Cazden, C. (2001). *Classroom discourse: The language of teaching and learning*. Portsmouth: Heinemann.
Chin, C., & Osborne, J. (2010). Supporting argumentation through students' questions: Case studies in science classrooms. *Journal of the Learning Sciences, 19*(2), 230–284.
Dewey, J. (1933). *How we think*. Buffalo, NY: Prometheus Books (Originally published in 1910).
Dillon, J. T. (1984). Research on questioning and discussion. *Educational leadership, 42*, 50–56.
Dillon, J. T. (1988). The remedial status of student questioning. *Journal of Curriculum Studies, 20*(3), 57–74.
Engle, R. A., & Conant, F. R. (2002). Guiding principles for fostering productive disciplinary engagement: Explaining an emergent argument in a community of learners classroom. *Cognition and Instruction, 20*(4), 399–483.
Graesser, A. C., Lu, S., Jackson, G. T., Mitchell, H., Ventura, M., Olney, A., & Louwerse, M. M. (2004). AutoTutor: A tutor with dialogue in natural language. *Behavior Research Methods, Instruments, and Computers, 36*(2), 180–193.
Graesser, A. C., McNamara, D. S., & VanLehn, K. (2005). Scaffolding deep comprehension strategies through Point&Query, AutoTutor, and iSTART. *Educational Psychologist, 40*, 225–234.
Habermas, J. (1984). *The theory of communicative action*. Boston, MA. Beacon Press.
Hardman, M., & Delafield, B. (2010). Philosophy for Children as dialogic teaching. In K. Littleton & C. Howe (Eds.), *Educational dialogues: Understanding and promoting productive interaction* (pp. 149–164). London: Routledge.
Henderson, B., & Moore, S. G. (1979). Measuring exploratory behavior in young children: A factor-analytic study. *Developmental Psychology, 15*(2), 113–119.
Koppa, K. J., Britt, A. M., Millis, K., & Graesser, A. C. (2012). Improving the efficiency of dialogue in tutoring. *Learning and Instruction, 22*(5), 320–330.
Lipman, M. (2003). *Thinking in education* (2nd ed.). Cambridge: Cambridge University Press.
Lipman, M., & Sharp, M. (1978). *Growing up with philosophy*. Philadelphia: Temple University Press.
Lipman, M., Sharp, A. M., & Oscanyan, F. S. (1980). *Philosophy in the classroom* (2nd ed.). Philadelphia: Temple University Press.
Ludvigsen, S., Rasmussen, I., Krange, I., Moen, A., & Middleton, D. (2011). Intersecting trajectories of participation: Temporality and learning. In S. Ludvigsen, I. Rasmussen, A. Lund & R. Säljö (Eds.), *Learning across sites: New tools, infrastructures and practices* (pp. 105–121). New York: Routledge.
Passmore, J. A. (1970). *Philosophical reasoning* (2nd ed.). London: G. Duckworth.
Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.
Sanders, N. (1966). *Classroom questions: What kind?* London: Longman.
Schwarz, B. B., & Asterhan, C. S. C. (2010). Argumentation and reasoning. In K. Littleton, C. Wood & J. Kleine Staarman (Eds.), *International handbook of psychology in education* (pp. 137–176). Bradford, UK: Emerald Group Publishing.
Schwarz, B. B., & Asterhan, C. S. C. (2011). E-moderation of synchronous discussions in educational settings: A nascent practice. *The Journal of the Learning Sciences, 20*(3), 395–442.
Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.
Topping, K. J., & Trickey, S. (2007). Collaborative philosophical enquiry for school children: Cognitive effects at 10–12 years. *British Journal of Educational Psychology, 77*(2), 271–288.
Wong, B. Y. L. (1985). Self-questioning instructional research: A review. *Review of Educational Research, 55*, 227–268.
Zuckerman, G. A., Chudinova, E. V., & Khavkin, E. E. (1998). Inquiry as a pivotal element of knowledge acquisition within the Vygotskian paradigm: Building a science curriculum for the elementary. *Cognition and Instruction, 16*(2), 201–233.

38

Thinking, interthinking, and technological tools

Simon Knight

KNOWLEDGE MEDIA INSTITUTE, OPEN UNIVERSITY, UK

Karen Littleton

CENTRE FOR RESEARCH IN EDUCATION AND EDUCATIONAL TECHNOLOGY, OPEN UNIVERSITY, UK

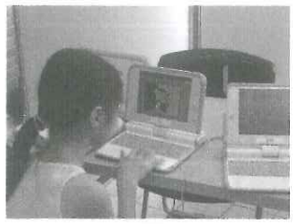
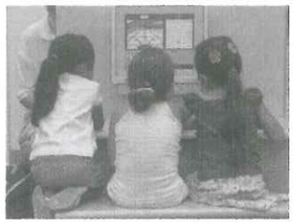
Introduction: the development of individual and collective thinking

The pictures here (see Figure 38.1) will be familiar to most who have had any contact with educational settings in the last 20 or so years. Indeed, one of our most recent books (Littleton & Mercer, 2013) reflected on one of the first pieces of research into school-classroom based dialogue from that time. There, it was noted that in many cases group work around computers was conducted not due to any underlying pedagogic strategy, but because of a lack of resources. For many this will be a familiar story, but along with colleagues, we have spent considerable effort in investigating what constitutes effective learning in group activity particularly that mediated by technological devices. Of course, many educators – as was the case in that original research – will have had the experience of frustration in some such situations, finding occasions when group work seemed to be ineffective and suspecting that a better use of resources would be to set students on individual tasks. Indeed, what is so potent about many new technologies is their ability to open up new worlds of learning for individuals. Yet, in this chapter we will argue that to see technology as primarily an *individual* pursuit is to miss out on two important considerations: firstly, many modern technologies vastly expand the potential for inter-textual and inter-active elements (Wegerif, 2013) through our interaction with which we are exposed to the thoughts and arguments of others and, secondly, technology can be an invaluable aid in resourcing and supporting both co-located and remote small group activity.

Throughout this chapter we aim to highlight the ways in which shared use of technology can be seen as both an individual and collective resource, and foreground the importance of dialogue as being of fundamental importance in such contexts.

Language and thinking

The Russian psychologist, Lev Vygotsky, highlighted the importance of language for thinking, emphasising that:


1 By Allen Timothy Chang, licensed under CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0/). Retrieved from: https://commons.wikimedia.org/wiki/File:Girl_using_OLPC.JPG.
2 By San José library, licensed under CC-BY-SA-2.0 (https://creativecommons.org/licenses/by-sa/2.0/). Retrieved from: https://www.flickr.com/photos/sanjoselibrary/3887312861.
3 By Will Kay, licensed under CC-BY-SA-2.0 (https://creativecommons.org/licenses/by-sa/2.0/). Retrieved from: https://www.flickr.com/photos/william-a-kay/5015161355.

Figure 38.1 Diverse contexts for the potential of technology for thinking and interthinking.

