A key element of new technology (indeed any technology) is the ways in which it can externalise learning processes making these newly visible and traceable. The Myart space mentioned earlier for example combines mobile phone and web technology to enable students' expressions and interpretations of gallery and museum experiences visible through their creation of personalised online galleries. Research on Learning Trails (Walker 2007) explores the hypothesis that it helps a person learn to record or create a trail (for themselves or for someone else) of where they have been and the objects they have seen. This research suggested that trails filter and connect individual learning objects through the provision of narrative structure using technologies for recording experiences (e.g. location-tracking technologies, and mobile devices). The Ambient wood project (Price and Rogers 2003) drew on theories of external cognition

and employed new technologies to create 'a field trip with a difference' where children explored and reflected upon a physical environment augmented with multimodal representations – visual, audio and animated - to trigger and present added digital information. These were designed to provoke children to interact with aspects of the physical environment and to discover, hypothesize about, and experiment with biological processes taking place within a physical environment. These projects illustrate different ways in which the trails of student attention, selection, engagement and interest can be built as a digital layer over a physical space. In this process interaction can be made visible, a visual sign that can stand to represent activity and one that can be followed by another learner, and remade.

Interpreting multimodal meaning

Digital technologies have the potential to bring a wide range of multimodal resources into the classroom and to change the representations that students are working with. This changes the work of interpreting (and producing) resources in the classroom as well as what students need to attend to and what they need to specify. Reading is a matter of the reader selecting what she or he understands as being relevant. The multimodal resources, combined with hyperlinks and different layers of content, offered by new technologies serve to foreground this aspect of reading/interpreting. The work of interpreting multimodal resources is illustrated through the example taken of students in a science classroom using the CD-ROM *Multimedia Science School*. The students are engaged with the CD-ROM in the work of prediction, observation, interpretation, explanation and drawing scientific conclusions to investigate the topic states of matter and particles. A key aspect of 'reading' the multimodal resources of the CD-ROM is for the students to understand what it is that they should attend to as relevant and important – the semiotic work of understanding what is salient.

The visual representation of the transformation from 'liquid to solid' was a particularly problematic representation for students to 'read' and to make sense of. This was a consequence of a clash between the designers' use of the modal resources of colour, texture and shape, and the students' principles for understanding these resources.

The representation of a liquid as a light pale blue, and a solid represented as a heavier, stronger blue indicated the designer's principle of the use of colour as a marker of 'density', 'compactness' or 'lack of movement'. Through the semiotic resources of the saturation of colour the solid was represented as a 'condensed' version of the liquid. The students, however, associated the paler blue of the liquid with the pale translucence of ice and a general 'coldness'. Using the same principle associating change in colour as an everyday sign of change in temperature, the students read the darker blue, used to represent the ice, as being warmer and therefore water. The more intense saturation of the colour, where 'intense' seems to have been the feature that the students have focused on, and was interpreted as 'energy' and 'warmth'. In addition the students did not read the texts multimodally, as was anticipated by the designers of the CD-ROM. Students can privilege one mode over another in their readings and in this particular instance they privileged image and colour over writing and movement. The students had to resolve a contradiction between the scientific

representation on screen and their knowledge of solid and liquids. In this case the students relied on 'everyday' principles of meaning making, and visual modes to make sense of what is displayed on the screen. This can be understood as a result of the students' trust of the colour and image, perhaps in response to the position of these modes as empirical evidence within the CD-ROM. Their comments during the lesson showed that they considered change in colour a criterial aspect of the transformation. (This was interesting as experiments in school science do often rely on change in colour as a key indicator). This highlighted the importance of the teacher in mediating the use of computer applications in the classroom.

The difficulty that some of the students experienced in interpreting the representation of the transformation from a liquid to a solid can also be understood decision not to read all of the modes on screen as being meaningful and to focus on the visual. These students were at an early stage of their induction into the realism of school science. They were faced with the challenge of 'reading' and untangling the tensions between the everyday and the scientific representations that the CD-ROM offered them. The students who were observed did not 'take up' (i.e. attend to) the written information offered by the scientific frame of the CD-ROM – information that clearly indicated the particular simulation they were watching. This is an example of the dominance of the visual mode and a de-centring of the role of written language on framing the screen discussed earlier.

