A dialogical understanding of the relationship between CSCL and teaching thinking skills

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Abstract. This paper reviews the literature linking ICT to teaching thinking skills and advocates a new dialogic framework which has implications for practice. The main conceptualisations of the relationship between ICT and teaching thinking are described as, the computer as tutor, the computer as cognitive tool and the computer as support for collaborative learning. The computer supported collaborative learning movement is critiqued for not always taking into account the radical implications of the concept of dialogue or 'dialogic' which is the idea that meaning-making requires the inter-animation of more than one perspective. It is then argued that dialogic lies at the heart of higher order thinking and that ICT has some unique affordances to help teach thinking through the deepening and broadening of dialogue. A dialogic theoretical framework for understanding the relationship of ICT to the aim of teaching thinking is presented with several implications for practice
Keywords: Collaboration, Dialogic, Thinking skills, CSCL, affordances, Heidegger

INTRODUCTION

From its inception the use of computers in education has been linked to the teaching of thinking skills. However the relationship between computers and teaching thinking has been conceptualised in a range of different ways reflecting both developments in the technology and a dialogue between theories of teaching and learning. Initially computers were seen as teaching machines programmed to directly instruct students in content and skills. Seymour Papert and others responded to this with a constructivist learning theory and software that could serve as tools and environments for actively learning thinking skills. Both these movements tended to focus on individual learners. Perhaps in reaction to this, and perhaps also reflecting the development of networked technology, there has been a development of research on computer supported collaborative learning (CSCL) in the last two decades drawing on various theoretical sources including socio-cultural theory and situated learning theory. In the CSCL movement there is considerable interest in teaching group thinking skills in the form of computer mediated collaborative problem-solving and argumentation. This paper argues that, beyond CSCL, a truly 'dialogic' perspective could be usefully applied to clarify the relationship between information and communications technology (ICT) and teaching thinking in a way that can guide practice. This dialogic view shares with socio-cultural theory the idea that individual thinking skills originate in mediated dialogues, however it goes further in also arguing for the central significance of establishing and maintaining a dialogic space in which different perspectives co-exist and inter-animate each other.

In order to develop this argument the paper begins with a brief account of thinking skills and a recapitulation of some of the main positions relating thinking skills to ICT.

THINKING SKILLS AND ICT

'Thinking skills' and related terms such as 'learning to learn' are used to indicate a desire to teach processes of thinking and learning that can be applied in a wide range of real-life contexts. The list of thinking skills in the English National Curriculum is similar to many such lists in including information-processing, reasoning, enquiry, creative thinking and evaluation. While some approaches to teaching thinking treat such skills as separate, other approaches treat them all as aspects of high quality thinking or 'higher order thinking'. Higher order thinking is said to be complex thinking that requires effort and produces valued outcomes (Resnick, 1997). Thinking skills programmes do not all focus on the narrowly cognitive but promote a variety of apparently quite different kinds of things including, strategies, habits, attitudes, emotions, motivations, aspects of character or self-identity and also engagement in dialogue and in a community of enquiry. These 'thinking skills' are not united by any single psychological theory. The best that one can say is that they are all those sorts of things that

practitioners believe can and should be taught or encouraged in order to improve the perceived quality and/or the effectiveness of their students' thinking. (Wegerif, 2003)

Computers have always been seen as 'smart' and the idea that working with computers will make children smarter is widespread. It is noticeable that toys for toddlers with computer chips in them have names such as `IQ builder', `L'il Genius' or `Brain Booster'. Popular Science Fiction films frequently show characters 'downloading' skills directly into their brains from computers. The implication is that human skills and computer programmes are isomorphic. Richard Clark refers to the cause of this popular linking of computers and thinking skills as the reification of a metaphor: the computer metaphor of mind popular in cognitive science (Clark, 1990, p268). When the mind is seen as a kind of computer it then seems plausible that working with computers can provide mind skills.

Another, rather different, source for the linking of ICT and teaching thinking is the view that ICT is changing the nature of work. A literature search on ICT and teaching thinking reveals the widespread belief that the proliferation if new information and communications technology is bringing about a new kind of economy in which the main products are information and knowledge rather than material goods (e.g Levin and Rumberger, 1995). Workers in this new economic climate are said to require transferable thinking skills more than content knowledge or task-specific skills. They particularly require an ability to learn how to learn new things since, it is claimed, accelerating technological change is making old skills (and knowledge) redundant and generating needs for new skills (and knowledge). Many of the flexible learning skills that new workers are said to need are ICT related. If all knowledge is soon to be available on the internet, so the argument goes, then we should not teach knowledge itself but the skills to search for and make sense of knowledge.