> what children gain from their 'intermental' experience (communication between minds through social interaction) shapes their 'intramental' activity (the ways they think as individuals). What is more, he suggested that some of the most important influences on the development of thinking will come from the interaction between a learner and more knowledgeable, supportive members of their community.
>
> *(Mercer, 2003)*

Building on this premise, one of us (Simon Knight) in earlier work on the importance of dialogue in the effective use of interactive white boards (IWB) noted that:

> With respect to direct pedagogical functions (as opposed to social functions such as behaviour management), dialogue seems to serve several purposes:
>
> 1 supporting individuals' subject learning
> 2 supporting psychological development – the development of oral language and reasoning skills
> 3 promoting whole class and small group understanding or commonality
> 4 enabling sharing of ideas that can be improved together (both whole class and small group) – a purpose the IWB is particularly well placed to serve.
>
> *(Knight, 2013b)*

Traditionally educational researchers have been particularly interested in the first two of these concerns, regarding the effectiveness of group work for individual learning. Similarly, psychological research has tended to focus on the individual impact of social interaction on thinking and learning. The focus, then, has been on how collaboration changes individuals, as opposed to how collaboration might be an object of inquiry in its own right. The implication is that there are clear individual benefits to high quality dialogue; that taking individuals as the focus is not such a poor strategy in the analysis of classroom dialogue. Of course this will be of little surprise. When in conversation a person informs you of some fact, which you then use, some learning has taken place. Moreover, when they demonstrate some linguistic method such as a particular argumentation structure, you may use that format to resource your own subsequent thinking. It is for this reason that in both

philosophy and psychology there is an increasing interest in 'testimonial knowledge' – the knowledge we gain from other's testimony, largely through speech – and as Harris (2012) has noted, the trusting of what you are told is at least some of the time fundamental to the learning experience.

There is a parallel to this focus on learning directly from others, in the use of technology in the classroom. When teachers stand at the front of classrooms and provide students with information, or warn them of dangers in science experiments and so on we expect students to trust that information. Similarly, when we ask students to engage in research, using books and increasingly the internet, we hope that they will use their critical skills to engage with some of the information that they find. High quality dialogue, then, could simply be an enhanced version of this type of exchange; the appropriation of claims from reliable informants.

Much group work takes this individualistic level of analysis as its focus. For example, this notion of information exchange has sometimes been termed 'transactivity' which has in some circumstances been operationalised at an individualistic level, with individuals placed into situations in which they have information required by other group members for the completion of some task. Indeed, much group work research takes this level of analysis as its focus – the individual, as opposed to the collaborative unit. This focus on individual activity in collaborative contexts in contrast to collaborative units is common to much group work research, for example Azmitia and Montgomery's (1993) analysis of information transmission via individual's explicit statements (rather than on the language used to co-construct). It is to this perspective on dialogue, as a co-constructive tool to interthink, that we turn in the next section.

Interthinking

We began the preceding section by noting the significance of Vygotsky in our understanding of learning. However, as we note in the previous section, this view of the transmission of knowledge from experts to novices provides only one – albeit important – facet of the potential of dialogue for learning. There is now strong consensus that high quality educational dialogue among peers is associated with positive learning outcomes (see the collection edited by Littleton and Howe (2010)). Engaging children in extended talk which encourages them to 'interthink' and reason together in talk, impacts both their subject learning, and general reasoning skills (Dawes, Mercer, & Wegerif, 2004; Mercer, Dawes, Wegerif, & Sams, 2004; Mercer & Littleton, 2007; Mercer, Wegerif, & Dawes, 1999; Mercer & Sams, 2006; Rojas-Drummond, Littleton, Hernández, & Zúñiga, 2010) as well as their social and language skills (Wegerif, Littleton, Dawes, Mercer, & Rowe, 2004).

However, a common concern in computer-based tasks, is that the shared nature of the resource may reduce the need for children to talk and articulate their knowledge explicitly. This suggests the need for task-based studies which explore the ways that discourse is used (Clark & Brennan, 1991; Pickering & Garrod, 2004). Indeed:

> some problems that learners may encounter in Computer Supported Collaborative Learning (CSCL) environments seem to be enhanced in these contexts, for example, due to a lack of social presence or limited nonverbal cues such as gestures and facial expressions (Daft & Lengel, 1986; Kreijns, Kirschner, & Jochems, 2003; Short, Williams, & Christie, 1976).
>
> *(Janssen & Bodemer, 2013, p. 40)*

Partly in response to such concerns, Mercer and colleagues have extensively researched what constitutes effective educational dialogue, including in CSCL contexts. They have developed an intervention strategy called '*Thinking Together*' designed to explicitly teach children how to engage

Table 38.1 Mercer and colleagues' typology of talk

Type of talk	*Characteristics*	*Analysis*
Disputational	'Characterised by disagreement and individualised decision making. There are few attempts to pool resources, to offer constructive criticism or make suggestions.'	'Short exchanges, consisting of assertions and challenges or counter-assertions ("Yes it is." "No it's not!").'
Cumulative	'Speakers build positively but uncritically on what the others have said. Partners use talk to construct "common knowledge" by accumulation.'	'Cumulative discourse is characterised by repetitions, confirmations and elaborations.'
Exploratory	'Partners engage critically but constructively with each other's ideas. Statements and suggestions are offered for joint consideration. These may be challenged and counter-challenged, but challenges are justified and alternative hypotheses are offered. Partners all actively participate, and opinions are sought and considered before decisions are jointly made. Compared with the other two types, in exploratory talk knowledge is made more publicly accountable and reasoning is more visible in the talk.'	Explanatory terms and phrases more common – for example, 'I think' 'because/'cause', 'if', 'for example', 'also'.

Source: Adapted from Mercer and Littleton, 2007, pp. 58–59.

in constructive dialogue in classroom contexts through the teaching of particular types of talk, and the use of pedagogic strategies such as generating and establishing 'ground rules' for talk designed to foster effective group work.[1] The team have highlighted a particular form of productive dialogue which, adapting the term from Douglas Barnes' (Barnes & Todd, 1977) original broadly individualistic description, they have termed 'exploratory'. They contrast this with two other types of, typically less productive, talk – disputational, and cumulative, as in Table 38.1.

Other researchers have offered similar characterisations of educationally productive dialogue. For example, '*Accountable Talk*' (see Michaels, O'Connor, Hall, & Resnick, 2002; Resnick, 2001) has been described as encompassing three broad characteristics:

1 accountability to the learning community – in which participants listen to and build their contributions in response to those of others;
2 accountability to accepted standards of reasoning, talk that emphasises logical connections and the drawing of reasonable conclusions; and,
3 accountability to knowledge, talk that is based explicitly on facts, written texts, or other public information.

(Michaels, O'Connor, & Resnick, 2008, p. 283)

As with the typology of talk developed by Mercer and colleagues, the emphasis of Accountable Talk is on learning to engage constructively, yet critically, with other's ideas, and in so doing develop and use the skills of explanation and reasoning – learning to use language as a tool for thinking together rather than focusing solely on learning a particular subject or topic

knowledge. Thus, while the individualistic focus of much psychology research may initially have appeared reasonable, it seems less appropriate given closer scrutiny. In many cases problem solving and learning more generally involves deploying the resources around you – including the minds of other people. Indeed, learning and teaching are fundamentally communicative acts; as we noted, this claim is receiving renewed focus in both philosophy and psychology (see, for example, Fricker, 2012; Haddock, Millar, & Pritchard, 2010; Lackey & Sosa, 2006; Lackey, 2008) and their analysis of 'testimonial knowledge', the role of, as Harris puts it, 'trusting what you're told' (Harris, 2012), but simple *appropriation* of claims will not do. This highlights the significance of dialogue in learning. Wherever education is taking place, commonality – a shared perspective – is imperative, and dialogue is the tool used to co-create and constitute such a perspective (Edwards & Mercer, 1987). Furthermore, the dialogue used to create 'common knowledge' is related to the educational development of children.