When working with multimodal texts and interaction students usually have to work across or 'translate' between modes. This 'transduction' (a kind of modal 'translation') can be complicated by the designed relationship between modes (Stein 2003). This is especially so where there is a lack of coherence between modes, when different modes are designed to realise specific layers or domains of knowledge, or when the designers of a text and the readers/users of it draw on different principles (and values) of truth and reliability. Reading a text draws on the reader's interests, and among other things the principles that they employ to decide on a text's reliability. The reading of a multimodal text is shaped by how they engage with different modes and contexts. For instance, in some contexts a person may think of images as something to be scanned or more or less ignored. In another context, images may be the primary focus and navigate the reading of a text. How students engage with multimodal texts and interaction in the classroom is in part a matter of *modal preference*. Modal preference is used here to refer to a preference that is socially shaped, fluid, changing and contextual, rather than Gardner's notion of 'multiple intelligence' in which people have a fixed modal preference or cognitive ability (Gardener 1999). Modal preference is as much an issue when students are producing texts and interacting as when they are interpreting these. As discussed earlier the interpretation of meaning is itself a remaking, a design of meaning anchored in context.

Teachers' access to and use of multimodal resources (e.g. websites, CD-ROMs, simulations, textbooks and worksheets) in the classroom is critical for the construction of curriculum knowledge and learning. Ethnographic studies of multimodal practices of Science and English classrooms in the UK show that this holds true even in a curriculum context such as English where talk and writing dominate the classroom (Kress *et al*. 2005). The Multimodal Production of School English project involved detailed video recording and observation of nine English teachers in three inner-London schools, as well as interviews with teachers and

students and the collation of texts made and used in the classroom. The project showed the complex ways in which image, gesture, gaze, interaction with objects, body posture and writing, speech interact in the classroom production of school subject knowledge. The School English project highlighted how students and teachers co-produce notions of ability, resistance and identity in the classroom through their non-verbal interaction. The way in which classroom displays, space, furniture, and artefacts were designed to realise versions of English as a school subject was also documented. This research showed that the work of interpreting school English is beyond language and requires the ability to make sense of a range of modes and the relationships between them. It also highlighted the complex multimodal identity work that students are engaged with in the classroom.

Along with the choice of what mode to read and how to read across modes, the structure of many digital texts opens up options about where to enter a text—what reading path to take. This question is intrinsically linked to the central focus of this chapter, how the multimodal resources of screen both shape knowledge and the practices of learning.

Structure and learning

The facilities that digital technologies provide for structuring texts and interaction, such as hyperlinks and layers as well as the inter-semiotic relations that they enable, contribute to the production of multiple and distinct epistemological discourses or viewing positions. The presentation of parallel discourses and viewing positions is common in both print and digital media. However, the possibility to interact with multiple discourses in a digital text may be greater than those presented by a printed resource, for example in the image and writing on a textbook page. The facility to switch between, link or overlay epistemological views impacts on students' practices of engagement and learning. In particular it realises a potential for reflection, critique, contrast and comparison.

The hyper-link structure of the CD-ROM version of the novel *Of Mice and Men*, for example, offered the students using it in the English classroom the potential to engage with the novel as either an 'imaginative fictional' text or a 'historical factual' text. As already mentioned the CD-ROM novel included hyperlinks to factual information on the historical and social context of the novel, actors, and Steinbeck himself. The entity 'character' was represented in the CD-ROM in a number of ways. This included 'character' as it was realised in the novel, and notes and images referring to theatre and film productions of the novel, as well as the realisation of Steinbeck's imagination (and life), and the fictional diary account of the harsh reality of the lives of 'real' people in the period the novel is set in. The possibility for students to engage with the novel both as fact and as fiction was designed into the application. It demanded that students shift between the domain of fact and fiction. This offered the potential for comparison and demands different kinds of imaginative work of the 'reader' than the novel as fictional literature.