Surveys of the use of computers to promote thinking skills by Hughes (1990) and by Underwood and Underwood (1990) draw a sharp distinction between the use of computers as a tutor to teach thinking skills and the use of computers as a tool in order to develop skills indirectly. According to Solomon (1987) these conceptualisations, computer as tutor, computer as tool (Taylor, 1980) are reflections of two traditions in educational psychology: the Behaviourist/Empiricist tradition that conceptualises learning as acquiring and applying associations and the Cognitivist/Rationalist tradition that conceptualises learning as acquiring and using conceptual and cognitive structures (Greeno, Collins and Resnick in the 1996 Handbook of Educational Psychology). In the handbook of educational psychology Greeno et al also outline a third, more recent, strand which they refer to as the Situative/Pragmatist-Sociohistoric conceptualising learning as becoming attuned to constraints and affordances through participation. This third tradition has become an important influence in studies of ICT in education (see, for example, Crook 1994, Littleton and Light 1998). However, as Greeno et al point out, the idea of thinking skills that transfer from one context to another is highly problematic in the participative paradigm and on the whole this tradition of research has avoided the question of teaching general thinking skills in favour of studies of how learners appropriate local and situated cognitive skills (Rogoff et al, 1991).

Computer as tutor

The earliest conceptualisation of the role of computers in teaching and learning, sees the computer as a kind of teaching machine able to directly teach not only content knowledge but also some general thinking and learning skills. This conceptualisation, building on the mechanical teaching machines built by Skinner and associated with the work of Patrick Suppes (1979) is linked to the behaviourist tradition in psychology. Although it tends to be applied to drill and practice software teaching what Bloom (1956) would call lower order skills such as basic adding up, it can equally be applied to teaching what Bloom would call 'higher order skills' such as making effective generalisations. Gagne's instructional design principles recommend breaking down desired learning outcomes into a learning hierarchy with more complex skills resting on simpler skills (Gagne et al, 1992). To support 'transfer' he recommends, for example, providing practice of that skill in a variety of contexts with feed-back and assessment. This approach has been applied directly to teaching general thinking skills using reasoning test problems as the content to be taught (for example Riding and Powell, 1985)

Computer as 'mind tool'.

Seymour Papert applied constructivism to the role of computers (1980, 1993) advocating the use of programming and other active modelling environments to support learning (where learning was seen as the active construction of meaning).

For Papert, the exploration of programming environments offers children a key to understanding ideas in arithmetic, algebra and geometry, something that leads children from their own personal experience and knowledge to an appreciation of more formal, abstract mathematics. These experiences help to make the task of learning mathematics more relevant by creating a meaningful context in which they can experiment with mathematical concepts. Papert thought of this in terms of providing children with a living language with which to talk mathematics to the computer. According to Papert the act of programming helps to develop skills such as

that of breaking down problems into manageable units, and these skills can then be applied to other situations. Papert refers to these generalizable problem-solving skills as 'powerful ideas' and points to the opportunity that programming provides for children to reflect on their own thinking.

Underlying Papert's work is the theory of Jean Piaget and its distinction between 'concrete' and 'formal' thinking. Papert regards the computer experience as a way of making concrete and personal the abstract and formal:

> *... it is not just another powerful educational tool. It is unique in providing us with the means for addressing what Piaget and many others see as the obstacle which is overcome in the passage from child to adult thinking. I believe that it can allow us to shift the boundary separating concrete and formal.*
> (Papert, 1980, p. 21)

Constructivism is now probably the dominant paradigm in the design of educational multimedia (Boyle, 1996, p83). Writing about so-called 'Mindtools' Jonassen (2000) outlines the significance of cognitive psychology and constructivism for the use of technology to promote the development of thinking skills.

Mindtools are computer applications that, when used by learners to represent what they know, necessarily engage them in critical thinking about the content they are studying. Mindtools scaffold different forms of reasoning about content. That is, they require students to think about what they know in different, meaningful ways. For instance, using databases to organize students' understanding of content organization necessarily engages them in analytical reasoning, where creating an expert system rule base requires them to think about the causal relationships between ideas. Students cannot use Mindtools as learning strategies without thinking deeply about what they are studying (Jonassen, 1998).