Recently Littleton and Mercer (2013) considered the complexity of common knowledge context as both historical and dynamic:

> Successful interthinking requires partners to have, and to develop, a foundation of common knowledge to underpin their discussions. We have distinguished two types of common knowledge, both of which can be important. The first of these is accumulated through the activities of a group, as members develop a shared history. They have knowledge in common because it has been generated by their joint activities and associated conversations. It is the kind of common knowledge which allows a teacher to refer only briefly to the content of a previous lesson and expect students to have some recollection what it had been about. We have called this dynamic common knowledge, because it is produced by the dynamics of the group's own extended activity. The second type, which we call background common knowledge, is that which any established member of a community of practice can take for granted as being shared with other members and does not therefore need to be explained from first principles.
>
> *(p. 112)*

Language is thus an important cultural tool. Even if we disagree with particular claims, our shared language allows us to draw upon our common knowledge as a resource for interthinking. Technologies, including books, afford grounding for this resourcing of our dialogue. Thus, through the use of technology, we are able to draw on the voices of others across time and space (Wegerif, 2013). It is for this reason that the transmissive view of language and technology use described above offers only a partial perspective on the potential of language: our capacity to interthink is fundamental to our capacity to engage with the ideas of others.

Technological tools

We invite the reader to return to the images presented at the beginning of this chapter, or indeed to consider any number of other scenarios: children sat next to each other but not working together; squabbling over control of the keyboard; children communicating via text remotely; the posting of comments on blogs and status updates, and so on.

Our reason for raising these examples is not to highlight the randomness with which technological use will be of success. Rather, it is to foreground that many technologies fit seamlessly into our everyday practices, technologies afford opportunities for particular types of interaction, but the contexts in which they are used (including classroom task) are of fundamental importance. In all cases, it is interesting to think about the individual and collective benefits of

technology use; for example, many tools facilitate the division of labour on tasks, and such facilitation may be productive both for a shared goal and for the individuals engaged. However, such examples do not facilitate the kind of 'interthinking' to which we refer above. In contrast, some tools, through their reification of participation are more facilitative of co-constructive processes.

Considering technology as anything other than 'tool-mediated social practices' (Cole & Derry, 2005, p. 210) is problematic. We do not doubt the transformative power of many technologies – indeed, we note that such transformation is common through human history – however, we wish to highlight that technologies do not exist in a socio-cultural vacuum. Hype around many of these technologies is problematic, and can distract from the scrutiny of the quality of learning, and interaction when using such tools. We now discuss some specific examples of tool use, highlighting their relevance to both individual thinking and interthinking. In particular, we draw the reader's attention to the ways in which people engage in co-constructing representations, *and* the ways in which representations are resourced by co-constructed representations through their engagement with background common knowledge. The examples are intended to exemplify the kinds of interactions with the ideas of others that learners engage in through the use of technologies, of course, there are many more such examples, and one of our claims here is that the boundary between using background common knowledge, and engaging in co-construction of representations is not firm; interthinking, working with the ideas of others, inevitably involves building on a shared *background*, and *dynamic* common knowledge.

Dynamic common knowledge: co-construction of representations

The seeking of information is a classic example in which the benefits of the activity appear to be entirely conferred on the individual. We seek information because we (as individuals) wish to know something. Indeed, this appears to be a direct analogue of question–answer exchanges. In a sense this is true, however, as that analogue indicates, there are at least two ways in which information seeking goes beyond individuals. First, much information seeking can be seen in the context of larger discussions than simple question and answer exchanges (and of course, information can flow in both directions in such exchanges). Secondly, when we seek information, particularly on the web, we engage with a network of linked documents with a rich set of intertextual ties; in a very real sense, reading much of the web involves an interaction with the thoughts of many people, through blog and micro-blog posts, videos, and images, all of which 'readers' may comment on.

This example is in fact particularly interesting because, unfortunately children in particular are rather poor at the use of search engines, and this paucity appears to be only marginally related to their lack of technological skill. This lack of skill has led one researcher who explored collaborative information seeking in educational settings to suggest that teenagers may be 'largely unable to select appropriate search strategies (planning), check their progress (monitoring) and assess the relevance of search outcomes (evaluating)' (Lazonder, 2005, p. 466). In that research, on how pairs of teens searched for information together, Lazonder was interested in the effect of collaboration on this 'inert knowledge problem' (Lazonder, 2005, p. 466). Lazonder's suggestion was that through the use of verbalisation learners might improve their self-regulatory processes, prompting users into better negotiating the search process. Indeed, in this example from a sample of 20 students with a mean age of 20, Lazonder found that pairs did perform better, and faster, than individuals. They also used more varied search strategies and evaluated websites marginally better than the individuals.

This example can be read in two ways; the first (suggested by Lazonder) implicates the second of the dialogue purposes noted above – that language can facilitate individual psychological

development. However, a second interpretation is motivated by our understanding of interthinking. This interpretation implicates the role of effective collaborative dialogue in the co-construction of shared knowledge. Indeed, one of us (Knight, 2013c) has noted that the possible association between more advanced epistemic working and exploratory or dialogic dialogue (Reznitskaya & Gregory, 2013) has direct implications for information seeking contexts in which our evaluation skills (fundamentally epistemic in nature) are utilised. Indeed, in earlier work (Knight & Mercer, forthcoming; Knight, 2012) one of us (SK) has explored precisely this relationship between collaborative classroom dialogue and search based tasks. In that work, despite generally similar academic attainment, the success of the small number of groups appeared to be directly related to their ability to use the kind of exploratory dialogue described above. In that work we noted that the least successful group also engaged in the least exploratory talk, as well as reflecting very little on the relationship between the information they found and the purpose for which they were seeking it. Indeed, that group appeared to be primarily concerned with the quantity, ease of access, and aesthetic value of information. In contrast the other two groups focused on the 'importance' of information and particularly that information was 'explained'; and the detail and novelty of information, respectively. The point here is not to suggest that individual learning does not take place in information seeking tasks. Rather, it is to highlight that such tasks can involve a range of levels of work – and that at times it might be appropriate to set information seeking tasks that involve *interthinking*. To draw an analogy, just as whole class questioning can involve a range of question types (including open or closed, and those aligned at a stage on the popular Bloom's Taxonomy (1956)) so too can search tasks.

In search tasks, then, there is potential in thinking about open questions, and considering the ways in which questions should be broken down into components to understand how one question might lead to another ('What is the name today of the town where the founder of the Boy Scouts of America was born?'). Indeed, the seeking of information is a prime context for the promotion of dialogue to explore misconceptions, discuss evaluation of results, and sharing of strategies.[2] Of course, searching for information also involves identification with other points of view – representations of knowledge which are 'given', and served up through the search engine – and we turn to this now.

Background common knowledge: co-constructed representations

Orientation to other's points of view, as we search the internet, talk to peers, read books, and so on is an important part of the learning process. In engaging in such activity we work with 'given' knowledge, representations that can be shared, and form a part of our common knowledge. With such resources we can engage in a rich history of ideas, and use 'co-construct*ed* representations' to engage in the 'co-construct*ion*' of representations.