The multimodal resources of new technology create or reveal new problems for learning at the same time as they resolve difficulties for learners in understanding some representations. Multimedia Science School CD-ROM, for instance, used an animated representation to show the transformation of particles from one state of matter to another. This resolved the common problem of students thinking particles

are *either* gas particles or liquid particles or solid particles. This new representation also caused some difficulties for students when interpreting the representation of the entity 'states of matter' – in a similar way to the difficulties of reading colour described earlier. One area these difficulties were located around was reading two distinct representations arranged as layers – the work of distinguishing between these and connecting across them. As noted earlier, two viewing positions were offered by the Multimedia Science School CD-ROM: the Hide Particles viewing option displays these entities from the perspective of the 'everyday' world while the 'View Particles' option displays a scientific view of particles. The visual resources of the screen provided the students with a representation of the arrangement of particles in a liquid. In the lesson some of the students' had difficulty interpreting the relationship between the 'particles' and the background. The representation of 'particles' is overlaid on the water. One student saw the particles, as 'held in the water like jelly' rather than representing the water itself. This student's reading did not distinguish between the visual resources of background or foreground (overlay). She did not understand the image of the particles as a representation of the water. As a result her construction of the entity particle is of something that 'exists within' a liquid, a solid or a gas rather than the thing that constitutes it. The use of two overlay views of particles (everyday and scientific) presented the potential to merge the two views and produce a third reading of particles as floating in the state of matter.

Entry points and paths
The multimodal character of the screen does not indicate a single entry point, a beginning and an end, rather it indicates that texts are layered and offers multiple entry points.

The multimodal configuration of character in the Of Mice and Men Novel as CD-ROM introduced earlier enables the students to 'enter' the text in a number of ways. They could do this through the visual display and summaries of events, the multimodal video clips of key moments in the narrative, and/or the musical narrative created via the audio clips. The students could literally 'by-pass' the novel as a written entity. For example, two of the students selected all of the video clips and watched them in sequence as a mini film. Two others moved almost seamlessly between the songs on the CD-ROM forming a musical version of the novel. They can engage with the novel multimodally as 'film', 'animation' or 'musical'. The students' movement through the CD-ROM - their choices and selections – create different texts. This makes different aspects of character and novel available to the reader. It also enables the potential for the 'high' literary aesthetic of the novel to be transformed by students' form of 'readings' to 'popular' forms, such as film and cartoon. Students brought forms of engagement to the English classroom that they might be familiar with in their everyday literacy practices. In this way they expanded the notion of school literacy at that moment, even if temporarily.

As this example illustrates, the reader is involved in the task of finding and creating reading paths through the multimodal, multidirectional texts on the screen—a fluidity that as discussed earlier is beginning to seep out onto the page of printed books (Kress 2003). Writing, image and other modes combine to convey multiple meanings and encourage the reader to reject a single interpretation and to hold possible multiple readings of a text. This offers the reader new potentials for reading a text and the design of the text through engagement with it. While it is certainly the case that

multiple reading paths are always a part of the repertoire of an experienced reader (Coles and Hall 2001), the facilities of new technologies make non-linear narrative a design decision that is more readily available.

Dispositions to learning

In the context of contemporary theories of education and communication, learning is increasingly discussed in terms of the creation of particular dispositions and orientations to the world rather than people who are in command of a body of knowledge. Such dispositions, this chapter argues, are multimodal and go well beyond how people speak and what they say. Marsh in her research studies on new technologies and the meaning making practices of young children (2005) discusses how global discourses of Disney enter into children's literacy practices, and are mixed up and remade into the local. Marsh mapped children's mediascapes and patterns in media use drawing on two studies involving interviews, literacy diaries over a month period, questionnaires and observation during home visits with 62 families of young nursery school children (age 2.5 to 4 years). The research concludes that media has a fundamental role in very young children's identify formation and construction of themselves as literate and that understanding children's mediascapes is essential to negotiate their social culture in late modernity. This and other multimodal studies highlight the need to be sensitive to how children's meaning making practices cross over modes, discourses and the spaces they traverse (including physical and technologised spaces) (Pahl 1999; Leander 2007; Alverman *et al* 2001).