The main idea, also articulated by Underwood and Underwood, (1990) and by Salomon, (1990), is not that computers will directly teach thinking but that, after working in partnership with computers, the student will internalise the way that computers think as a cognitive tool for their own use.

Computer Supported Collaborative Learning and teaching thinking.

In a ground-breaking book entitled 'Understanding Computers and Cognition' (1986) Winograd, one of the leaders in Artificial Intelligence research, and Flores convincingly criticised the view of minds as symbol processing machines like computers. They argued that that computers do not help us think by mimicking human intelligence but that they can support those human practices, particularly communicative practices, in which cognition is embedded. Crook (1994, p 67) argues similarly that computers are not capable of sustaining the kind of intersubjectivity that teaching and learning requires but that they have a potential role in resourcing and supporting collaborative learning. Although their arguments have similarities they reference different intellectual traditions. It is interesting that Winograd and Flores (1986) refer to Heidegger frequently and Vygotsky not at all while Crook (1994) refers to Vygotsky frequently and Heidegger not at all.

The development of a focus on computer supported collaborative learning (CSCL) has been marked in the last decade with new CSCL societies, conferences and publications emerging. Numerous and varied intellectual sources are referred to by writers who situate themselves in this new CSCL tradition. Koschman refers to CSCL as a new paradigm in instructional technology research defined through socio-cultural theories of learning (Koschman, 2000), but writers in CSCL also draw on Hermeneutics (e.g Stahl, in press), situated learning theory, distributed cognition, social constructivism, Bandura's social learning theory (Ravenscroft, 2003), phenomenology (McConnell, 2000) amongst other sources.

While some of the claims for the coherence of CSCL as a new paradigm might be exaggerated nonetheless there is clearly a focus on social rather than individual learning that distinguishes this new approach from both the behaviourist and the cognitivist/constructivist traditions that underlay previous approaches to ICT and teaching thinking. Most writers in the CSCL tradition do refer to the ideas of educational psychologist Lev Vygotsky (1986) to provide intellectual authority for a turn towards the social dimension of learning. Vygotsky, a Marxist, is often presented as providing a psychological version of Marx's claim that individual thought is a product of the social and historical context (e.g. Edwards, 1996, p43). In particular Vygotsky claims that language is a tool-system that mediates thought and the development of thought. If language can play the role of a cognitive technology mediating and supporting thought then this perhaps implies that so can other technologies of communication. Vygotsky claimed that the higher mental faculties including reason were internalised versions of forms of social interaction. Neo-Vygotskians move from this to focus on the forms of interactions themselves as incarnating higher order thought (Stahl, 2005, Wegerif, 2004). In the CSCL approach the idea of information and communications technology is intimately connected to the idea of teaching thinking in the form of social interactions such as argumentation and collaborative problem solving.

The roots of the enterprise of teaching critical thinking are not necessarily individualist. John Dewey, an advocate of teaching thinking, saw thinking as a product of social interaction and teaching thinking as a way of contributing to the creation of a better society (Dewey, 1933). This is reflected in statements from leaders of the applied teaching thinking movement that locate 'thinking skills' in dialogues and in communities of inquiry

(Paul, 1997; Lipman, 2002). Jurgen Habermas (1991), has argued in a similar way to Dewey that rationality implies the ideal of a more genuinely democratic society in which all relevant voices are really listened to and decisions are taken on the basis of the quality of arguments rather than on the basis of coercive power. One educational implication of Habermas's argument is that teaching thinking skills involves changing the social context to create conditions that at least approximate to what he calls an 'ideal speech situation'. There have been a number of claims that the structural properties of CMC, the ease with which anyone can 'take the floor' and the possibility of multiple threading for example, make it a better medium for an 'ideal speech situation' than face-to-face dialogue (Graddol, 1989; McConnell, 2002) and suggestions that new technologically could serve to support better collective thinking in institutions such as schools and in society at large (Selwyn, 2003).