The field of CSCL has a particular interest in this kind of 'knowledge building' (Scardamalia & Bereiter, 2003, 2006), the ways in which background common knowledge can effectively resource the co-construction of dynamic common knowledge through the use of representational tools. Thus, much work in CSCL has focused on developing environments that support particular types of efficacious dialogue. As we discuss below, there is evidence that suggests that CSCL representations used to resource collaborative group work, and mediate interactions with common knowledge, have a significant role to play in mediating effective group dialogue. However, we note that although such environments play an important role, types of productive dialogue which bear striking resemblance to those in our own work are not 'automatically' produced in the use of structured environments (see, for example, Vries, Lund and Baker 2002). Moreover, Dillenbourg (2002) notes that some CSCL environments risk 'over structuring' with

the consequence being that they restrict the use of educationally productive types of dialogue. So whilst design may reduce some difficulties (for example, by introducing threading to discussions) context is fundamental to understanding the dynamic features of dialogue through which learning is co-constructed. Computer environments may be seen as complementary to such dialogue, in particular where they embody some of the systems through which exploratory and accountable talk are more likely to occur – the 'ground rules' of each.

Work has thus focused on the ways in which the provision of a shared set of representations may support the development of productive dialogue, and the co-construction of further representations. Building on earlier work (Suthers & Hundhausen, 2003; Suthers, 2006), Suthers (2008) reports on three possible influences of CSCL representations on collaborative processes:

1 Negotiation potentials – because the representation is shared, participants feel obliged to negotiate over changes to it.
2 Referential resource – because the representation has shared history, it becomes imbued with meanings.
3 Mutual awareness – Because the representation is external, it is a shared resource which creates a shared frame for activity.

With respect to the third point above, in a review of the literature on awareness in CSCL, Janssen and Bodemer (2013) note the importance of both content and social (or relational) group awareness – with the former relating to aspects such as awareness of knowledge states while the latter relates to the quality of collaborative processes. This is of particular interest given the concern raised that too much CSCL research has focused on information sharing (between learners exchanging 'facts'), at the cost of analysing the interactional conditions for learning, despite the fact that informational sharing is not a good predictor of collaborative performance (Suthers, Medina, Vatrapu, & Dwyer, 2007; Suthers, Vatrapu, Medina, & Dwyer, 2007; Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2007).

In those studies, Suthers et al. note that despite one group outperforming another on knowledge construction involving the integration of multiple sources, those groups appeared not to share any more information (as indicated by individual referencing in an essay) and that their performance was best associated with 'interaction', as characterised by 'round trips' of information. These 'round trips' describe the reuse of information previously stated, the building of ideas between collaborators – perhaps the *interthinking* of collaborators using and developing shared artefacts. Building on work by Wells (1999), Twiner (Twiner, Littleton, Coffin, & Whitelock, 2014; Twiner, 2011) has suggested that such artefacts can function as 'digital improvable objects' – providing a cumulative basis of common knowledge upon which future discussions and other activities can draw and progressively build. Thus, the ways in which existing representations – the 'co-constructed' of our section heading – are used in the resourcing of co-construction is an important consideration.

Conclusion

We have shown that the use of various kinds of digital tools, whether a shared display such as an interactive whiteboard, an asynchronous chat tool, or the various kinds of social media and their facilities for commenting and sharing, can provide some valuable support for productive discussion. The ways in which technologies support access to representations, and the co-construction of representations, provides important support for not only thinking, but interthinking. Such representations and technologies can resource what Wegerif (2010) has called a 'dialogic space'

in which different ideas, perspectives and understandings can be collectively explored, and material can be modified to record the development of a discussion and capture emerging ideas.

Wegerif's (2010) claim is that, for a dialogic use of technology, we should consider:

1 Opening dialogic spaces (e.g. by adding comments to blogs), but also teaching to do this (e.g. through the use of ground rules for talk, and philosophy for children).
2 Widening dialogic spaces – understanding more points of view, and the background behind them, for example through WebQuest activities in which different perspectives – and their assumptions – are explored.
3 Deepening dialogic spaces – increasing reflection on assumptions made in arguments by students and others, shared awareness tools to make explicit the arguments being made (and their structures) can support such deepening.
4 Teaching content through induction into fields of dialogue – Wegerif notes 'interactivity makes it easy for software to simulate multiple points of view in a dialogue, thus allowing learners to be inducted into a field of dialogue rather than into fixed "truths"' (Wegerif, 2010, p. 350) noting that, the internet can be a cacophony of voices, rather than a dialogue, but through designed spaces – such as WebQuests, and the emailing of links between geographically distant groups – presence and dialogue can be mediated to encourage reflection and learning.

This final point is not only a claim about collaborative dialogue, but one about the very nature – the unstructured, messy nature – of the internet, and its use for developing space to explore multiple viewpoints. Crucially, if our targets are higher level reflection and conceptual understanding, such space must be created in contrast to many current educational systems, reiterating the point that collaborative task context is as important as collaborative tool design (Rick & Guzdial, 2006). Importantly, this highlights the need to consider the use of technology in context, and not just the design of technology itself.

The 'interpretative flexibility' of technologies is important. When we observe or deploy technologies we should consider the particular social setting, and be mindful of not falling into the trap of technological determinism (Hamilton & Feenberg, 2005). Expectations for the transformative power of technologies should be mitigated by an understanding of the place of technology in the wider social system (Crook & Lewthwaite, 2010), which dialogue plays a fundamental role in and consideration of the kinds of interaction we are aiming for (Oliver, 2011).

Thus digital technologies offer opportunities for students to interthink online, and to do so without the constraints of time and location that arise in more conventional educational settings. However, we have also noted that any technology has its own limitations, and new technologies do not necessarily lead to improved learning outside of the context of high quality dialogue.

The conclusion we draw from research on technology and dialogue is that consideration should be given to the ways in which task, representation, and collaborative dialogue are brought to bear on learning. Working alone, and together, with or without technologies can confer benefits on individual thinking. However, the benefits of interthinking – and the facilitative role of technology in such activity – extend beyond this, offering opportunity for building new ideas together in ways that can be transformative.

Notes

1 See the *Thinking Together* materials hosted at the University of Cambridge: http://thinkingtogether.educ.cam.ac.uk/.

2 The first author has written some teacher notes on this point, available (under a Creative Commons licence) here: http://sjgknight.com/finding-knowledge/edusearch-tips/ and, in abridged form, published (Knight, 2013a).

References

Azmitia, M., & Montgomery, R. (1993). Friendship, transactive dialogues, and the development of scientific reasoning. *Social Development, 2*(3), 202–221.

Barnes, D., & Todd, F. (1977). *Communication and learning in small groups*. London: Routledge & Kegan Paul.

Bloom, B. S. (1956). *Taxonomy of educational objectives, handbook 1: Cognitive domain* (2nd ed.). New York: Addison Wesley Publishing Company.

Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. *Perspectives on Socially Shared Cognition, 13*(1991), 127–149.

Cole, M., & Derry, J. (2005). We have met technology and it is us. In R. J. Sternberg & D. D. Preiss (Eds.), *Intelligence and technology: The impact of tools on the nature and development of human abilities* (pp. 209–228). London: Taylor & Francis. Retrieved from: http://books.google.co.uk/books?hl=en&lr=&id=NzoaEVBuipwC&oi=fnd&pg=PA209&dq=we+have+met+technology+and+it+is+us&ots=Nmi9wuWY38&sig=HgYE4escyDtSCnraIW1OxhsTGGs.