A learner's disposition can be understood as their stance to learning, their relationship to the process of learning. Alongside this learners are also positioned to learning – given positions to knowledge by educators and designers of educational resources. The imagined learner and 'what it means to be a learner' is built into learning resources. The application design realises a learner position in a variety of ways, through the suggested potential for interaction, the notion of 'ability' embedded in the design (e.g. levels of activity), the degree of instruction made explicitly available, and the potential positions to knowledge (discourses of identity) made available. This is only ever an offer and the student can attempt to usurp, adapt or reject the learner position embedded in the design of an application. (Although the extent to which they can do this depends in part on their power in the context they are using the technology.)

Returning again to the CD-ROM *Multimedia Science School*, the design of the application offered the students two positions or roles: a passive *observer* and an active *investigator*. Students who saw themselves as active agents in the investigation linked their actions with the display of the transformations from one state to another. Other students spoke of themselves as observers of the investigation. Through their use of the *Multimedia School Science* CD-ROM the students adopted different roles in relation to the production of knowledge including the role of the 'expert' and 'peer-tutor', 'observer' and 'questioner – student'. The students' choice of viewing position in the CD-Rom (hide particles or view particles) offered them different positions to the learning of school science. The students that worked only with the 'Hide Particles' option focused their observation on the empirical representation of the phenomena and the task of predicting what will happen. This choice positions the learner as being able to imagine the 'particles', of having a given knowledge of the scientific theory that underpins the explanation of what she observes. Students who worked with the

'View Particles' option were engaged with the scientific explanation of the phenomena. Their task was to relate the visualised particle theory to their everyday experience and knowledge. This work is a matter of interpretation of the explanation presented on screen.

The ways in which people use language and make sense is inextricably linked to the beliefs and values of particular communities and the sense of self. A change in discourse practices is Gee (2003) states a change of identity and therefore learning involves the ongoing design and redesign of identities across the social and cultural practices of meaning making. Learning often involves adopting a specialist language, an epistemological shift leaving one world of experiences for another. This can be expressed as both the loss and a gain of new possibilities and new identities. The design of learning needs to make the gain clear and this has to offset the risk of what is to be lost (Gee 2003; Kress 2003; Bezemer and Kress 2008). The different viewing positions offered by both of the CD-ROMs discussed above bring forth, relate to, different discourses of what is being represented. The former is a discourse of the everyday. The latter is a discourse of school science – the arrangement and behaviour of 'particles'. Adopting these discourses impacts on the position of learners

In order to understand the work of learning (and to learn) in the contemporary classroom it is essential, as these examples have illustrated, to look beyond language and attend to *how* students engage with a variety of modes and to account for how the design of the multimodal resources of a computer application works to re-mediate the practices of students that may lead to learning.

Conclusion

Understanding the practices of learning in the digital communicational landscape of contemporary classrooms requires a theory and method that looks beyond language, that is a multimodal perspective. From a multimodal perspective meaning is understood as made and remade across all modes, each of which makes available distinct semiotic resources, logics and affordances and these contribute to the shaping of curriculum knowledge in specific ways. It follows, therefore, that all modes are partial and need to be understood as a part of a multimodal ensemble. From this position a focus on language as the primary route to learning is rejected. Even when speech and writing are the dominant modes in a communicative event in the classroom their meanings are nestled and shaped by the multimodal ensemble of which they are a part (indeed some might argue their meanings are dependant on this).

The concept of mode, semiotic resource, modal affordance and multimodal ensemble provide analytical tools to examine the complexity of multimodal meaning making. From this perspective meaning making centres on people's selections from the semiotic resources that modes make available in a particular time and place that most aptly express the meaning they wish to make. These semiotic resources and the affordances and logics that they bring forth are arranged into multimodal ensembles. Mode refers to organized sets of semiotic resources for meaning making which are the product of the work of culture and social usage. Using these tools to conduct multimodal studies of the classroom will assist in building a better understanding of how these resources feature in the classroom and their impact on teaching and learning. Linguistics and discourse analysis has provided valuable insights on how speech and writing can be used to shape effective teaching and learning, and the

barriers to this. Multimodal research can extend this work to explore all modes (including speech and writing).