TOWARDS A NEW 'DIALOGIC' PARADIGM

The term dialogic is now used quite loosely for anything pertaining to dialogue in education. Vygotsky's theories applied to education are sometimes referred to as dialogic (e.g Wells, 1999). This misses an opportunity to make a more radical and useful distinction between truly dialogic and essentially monologic theories. Sources of dialogic theory in the writings of Bakhtin (1981), Volosinov (who many see as also Bakhtin, 1986) Rommetveit (1991) and Linell (1998) suggest a very simple and clear distinction between the dialogic and the monologic. While a monologic utterance pretends to the status of a fixed and settled truth, a dialogic utterance cannot be understood without reference to the context in which it occurs in a dialogue. Or even more simply, monologic assumes a single perspective while dialogic assumes the interanimation of more than one perspective. This simple and clear distinction points to a philosopher who has not figured so far in the varied intellectual sources of CSCL, Derrida who argued for the importance of the thinking of difference as opposed to the thinking of identity (Derrida, 1967). Derrida's main point is that difference precedes and exceeds identity but that human thought always reduces difference to identity because the consequences of thinking through difference are too radical and undermining of deep preconceptions. Dialogue is a relation of difference (or différance) in the Deriddean sense, it is the creative space opened up between two or more identities which is not reducible to identity because defined through the inter-animation of more than one perspective. It follows that methods which attempt to pin down the exact meaning of utterances in a dialogue are misguided because the meaning depends on a dynamic context of interpretation which can never be completely closed or finalised. Dialogues do not only work through exchanging more or less precise meanings but also through opening up a space of multiple possible meanings.

Dialogic is implicated in the idea of consciousness and of learning to think creatively. The evidence from developmental psychology (e.g Hobson 2002) suggests that babies and toddlers learn to become aware of things as separate and nameable, through being drawn into a dialogic relationship with their mother or primary care-giver which enables them to see things from two perspectives at once. Hobson goes on to argue that an individual sense of self-awareness and an ability to think creatively when alone are a product of the internalisation of dialogues with significant others (Hobson, 1998). He refers to such dialogues, beginning with peek-a-boo games in the cradle, as opening up mental space, a space of possibilities from which things become thinkable.

Hobson's idea of dialogic as mental space suggests a link between dialogic and thinking skills. This is not the external explicit link sought for by research on how knowledge building occurs in conversations but the internal implicit link through the creative opening offered by dialogue. Dialogue itself, a capacity to engage in dialogue and to see things dialogically, appears to be the primary thinking skill from which other higher order skills are derivative.

Hobson was working with babies up to 18 months but there is also experimental evidence from primary schools that the quality of individual thinking can be improved through improving the quality of dialogue in groups and classes (Wegerif, 2001; Wegerif, Mercer and Dawes, 1999). This evidence further supports the theory that individual thinking skills originate in conversations where we learn to reason, to evaluate, to join in creative play and to provide relevant information. Beyond the normal interpretation of Vygotsky: what is being internalised into individual thought is not only knowledge building strategies but also a dialogic mental space..

Approaches, sociocultural or otherwise, which refer to computers supporting learning through dialogue without acknowledging the dialogic nature of the creative space opened up by dialogue, remain in danger of a reduction to identity thinking. For example it is quite possible to study the learning in dialogues in terms of explicit outcomes resulting from explicit mechanisms as if machines without consciousness could have learnt equally well from the dialogue as humans. Through a reduction to identity such approaches obscure the important possibility that teaching thinking skills is not only about teaching explicit skills but also about deepening and extending dialogue as an end in itself.

A FRAMEWORK FOR ANALYSING TEACHING THINKING WITH ICT

A dialogic perspective on the relationship between ICT and teaching thinking suggests a number of analytic principles that amount to a framework for use as a guide to practice.

Technology deepening and broadening dialogue

Loveless (2003) reports that the particular strengths of ICT in education can be mapped as:

- Provisionality: the ability to change texts and other outputs with minimum cost
- Interactivity: the capacity for feedback and response
- Capacity and Range: the capacity to handle large amounts of information and overcome barriers of distance
- Speed and Automatic functions: enabling routine tasks to automated

In addition, as we have just noted, the capacity to support multi-modal dialogues is also relevant. All of these strengths can be put to use in deepening and broadening dialogues. Provisionality can support reflection and the development of joint ideas through products, including texts and other artefacts, that are not as ephemeral as speech and not as apparently fixed and changeless as print. Interactivity can be used to provide contingent support for dialogues, even the simple prompts, 'what do you think?' and 'why do you think that ?' in the right place can have a profound effect on learning (Wegerif, 2004 b). Interactivity makes it easy for software to simulate multiple points of view in a dialogue. Capacity and range enable ICT to expand dialogues to every corner of the world and to include every perspective, the internet and uses of the internet to exchange information in multi-modal forms such as Oxfams OneWorld.tv site where video stories from across the world are exchanged illustrate this (http://tv.oneworld.net/). Finally speed and automatic functions can enable access to important dialogues for a wider range of participants - visualization tools allowing participants to use complex information for example.