Crook, C., & Lewthwaite, S. (2010). Technologies for formal and informal learning. In K. Littleton, C. Wood & J. K. Staarman (Eds.), *International handbook of psychology in education* (pp. 435–461). Bradford, UK: Emerald Group Publishing. Retrieved from: http://books.google.co.uk/books?hl=en&lr=&id=-tNepO17yQO4C&oi=fnd&pg=PA435&dq=%22technologies+for+formal+and+informal+learning%22+littleton&ots=4A-6OuQT-n&sig=dR1Rqv-uw2dV-8eKUPX1ONgbbSg.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science, 32*(5), 554–571.

Dawes, L., Mercer, N., & Wegerif, R. (2004). *Thinking together: A programme of activities for developing speaking, listening and thinking skills for children aged 8–11*. Birmingham, UK: Imaginative Minds.

De Vries, E., Lund, K., & Baker, M. (2002). Computer-mediated epistemic dialogue: Explanation and argumentation as vehicles for understanding scientific notions. *Journal of the Learning Sciences, 11*(1), 63–103. doi:10.1207/S15327809JLS1101_3.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. *Three Worlds of CSCL. Can We Support CSCL?* (pp. 61–91). Retrieved from: http://www.ou.nl/Docs/Onderzoek/Oraties/2002/oratieboek_PKI_DEF_Klein_ZO.pdf.

Edwards, D., & Mercer, N. (1987). *Common knowledge: The development of understanding in the classroom*. London: Routledge.

Fricker, M. (2012). Group testimony? The making of a collective good informant. *Philosophy and Phenomenological Research, 84*(2), 249–276. doi:10.1111/j.1933-1592.2011.00565.x.

Haddock, A., Millar, A., & Pritchard, D. (2010). *Social epistemology*. Oxford: Oxford University Press.

Hamilton, E., & Feenberg, A. (2005). The technical codes of online education. *Techné: Research in Philosophy and Technology, 9*(1), 104–121.

Harris, P. L. (2012). *Trusting what you're told*. Cambridge, MA: Harvard University Press.

Janssen, J., & Bodemer, D. (2013). Coordinated computer-supported collaborative learning: Awareness and awareness tools. *Educational Psychologist, 48*(1), 40–55.

Knight, S. (2012). *Finding knowledge – the role of dialogue in collaborative information retrieval in the classroom* (Masters). University of Cambridge, Cambridge.

Knight, S. (2013a). Appendix C7.1: Resources for searching with the internet. In S. Hennessy, P. Warwick, L. Brown, D. Rawlins & C. Neale (Eds.), *Developing interactive teaching and learning using the IWB*. Milton Keynes, UK: Open University Press.

Knight, S. (2013b). Creating a supportive environment for classroom dialogue. In S. Hennessy, P. Warwick, L. Brown, D. Rawlins & C. Neale (Eds.), *Developing interactive teaching and learning using the IWB*. Milton Keynes: Open University Press.

Knight, S. (2013c). *Learning analytics for epistemic commitments in a collaborative information seeking environment* (Technical Report No. KMI-13-04). Milton Keynes: Open University. Retrieved from: http://kmi.open.ac.uk/publications/techreport/kmi-13-04.

Knight, S., & Mercer, N. (Forthcoming). The role of exploratory talk in classroom search engine tasks. *Technology, Pedagogy and Education*.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behavior, 19*(3), 335–353.

Lackey, J. (2008). *Learning from words: Testimony as a source of knowledge*. Oxford: Oxford University Press.

Lackey, J., & Sosa, E. (2006). *The epistemology of testimony*. Oxford: Oxford University Press.

Lazonder, A. W. (2005). Do two heads search better than one? Effects of student collaboration on web search behaviour and search outcomes. *British Journal of Educational Technology, 36*(3), 465–475. doi:10.1111/j.1467-8535.2005.00478.x.

Littleton, K., & Howe, C. (2010). *Educational dialogues: Understanding and promoting productive interaction*. Abingdon, UK: Routledge.

Littleton, K., & Mercer, N. (2013). *Interthinking: Putting talk to work*. London: Routledge.

Mercer, N. (2003). *New perspectives on spoken English in the classroom. English. 2003: discussion papers*. Qualifications and Curriculum Authority. (p. 74). Retrieved from http://dera.ioe.ac.uk/6062/1/6111_new_perspec_in_spoken_eng_class_room.pdf

Mercer, N., Dawes, L., Wegerif, R., & Sams, C. (2004). Reasoning as a scientist: Ways of helping children to use language to learn science. *British Educational Research Journal, 30*(3), 359–377.

Mercer, N., & Littleton, K. (2007). *Dialogue and the development of children's thinking: A sociocultural approach* (New ed.). Abingdon, UK: Routledge.

Mercer, N., & Sams, C. (2006). Teaching children how to use language to solve maths problems. *Language and Education, 20*(6), 507–528.

Mercer, N., Wegerif, R., & Dawes, L. (1999). Children's talk and the development of reasoning in the classroom. *British Educational Research Journal, 25*(1), 95–111. doi:10.1080/0141192990250107.

Michaels, S., O'Connor, M. C., Hall, M. W., & Resnick, L. (2002). *Accountable talk: Classroom conversation that works*. Pittsburg: University of Pittsburgh Press.

Michaels, S., O'Connor, C., & Resnick, L. B. (2008). Deliberative discourse idealized and realized: Accountable talk in the classroom and in civic life. *Studies in Philosophy and Education, 27*(4), 283–297.

Oliver, M. (2011). Technological determinism in educational technology research: Some alternative ways of thinking about the relationship between learning and technology. *Journal of Computer Assisted Learning, 27*(5), 373–384. doi:10.1111/j.1365-2729.2011.00406.x.

Pickering, M. J., & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *Behavioral and Brain Sciences, 27*(2), 169–189.

Resnick, L. B. (2001). Making America smarter: The real goal of school reform. In A. L. Costa (Ed.), *Developing minds: A resource book for teaching thinking* (pp. 3–6). Alexandria, VA: ASCD.

Reznitskaya, A., & Gregory, M. (2013). Student thought and classroom language: Examining the mechanisms of change in dialogic teaching. *Educational Psychologist, 48*(2), 114–133. doi:10.1080/00461520.2013.775898.

Rick, J., & Guzdial, M. (2006). Situating CoWeb: A scholarship of application. *International Journal of Computer-Supported Collaborative Learning, 1*(1), 89–115. doi:10.1007/s11412-006-6842-6.

Rojas-Drummond, S., Littleton, K., Hernández, F., & Zúñiga, M. (2010). Dialogical interactions among peers in collaborative writing contexts. In K. Littleton & C. Howe (Eds.), *Educational dialogues: Understanding and promoting productive interaction* (pp. 128–148). Abingdon, UK: Routledge.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In J. W. Guthrie (Ed.), *Encyclopedia of Education* (2nd ed., pp. 1370–1373). New York: Macmillan. Retrieved from: http://ikit.org/fulltext/2003_knowledge_building.pdf.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 97–118). New York: Cambridge University Press.

Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunications*. Retrieved from: http://www.citeulike.org/group/1662/article/327279.

Suthers, D. D. (2006). Technology affordances for intersubjective meaning making: A research agenda for CSCL. *International Journal of Computer-Supported Collaborative Learning, 1*(3), 315–337. doi:10.1007/s11412-006-9660-y.

Suthers, D. D. (2008). Empirical studies of the value of conceptually explicit notations in collaborative learning. In T. Sherborne, S. J. B. Shum, & A. Okada (Eds.), *Knowledge cartography* (pp. 1–23). Springer: London. Retrieved from: http://link.springer.com.libezproxy.open.ac.uk/chapter/10.1007/978-1-84800-149-7_1.

Suthers, D. D., & Hundhausen, C. D. (2003). An experimental study of the effects of representational guidance on collaborative learning processes. *The Journal of the Learning Sciences, 12*(2), 183–218.

Suthers, D. D., Medina, R., Vatrapu, R., & Dwyer, N. (2007). Information sharing is incongruous with collaborative convergence: The case for interaction. In *Proceedings of the 8th international conference on computer supported collaborative learning* (pp. 715–717). Retrieved from: http://dl.acm.org/citation.cfm?id=1599730.

Suthers, D. D., Vatrapu, R., Medina, R., & Dwyer, N. (2007). Information sharing and interaction in collaborative convergence. *Frontiers in Artificial Intelligence and Applications 162*, 167–174.

Suthers, D. D., Vatrapu, R., Medina, R., Joseph, S., & Dwyer, N. (2007). Conceptual representations enhance knowledge construction in asynchronous collaboration. In *Proceedings of the 8th international conference on computer supported collaborative learning* (pp. 705–714). Retrieved from: http://dl.acm.org/citation.cfm?id=1599729.

Twiner, A. (2011). *Sociocultural understandings of technology-mediated educational practices: Improvable objects and meaning-making trajectories in the ICT-literate classroom* (PhD). The Open University. Retrieved from: http://oro.open.ac.uk/33539/.

Twiner, A., Littleton, K., Coffin, C., & Whitelock, D. (2014). Meaning making as an interactional accomplishment: A temporal analysis of intentionality and improvisation in classroom dialogue. *International Journal of Educational Research, 63*, 94–106.

Wegerif, R. (2010). Dialogue and teaching thinking with technology. In K. Littleton & C. Howe (Eds.), *Educational dialogues: Understanding and promoting productive interaction* (p. 304). Oxford, UK: Routledge. Retrieved from: http://books.google.co.uk/books?hl=en&lr=&id=cAXvoXtf-wwC&oi=fnd&pg=PA304&dq=rupert+wegerif+%22educational+dialogues%22&ots=2nNGRHkG3j&sig=l2sPQ4BR53tRReQPFzTcGVk-ZHU.

Wegerif, R. (2012). *Dialogic: Education for the internet age*. London: Routledge.

Wegerif, R., Littleton, K., Dawes, L., Mercer, N., & Rowe, D. (2004). Widening access to educational opportunities through teaching children how to reason together. *Westminster Studies in Education, 27*(2), 143. doi:10.1080/0140672040270205.

Wells, G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory of education*. Cambridge: Cambridge University Press.

Author index

ROUTLEDGE INTERNATIONAL HANDBOOKS

The Routledge International Handbook of Research on Teaching Thinking is a comprehensive guide to research on teaching thinking. Teaching thinking is key to growing a more successful economy, is needed for increased democratic engagement and is vital for the well-being of individuals faced with the complexity of a globalised world. However, there are questions about what we mean by 'thinking', how best to teach it and how best to assess it, and it is these questions that this handbook explores and addresses.

Containing surveys and summaries of international, cutting-edge research on every aspect of teaching thinking in a range of contexts, the handbook is thorough in its delivery, examining many different approaches and methods to help readers understand what teaching thinking is and how we can best take this movement forward. Key topics include:

- Theoretical perspectives on teaching thinking
- Approaches for teaching thinking
- Developing creative thinking
- Developing critical thinking and metacognition
- The assessment of thinking
- Teaching thinking in the context of STEM
- Collaborative thinking and new technology
- Neuro-educational research on teaching thinking

This book is an essential guide for policy-makers, teachers and researchers who are interested in teaching thinking.

Rupert Wegerif is a Professor of Education at the University of Exeter, UK.

Li Li is a Senior Lecturer at the University of Exeter, UK.

James C. Kaufman is a Professor of Educational Psychology at the Neag School of Education, University of Connecticut, USA.

EDUCATION

Routledge
Taylor & Francis Group
www.routledge.com/education

ISBN 978-0-415-74749-3

an informa business

Routledge titles are available as eBook editions in a range of digital formats

The Routledge International Handbook of Research on Teaching Thinking
Edited by Rupert Wegerif, Li Li and James C. Kaufman

ROUTLEDGE INTERNATIONAL HANDBOOKS

The Routledge International Handbook of Research on Teaching Thinking

Edited by Rupert Wegerif, Li Li and James C. Kaufman

The Routledge International Handbook of Research on Teaching Thinking

The Routledge International Handbook of Research on Teaching Thinking is a comprehensive guide to research on teaching thinking. Teaching thinking is key to growing a more successful economy, is needed for increased democratic engagement and is vital for the well-being of individuals faced with the complexity of a globalised world. However, there are questions about what we mean by 'thinking', how best to teach it and how best to assess it, and it is these questions that this handbook explores and addresses.

Containing surveys and summaries of international, cutting-edge research on every aspect of teaching thinking in a range of contexts, the handbook is thorough in its delivery, examining many different approaches and methods to help readers understand what teaching thinking is and how we can best take this movement forward. Key topics include:

- Theoretical perspectives on teaching thinking
- Approaches for teaching thinking
- Developing creative thinking
- Developing critical thinking and metacognition
- The assessment of thinking
- Teaching thinking in the context of STEM
- Collaborative thinking and new technology
- Neuro-educational research on teaching thinking.

This book is an essential guide for policy-makers, teachers and researchers who are interested in teaching thinking.

Rupert Wegerif is a Professor of Education at the University of Exeter, UK.

Li Li is a Senior Lecturer at the University of Exeter, UK.

James C. Kaufman is a Professor of Educational Psychology at the Neag School of Education, University of Connecticut, USA.