New technologies impact on the representational and communicative environment of the classroom in profound ways. Representations have a central role in mediating knowledge, identity, communication and cognition. The decisions curriculum resource designers, teachers, and students make when they represent curriculum knowledge in the classroom (e.g. concerning what modes to use, when and how) matter. They are significant for learning because this shapes how knowledge is constructed, what people can know about a concept and the processes through which they can know themselves in relation to it.

This chapter has focused on the reshaping of curriculum knowledge and classroom practices. It has identified and illustrated five factors that are central to this reshaping. Firstly, it has shown how the modes and semiotic resources that a technology makes readily available in the classroom brings the potential for new representations of school knowledge, in particular the visual and dynamic character of the screen. Secondly, new technologies place image and writing, action and image, and sound into new multimodal ensembles creating relationships between modes that contribute in significant ways to the realization of meaning. The ways in which these multimodal ensembles are transformed as they move across different sites of display remakes the textual cycle of the classroom, and the cumulative development of a curriculum concept across a lesson. What is lost and gained as a representation moves from the page of a textbook, to the computer screen, to the Interactive whiteboard screen is key in the construction of school knowledge (and the processes of learning). The possibilities for interaction that a technology provides as well as its potential for connection and dissemination are significant for learning and teaching.

The use of technologies can create a digital multimodal hub in the classroom. The question of how to use these multimodal resources effectively in the classroom is a matter of the pedagogic design of the semiotic resources each makes available. The question of which mode to use to represent a particular aspect of a curriculum concept demands consideration of what is to be learnt and what is to made salient. The design of modes into multimodal ensembles, through layout structures and hyperlinks, is central to the use of modes and the shaping of curriculum knowledge. As the illustrative examples used throughout this chapter have shown the relationships between modes in a learning resource, for instance between image and writing, make a contribution to its meaning potential. The ways in which information from a learning resource is taken up and circulates in the classroom, for instance moving across the site of display of a worksheet to the student exercise book, to the Interactive whiteboard screen impacts on the way in which information is made available in the classroom, as well as what can then be done with it. The possibilities for interaction, manipulation, dissemination and connection that new technologies bring into the classroom both shape the curriculum knowledge circulating in the classroom (and beyond) and the practices that students and teachers engage with in the classroom.

This chapter has provided an account of how the design of the multimodal resources of computer applications might re-organise or re-mediate the practices of students that may lead to learning. Students' texts can be understood as semiotic signs of learning

from a multimodal perspective. Multimodality takes the external material signs that students (and teachers) make can be understood as embodying (in some way) the patterned exchanges and interactions that they emerged from. This leads to the interpretation of student's material expressions as one kind of 'evidence' of their thinking and learning.

Technologies are taken up and embedded in teacher and student practices in specific ways, washed over by the social, cultural and historical practices of curriculum subjects, institutional contexts, and policy requirements. Throughout the chapter has illustrated the semiotic work involved in interpreting multimodal meaning. The need to focus on students' engagement with a range of modes in the classroom has been shown as crucial for gaining insight on learning in the multimodal environment of the classroom. The resources that students bring to this engagement, their interests and experiences, have been demonstrated as key to the process of interpretation in the ways that students select, adapt and transform aspects of the designs that they engage with. In addition, the modal preferences which students apply to make sense of the different kinds of digital learning materials that they work with in the classroom has been demonstrated as a key element of multimodal interpretation. The role of hyperlinks and layering structures the process of multimodal interpretation and learning. The consequences of these choices for the ways in which learners are positioned to knowledge and the creation of learner identities have also been discussed.

Multiplicity is a defining characteristic of texts in the fluid digital space of the contemporary classroom. This multiplicity is realised via the viewing positions offered, the different entry points available, the various reading paths possible, and the range of modes configured. This serves to foreground the question of how best to design for learning. It also highlights the changing analytical and the decision-making skills that are demanded of student in the classroom. For instance, the importance of being able to establish and read across modes within an ensemble, to read hyperlink connections and layers, as well as understanding how to identify salience as it is realised multimodally.

A multimodal perspective offers a lens with which to investigate and understand school knowledge and practices that might lead to learning in the contemporary multimodal digital landscape of the classroom (and elsewhere). It also provides insights and analytical tools with which to re-imagine and re-design the classroom.

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