Technology integrating levels and types and dialogue

Dialogues are a relationship between people or perspectives framing a flow of meaning. This flow of meaning is focused and articulated by signs and communications technologies but not reducible to those signs or technologies. This dialogic understanding provides us with a way to appreciate how different levels and types of dialogue can be integrated in flows and meaning. For example when groups of children talk together to create emails that they send to other groups of children who talk together to interpret them (Meij et al 2004) then the written email dialogue needs to be interpreted in the light of the oral dialogue. While the use of ICT to support learning dialogues is not simply the support of learning through talking, nonetheless we need to be aware of how orality and perceptual languages such as art and music are integrated into the learning that occurs through and around ICT mediated dialogue. The multi-modal dialogue made possible by ICT allows the interesting possibility of dialogic interaction between different representations of meaning, words, music, visual images and so on.

Dialogue with social and historical context

While the socio-cultural perspective and activity theory argue that cognition is embedded in social and historical contexts a dialogic perspective would argue that this is only one half of the story. What counts as social and historical context is an interpretation that is created through dialogues. One implication of the assumptions of activity theory is that the social and historical context is a relatively fixed framework in which the distinctions pointed to by Engestrom's analytic triangles (Engestrom, 2001) are always pertinent, distinctions such as 'subjects', 'objects', 'tools', 'division of labour' – all the apparatus of German idealist philosophy as reversioned by Marx. However in dialogues people can categorise the world in many different ways and these ways of categorising the world can then become significant factors behind their actions.

In a dialogue there is an apparent movement of meaning from outside the head, words embodied in sounds for example, to inside the head and back out again in new words. Vygotsky famously claimed that the development of higher order thinking resulted from a movement of internalisation. However in any dialogue moments of internalisation and externalisation are united in a whole flowing movement of meaning. This is true from moment to moment in a dialogue as we 'take on board' ideas, reformulate and respond to them internally and then express our response in new patterns of signs. It is also true over a longer timescale. We do not only internalise our social contexts over time we also externalise our thoughts in order to transform those contexts. In any shared enquiry we are not only in dialogue with a dialogue partner, we are also in dialogue with a culture and a tradition.

To picture thinking as a whole circular movement it might help to think of the way that we all, as creative speakers and writers, use words and phrases that we find already here, external to us, in the language around us, and yet we also shape the development of that shared resource of language. Language is a useful example

because, following Vygotsky, it is possible to refer to language as a cognitive technology that mediates the circle of thought. If language can be referred to metaphorically as a technology mediating the whole flowing movement of thought the same is more literally true for those information and communications technologies that carry and resource dialogues.

The terms 'internal' and 'external' are problematic. I am using them here only as an easily grasped short-hand. I would prefer Heidegger's (1967) formulation of the movement of thought as the circling of the Being of beings around the beings of Being. From a dialogic perspective this circling is part of the nature of dialogue and only occurs within the space opened up by dialogue.

While the way that we all participate in developing the spoken language is one example of the circling of dialogue and tradition, a more social technology focused example can be provided by the UK 'National Grid for Learning'. This was set up by the government with the intention that teachers learn from each other's best practice. The feedback was that teachers lacked the time, the access and the inclination to use it. Attention has increasingly turned to providing teachers and schools with cheap lap-tops at home, broad-band internet access, places and times when it is possible to access the network and shifting cultures and habits to make this more likely to happen. The message of this is that to improve the quality of collective thinking it is not enough to purify the language used or to improve the cognitive affordances of a conferencing environment, it is also necessary to design social environments and social practices that afford high quality thinking.

Three moments: internalisation, Mediation, Externalisation

In the light of the understanding that thinking is a technologically mediated whole circular movement uniting individual (internal) and social (external) moments it becomes apparent that interventions to improve the quality of thinking could occur at different moments. Most approaches to teaching thinking have focussed on the movement of internalisation when cognitive tools move from the social to become appropriated by the individual. It would equally make sense to support the moment of externalisation when collective thought is transformed creatively by an individual to become a participation in a context-creating dialogue or to intervene to improve the cognitive affordances of the technological mediation of shared thinking. To take a more Heideggerian perspective, this is the equivalent of saying that we need to look both at the movement of implication, whereby structures found in front of us in the world join the background and become implicit behind our thought and our actions, and at the movement of expression whereby new things emerge from the background and are made explicit.