The Routledge International Handbook Series

The Routledge International Handbook of Research on Teaching Thinking
Edited by Rupert Wegerif, Li Li and James C. Kaufman

The Routledge International Handbook of the Arts and Education
Edited by Mike Fleming, John O'Toole and Liora Bresler

The Routledge International Handbook of English, Language and Literacy Teaching
Edited by Dominic Wyse, Richard Andrews and James Hoffman

The Routledge International Handbook of the Sociology of Education
Edited by Michael W. Apple, Stephen J. Ball and Luis Armand Gandin

The Routledge International Handbook of Higher Education
Edited by Malcolm Tight, Ka Ho Mok, Jeroen Huisman and Christopher C. Morpew

The Routledge International Companion to Multicultural Education
Edited by James A. Banks

The Routledge International Handbook of Creative Learning
Edited by Julian Sefton Green, Pat Thomson, Ken Jones and Liora Bresler

The Routledge International Handbook of Critical Education
Edited by Michael W. Apple, Wayne Au and Luis Armando Gandin

The Routledge International Handbook of Lifelong Learning
Edited by Peter Jarvis

The Routledge International Handbook of Early Childhood Education
Edited by Tony Bertram, John Bennett, Philip Gammage and Christine Pascal

The Routledge International Handbook of Teacher and School Development
Edited by Christopher Day

The Routledge International Handbook of Education, Religion and Values
Edited by James Arthur and Terence Lovat

The Routledge International Handbook of Young Children's Thinking and Understanding
Edited by Sue Robson and Suzanne Flannery Quinn

Routledge International Handbook of Educational Effectiveness
Edited by Chris Chapman, Daniel Muijs, David Reynolds, Pam Sammons and Charles Teddlie

The Routledge International Handbook of Dyscalculia and Mathematical Learning Difficulties
Edited by Steve Chinn

International Handbook of E-learning, Volume 1: Theoretical Perspectives and Research
Edited by Badrul H. Khan and Mohamed Ally

International Handbook of E-learning, Volume 2: Implementation and Case Studies
Edited by Mohamed Ally and Badrul H. Khan

The Routledge International Handbook of Research on Teaching Thinking

Edited by Rupert Wegerif, Li Li and James C. Kaufman

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2015
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

and by Routledge
711 Third Avenue, New York, NY 10017

Routledge is an imprint of the Taylor & Francis Group, an informa business

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data
The Routledge international handbook of research on teaching thinking / edited by Rupert Wegerif, Li Li and James C. Kaufman.
pages cm
Includes bibliographical references and index.
1. Critical thinking—Study and teaching (Higher) I. Wegerif, Rupert, 1959- editor of compilation. II. Title: International handbook of research on teaching thinking.
LB2395.35.R68 2015
370.15′2—dc23
2014046580

ISBN: 978-0-415-74749-3 (hbk)
ISBN: 978-1-315-79702-1 (ebk)

Typeset in Bembo
by Swales & Willis Ltd, Exeter, Devon, UK

MIX
Paper from responsible sources
FSC® C013056

Printed and bound in Great Britain by
TJ International Ltd, Padstow, Cornwall

Dedicated to the memory of Robert Burden (1940–2014) and Anna Craft (1961–2014), contributors to this volume who died while it was being prepared. Their wisdom will be sadly missed.

Contents

Contributors

Sarit Barzilai is a faculty member of the Educational Technology Program at the Department of Learning, Instruction and Teacher Education in the University of Haifa's Faculty of Education. Barzilai's research interests are the study of epistemic thinking, metacognition and higher-order thinking in digital contexts, such as learning with multiple information sources and game-based learning. Barzilai develops new approaches and methodologies for analysing and assessing learners' epistemic thinking and engages in designing innovative digital technologies for advancing students' knowledge construction strategies and epistemic thinking. Her work has been recognised by the Israeli Council for Higher Education and the Israeli Science Foundation through a five-year research grant in the Israeli Center for Research Excellence on Learning in a Networked Society.

Benjamin Broome is a professor at Arizona State University, USA. His research foci include group facilitation, consensus-building processes, intercultural and intergroup dialogue, and collaborative problem solving. He has facilitated collective design processes with community groups, NGOs, corporations, indigenous communities, academic institutions, and government agencies in the Eastern Mediterranean, Western Europe, Black Sea region, Australasia, and North America.

Vivienne Baumfield is the international dean for Eurasia and South Asia at the University of Glasgow and also professor of Pedagogy, Policy and Innovation in the School of Education. She held the Nehru Chair in the Department of Human Development and Family Studies at MSU Baroda in 2013 and is a visiting professor at the University of Exeter and Jadavpur University, Kolkata. Her teaching and research focus is on the role of practitioner inquiry in teachers' professional learning through the development of a metacognitively rich pedagogy. She has devoted much of her career as an educational researcher to the promotion of collaborative working in school–university partnerships. She is the editor of two leading educational research journals and has published over 30 research papers on education. Before taking up her first academic post, Vivienne was a classroom teacher in secondary schools in disadvantaged areas in the UK.

Erin L. Beatty received her PhD in cognitive psychology from Lancaster University in 2012. She is currently a Canadian Government Laboratory visiting fellow at Defence Research and Development Canada, Toronto Research Centre. Her research interests include cognitive training, reasoning and decision making, creativity and design thinking.

Ronald A. Beghetto, is an associate professor of Educational Psychology at the University of Connecticut. Prior to joining the faculty at UConn, Dr Beghetto served as the College of Education's associate dean for Academic Affairs and associate professor of Education Studies at the University of Oregon. His research focuses on creativity in educational settings – examining

how teacher and student creativity is sometimes (inadvertently) suppressed and how it can be incorporated in the everyday classroom. He has published widely on this topic. His newest book *Killing Ideas Softly? The Promise and Perils of Creativity in the Classroom* is published by Information Age Publishing. Dr Beghetto is the editor-in-chief for the *Journal of Creative Behavior* and serves as an associate editor for the *International Journal of Creativity and Problem Solving*. He is a fellow of the American Psychological Association and the Society for the Psychology of Aesthetics, Creativity and the Arts (Div. 10, APA). Dr Beghetto has received numerous awards for excellence in teaching and research.

Robert Burden (1940–2014), conducted research in educational psychology which covered a wide range of topics but shared a concern with improving the quality of children's experience of school. His influential 'Myself as a Learner Scale' revealed the importance of how children think about and respond to education. In 2005, when he became a professor emeritus, he established the Cognitive Education Centre at Exeter, which later became the Cognitive Education Development Unit. This promoted his whole school approach to teaching thinking and has had an impact not only in the UK, where there are now many 'Thinking Schools' accredited by Bob and his team, but also in countries around the world.

Heather A. Butler is an assistant professor in the psychology department at California State University Dominguez Hills. She has a number of research interests that are grounded in human cognition (e.g., exploring the real-world implications of critical thinking, advanced learning technologies that improve thinking, cognitive bias in the legal system). She has written several book chapters about the assessment of student learning outcomes and critical thinking. Dr Butler was involved in the development of an educational 'serious' game, Operation ARA, which teaches scientific reasoning skills to college students.

Vivian M. Y. Cheng is currently working at the Hong Kong Institute of Education as assistant professor. She has been a science teacher in secondary schools and is now engaged in teacher training work. She has specialised in teaching and researching on creativity education for many years in the Institute. In the past, she led several large-scale educational projects, funded by the government, in promoting creativity reforms in a local context. She has written several Chinese books on creativity education and published a number of English papers in international journals in this area. Her recent interests are curriculum-based assessment of creativity, self-initiated transfer of creative learning, creativity for environmental sustainability, creativity in science education and creativity in teaching.

Egan J. Chernoff is an associate professor of Mathematics Education at the University of Saskatchewan. His research utilises logical fallacies and particular models from the field of (cognitive) psychology to account for prospective elementary, middle and high school maths teachers' normatively incorrect, inconsistent and, sometimes, inexplicable responses to a variety of probabilistic tasks. Egan is an ardent user of social media for mathematics education, is endlessly fascinated with Math Wars culture, and, one day, hopes to (help) popularise the teaching and learning of mathematics.