Internalisation

Vygotsky's idea of how teachers work through a 'zone of proximal development' to help learners acquire new skills refers to the moment of the internalisation by individuals of pre-existing cultural tools mediated by the scaffolding work of tutors. To give an example, the strategy of thinking up a range of alternative possible answers to a problem set could be modelled in group dialogue using concept-mapping, mediated by a tutor, and appropriated by an individual who is then able to use the same strategy alone with and without a physical external concept map (e.g Roth and Roychoudhury, 1994).

Externalisation

An individual or group's capacity to participate in shared social dialogues can be supported through the use of technology. Cobb and McClain illustrate how visualisation tools that allow users to grasp and manipulate complex statistical relationships can empower learners to participate in dialogues about public policy (Cobb and McClain, 2000). This form of empowerment enabling expression and participation, is a way of improving the quality of individual and collective thinking.

Technological mediation

On this model there is no unmediated thinking, internalisation and externalisation (implication and explication) are always mediated, but the quality of the mediating technology can also be addressed directly as a way of improving the quality of thought. Mallarmé expressed this approach to teaching thinking when he described the role of the poet as: "Donner un sens plus pur aux mots de la tribu" ('To give a purer meaning to the words of the tribe' Mallarme, 1879/1998). In a similar way the educational technologist can work to improve the affordances for clear and productive thinking provided by the conferencing system or software interface that mediates collaboration. A simple example of this would be to provide visual supports for argumentation (Kirschner et al 2003).

CONCLUSIONS

This paper outlines different conceptualisations of the relationship of ICT to the enterprise of teaching thinking and focuses on the recent Computer Supported Collaborative Learning (CSCL) model which stresses the role of technology in supporting dialogues. The paper argues for a truly dialogic approach to understanding the relationship between CSCL and thinking which has implications for practice. The most important of these implications is that the aim of teaching thinking should not only be the development of specific cognitive techniques and technologies but also the broadening and deepening of dialogue as an end in itself, both locally and globally, over the short-term and over the longer-term. The affordances of ICT in education are particularly suited to this aim. The dialogic framework for understanding the relationship between CSCL and teaching thinking that is proposed suggests that higher order thinking needs to be understood as a circular movement uniting individual with social thinking, implicit background thinking and explicit signs, and combining different levels and type of dialogue within a whole flow of meaning. At least three implications for practice follow from this framework: firstly that rather than focus on the moment of internalisation or the moment of expression or the technological mediation of social thought, to teach thinking effectively it is best to support all three moments of the circle of thought in a coherent way: secondly, that to have a maximum impact on the quality of thinking we should look at ways to support the integration of different levels and types of dialogue, perceptual, oral and written modes for example: and thirdly, that we should be very cautious in the use of media that attempt to pin-down meanings, for example through hidden ontologies that force users to choose between pre-defined types of utterance, instead preferring media that allow for creativity and a resonant relationship with the background of thought.

REFERENCES

Bakhtin, M. (1981) *The Dialogic Imagination*, University of Texas Press

Bloom, B.S. (Ed.) (1956) Taxonomy of educational objectives: The classification of educational goals: Handbook I, cognitive domain. New York ; Toronto: Longmans, Green.

Boyle, T (1997) Design for multi-media learning. Hemel Hempstead: Prentice Hall

Clark, R. E. (1990). Facilitating domain-general prolem solving: Computers, cognitive processes and instruction. In E. De Corte, M. C. Linn, H. Mandl and L. Verschaffel (eds) *Computer-Based Learning Environments and Problem Solving.* Berlin, Springer-Verlag**:** 265-287.

Claxton, G (1999) Wise-Up: the challenge of lifelong learning. London: Bloomsbury.

Cobb, P and McClain, K (2002) Supporting Students Learning of Significant Mathematical Ideas. In Wells, G. and Claxton, G (eds) Learning for life in the 21st Century.

Conceptualization. *Journal of Education and Work* **14** (1): 133-156.

Crook, C. (1994) Computers and the collaborative experience of learning. London and New York: Routledge.

Derrida, J. (1968) La Différance, in Théorie d'ensemble, Paris : Éditions de Seuil page 43 to 69. Also in Margins of Philosophy etc

Dewey, J. (1933) How We Think 2e, New York: D. C. Heath

Edwards, D. 1996. Discourse and Cognition. London: Sage.

Engestrom, Y., (2001). Expansive Learning at Work: Toward an Activity Theoretical

Forrester, M. A. (1992) The Development of Young Children's Social-Cognitive Skills, New Jersey: Lawrence Erlbaum Associates.

Gagne, R., Briggs, L. & Wager, W. (1992). Principles of Instructional Design (4th Ed.). Fort Worth, TX: HBJ College Publishers

Graddol, D., (1989) Some CMC discourse properties and their educational significance, in Mindweave, A. Kaye, Editor. Pergamon: Oxford.

Greeno, J., Collins, A. and Resnick, L. (1996). Cognition and learning. Handbook of Educational Psychology. D. Berliner and R. Calfee. New York, MacMillan: 15-46.

Habermas, J. (1991) The Theory of Communicative Action Vol 1. Cambridge: Polity Press.

Heidegger, M. *Identity and Difference*. Bilingual ed., trans. J. Stambaugh. New York: Harper and Row, 1969.

Higgins, S. and V. Baumfield (1998). A defence of teaching general thinking skills. Journal of Philosophy of Education 32(3): 391-398.

Hobson, R. P (2002) The Cradle of Thought : Exploring the Origins of Thinking. London: Macmillan

Hobson, R. P. (1998) The intersubjective foundations of thought. In S. Braten (ed.) *Intersubjective Communication and Emotion in Ontogeny*. Cambridge: Cabridge University Press, pp 283-96

http://www.medfac.unimelb.edu.au/ascilite2001/pdf/papers/koschmannt.pdf [Accessed 10th August 2004]

Hughes, M. 1990. Children's computation. In Understanding Children, edited by R. Grieve and M. Hughes. Oxford: Basil Blackwell.

Jonassen, D, Carr, C., Yueh, H (1998) Computers as Mindtools for Engaging Learners in Critical Thinking. TechTrends, v43 n2 p24-32

Jonassen, D. (2000). Computers as mindtools for schools: engaging critical thinking. 2e. New Jersey: Prentice Hall.

Kirschner, P Buckingham Shum S and C. Carr (Eds.) 2003 **Visualizing Argumentation: Software Tools for Collaborative and Educational Sense-Making**. Springer-Verlag: London

Koschmann, T. (2001). Revisiting the paradigms of instructional technology. In G. Kennedy, M. Keppell, C. McNaught & T. Petrovic (Eds.), *Meeting at the Crossroads.* Proceedings of the 18th Annual Conference of the Australian Society for Computers in Learning in Tertiary Education. (pp. 15 - 22). Melbourne: Biomedical Multimedia Unit, The University of Melbourne. Available online at:

Levin, H and Rumberger, R (1995) Education, work and employment in developed countries: Situation and future challenges. In J. Hallak and F. Caillods (eds) Educational Planning: The international dimension (pp. 69-88). UNESCO Bureau of Education, International Institute for Educational Planning. London: Garland.

Linell, P. (1998). *Approaching Dialogue: Talk, interaction and contexts in dialogical perspective*. Amsterdam, Benjamins.

Lipman, M. (2002, Second Edition) Thinking in Education. Cambridge: Cambridge University Press.

Littleton, K and Light, P (eds) Learning with Computers: analysing productive interaction. London: Routledge.

Loveless, A (2003) Creating Spaces in the Primary Curriculum: ICT in creative subjects. The Curriculum Journal 14, 1, 5 - 21

McConnell, D., (2000 Second Edition.)Implementing Computer Supported Cooperative Learning. London: Kogan Page.

Newman, D., Griffin, P. and Cole, M. (1989) The Construction Zone: Working for Cognitive Change in School. Cambridge: Cambridge University Press.

Papert, S (1993) The Children's Machine: Rethinking School in the Age of the Computer New York: Basic Books

Papert, S. (1981) Mindstorms. Brighton: Harvester.

Paul, R. W. 1987. Dialogical Thinking: Critical Thought Essential to the Acquisition of Rational Knowledge and Passions. In Teaching Thinking Skills: Theory and Practice, edited by J. B. In Baron and R. J. Sternberg. New York: H. Freeman and company.

Ravenscroft, A. (2003). From conditioning to learning communities: Implications of 50 years of research in eLearning interaction design. Association for Learning Technology Journal (ALT-J), Vol. 11, No. 3, pp. 4-18.

Resnick, L. (1987). Education and learning to think. Washington D.C, National Academy Press.

Riding, RJ, and Powell, SD (1985) The facilitation of thinking skills in pre-school children using computer presented activities. Educational Psychology 5(2).

Rogoff, B., G. Gauvain, and C. Ellis. 1991. Development viewed in its cultural context. In Learning to think, edited by P. Light, A. Sheldon and B. Woodhead. London: Routledge/OU.

Rommetveit, R. (1992). Outlines of a Dialogically Based Social-Cognitive Approach to Human Cognition and Communication. In A. Wold (Ed.), *The Dialogical Alternative: Towards a Theory of Language and Mind*, (pp. 19 - 45). Oslo: Scandanavian Press.

Roth, W. M., and Roychoudhury, A. (1994). Science discourse through collaborative concept mapping: new perspectives for the teacher. International Journal of Science Education, 16, 437-455.

Saljo, R (1998) Learning as the use of tools: a socio-cultural perspective on the human-technology link. In Littleton, K and Light, P (eds) Learning with Computers: analysing productive interaction. London: Routledge.

Scardamalia, M., and C. Bereiter. (1991) Higher levels of agency for children in knowledge building: a challenge for the design of new knowledge media. The journal of the learning sciences 1 (1):37-68.

Selwyn, N (2003) Citizenship, technology and learning: a review of the literature for NESTA FutureLab (http://www.nestafuturelab.org/) ISBN 0-9544695-2-6

Solomon, C. (1987) *Computer Environments for children*. Cambridge, Ma: M.I.T press.

Stahl, G (In press for 2005) Collaborating with Technology: Studies in the Theory and Design of Online Collaboration. Cambridge, Ma: MIT press

Stahl, G. (2000). *A Model of Collaborative Knowledge-Building*. In B. Fishman and S. O'ConnorDivelbiss (Eds.), Fourth International Conference of the Learning Sciences, Erlbaum, Mahwah, NJ, pp. 7077.

Suppes, P (1979) The future of computers in education. *Journal of Computer-Based Instruction*, **6**, 5-10

Taylor, R.P. (ed) (1980). *The computer in the school; tutor, tool, tutee.* New York; Teacher's College Press.

Underwood, J., and G. Underwood. (1990) Computers and Learning. Oxford: Basil Blackwell.
Van der Meij, H. , De Vries, B., Boersma, K., Pieters, J. Wegerif, R. (2004) An Examination of Interactional Coherence in Email Use in Elementary School. Computers in Human Behaviour.
Volosinov, V. N. (1986) *Marxism and the Philosophy of Language*, Cambridge,MA: Harvard University Press
Vygotsky, L. (1986) Thought and Language. Cambridge Ma: M. I. T Press.
Wegerif (2003) Thinking skills, technology and learning: a review of the literature for NESTA FutureLab (http://www.nestafuturelab.org/) ISBN 0-9544695-2-6
Wegerif R. (2001) . Applying a Dialogical Model of Reason in the Classroom. In Joiner, R, Faulkner, D Miell, D. and Littleton, K. (eds.) *Rethinking Collaborative Learning*, Free association Press.
Wegerif, R and Dawes, L (2004) Thinking and Learning with ICT: Raising achievement in the primary classroom. London: Routledge.
Wegerif, R (2004a) Towards an Account of Teaching General Thinking Skills That is Compatible with the Assumptions of Sociocultural Theory. Educational Theory and Research.
Wegerif, R. (2004b) The role of educational software as a support for teaching and learning conversations. Computers and Education.

Wegerif, R. and Mercer, N. (1997) A Dialogical Framework for Investigating Talk. In Wegerif, R. and Scrimshaw, P. (Eds) *Computers and Talk in the Primary Classroom*, pp 49-65. Clevedon: Multilingual Matters.
Wegerif, R., Mercer, N., and Dawes, L. (1999) From social interaction to individual reasoning: an empirical investigation of a possible socio-cultural model of cognitive development. Learning and Instruction. Vol. 9, 5, 493-516
Wells, G. (1999) Dialogic inquiry: Towards a sociocultural practice and theory of education. New York: Cambridge University Press.
Wenger, E. (1999) Communities of Practice. Learning, meaning and identity, Cambridge: Cambridge University Press.