Constance Ching is currently a PhD candidate at City University of Hong Kong, with a research focus on homelessness. She was the Project Supervisor of the City-Youth Empowerment Project, Department of Social Sciences at CityU. She has developed and implemented creative arts programmes with various populations, including underprivileged children and women in

crisis. Prior to this, She was a social worker working with the homeless population in New York. She obtained her MSW at Silberman School of Social Work at Hunter College, City University of New York through a full scholarship from the NYC Department of Health and Mental Hygiene. Constance was a recipient of the Phyllis and Joseph Caroff Scholarship Award for Outstanding Achievement in Clinical Social Work, and the Jacob Goldfein Award for Creative and Scholarly Work while at Silberman. In her private practice, Constance continues to integrate creative arts and imagery to help her clients on insight-orientated work.

Anna Craft (1961–2014) led the CREATE research cluster at the University of Exeter. She was also a professor at The Open University, England, and Director of The Open Creativity Centre. She was a founding co-editor of *Thinking Skills and Creativity* (Elsevier) and founding co-convenor of the *British Educational Research Association Special Interest Group, Creativity in Education*. She held a visiting appointment at Harvard University and has held visiting appointments at Hong Kong Institute of Education. Her latest book was published in 2011 with Trentham Books, entitled *Creativity and Education Futures*.

David Cropley is associate professor of Engineering Innovation at the University of South Australia in Adelaide. He has been a member of staff of the university since 1990, teaching across a range of engineering topics including digital electronics, microprocessors, engineering design and systems engineering. He has been active in creativity research for approximately 15 years, and has examined the role of creativity in engineering through the concept of functional creativity. In recent years he has studied a broad range of issues in creativity, including the role of expertise in assessing creativity, the application of creativity in crime and terrorism (malevolent creativity), the development of scales for measuring product creativity, and creativity as a driver of organisational innovation. He has published a number of papers, chapters and books on the subject, including, *Creativity and Crime: A Psychological Analysis* (2013), and *Creativity in Engineering: Novel Solutions to Complex Problems* (2014).

Areej M. Adel El Sayary is a mathematics coordinator for grades 5–6 and STEM coordinator for the middle school at Al Ittihad private school, Dubai with responsibility for curriculum planning, exam preparation and class visits. She received her BSc in Architecture Engineering from Alexandria University, Egypt. After a four-year career as an engineer, she decided it was time for a change of scenery (and weather) and moved to sunny Dubai, where she was offered a teaching position. In addition to teaching, she collaborated in a Differentiated Mathematics Program that has been established in Al Ittihad Private School and has been rewarded for her accomplishment. She recently earned a MED (science stream) from the British University in Dubai. The dissertation research was on 'The Effectiveness of Problem-based Learning Strategy in STEM Education for Enhancing students' 21st Century-Skills'.

Sibel Erduran is professor of STEM Education at the University of Limerick, Ireland where she is the director of the National Centre for Excellence in Mathematics and Science Teaching and Learning. She is an editor for the *International Journal of Science Education* and section editor for *Science Education*. She has held visiting professorships at Kristianstad University, Sweden and Bogazici University, Turkey. She has worked at University of Bristol and King's College London, United Kingdom. She serves as a director on the IHPST Council and acted as the NARST International Coordinator. Her higher education was completed in the USA at Vanderbilt (PhD), Cornell (MSc) and Northwestern (BSc) Universities. She has been a chemistry teacher in a high school in northern Cyprus. Her research interests focus on the applications

in science education of interdisciplinary perspectives on science, particularly the epistemic practices of science.

Carol Evans is a professor of Higher Education at the University of Southampton, President of the Education, Learning, Styles, Individual differences Network (ELSIN); and associate editor of the *British Journal of Educational Psychology*. She is also a visiting fellow at the UCL Institute of Education, She is national and principal fellow of the Higher Education Academy. Her research interests include individual differences in learning and the development of the Personal Learning Styles Pedagogy, and assessment and feedback practice.

Sufian A. Forawi is currently an associate professor of Science Education at the British University in Dubai. Dr Sufian obtained an EdD in Science Education from the University of Massachusetts Lowell, USA. He was awarded the distinguished US Fulbright Scholar exchange at the UAE University in 2007–2008. He has been a member of several science education organisations, NARST and AERA & ESERA. He is the editor of the *International Journal of Excellence in eLearning*. He has published widely in peer reviewed journals and participated in the publication of many books (*Opening and Operating Charter Schools: The Kansas City Experience*. Eds. Central Missouri State University Printing Service; *Science Teacher Professional Development: The United Arab Emirates' Challenges and Needs*, Sense Publisher). He has a strong external grant record, for example NSF and Emirates Foundation.

Merce Garcia-Mila is a professor at the Developmental and Educational Psychology at the School of Psychology (University of Barcelona, Spain). She teaches psychology of education and developmental psychology and she was a science teacher in high school in Barcelona. Her research background is on scientific reasoning, use of external representations and argumentation all addressed to science learning. She has also been a visiting scholar at Columbia University and Stanford University. She was the research coordinator of the Research Institute of Childhood and Urban World (CIIMU, Barcelona, Spain) for six years.

Owen Harney is a PhD candidate (Learning Sciences) at the School of Psychology, NUI, Galway. His PhD focuses on the design and evaluation of a new systems science education programme. To date, his research has investigated the social psychology of teams, types of feedback and the role of the facilitator in the context of systems science-based collaborative learning.

Yoram Harpaz is a senior lecturer in Beit Berl Teachers' College and in Al-Qasemi Islamic Teachers' College in Israel. He is also the chief editor of *Educational Echoes*, the largest education journal in Israel. Harpaz taught history and philosophy in the Boyer High School in Jerusalem, has worked as a journalist, a project manager in Branco Weiss Institute for the Development of Thinking in Jerusalem, and as the director of Mandel School for Educational Leadership in Jerusalem. He has published four books and many articles on teaching, learning and thinking. His book *Teaching and Learning in Community of Thinking: The Third Model* was published recently by Springer.

Mavis He is an assistant professor of the Department of Special Education and Counselling, The Hong Kong Institute of Education. Her research training is on both neuropsychology and educational psychology at the Chinese University of Hong Kong. Her research interests include creativity, giftedness and the cognitive approach to stress. She is especially interested in understanding the relevant factors that contribute to facilitate creative, intellectual and cognitive

functioning. Such factors include school contexts, enriching experiences, individual characteristics and biological bases.

Steve Higgins is professor of Education in the School of Education at Durham University in the UK. He has a long-standing interest in the development of children's thinking, particularly logical thinking and reasoning, which arose from his experience as a primary school teacher. He was a member of the Thinking Skills Research Centre at Newcastle University in the 1990s which worked with schools and teachers to develop strategies to support articulation of thinking in classrooms and to understand the impact of adopting thinking skills programmes on classroom processes and outcomes. He was one of the authors of *Frameworks for Thinking* (published by Cambridge University Press) which classifies and summarises over fifty taxonomies and frameworks for thinking. He has an interest in Pragmatism and the work of Dewey and Peirce, particularly how their ideas relate to the use of research evidence in teaching and learning in schools.

Michael Hogan, is a researcher and lecturer at NUI, Galway. His research foci include individual, social and technology factors contributing to adult learning, motivation and collaborative performance. He is a co-director of the Structured PhD in Perception, Cognition and Action, co-director of the Structured PhD in Learning Sciences, and leader of the Health and Well-being theme at the Whitaker Institute for Innovation and Social Change, NUI, Galway.

Weiping Hu has more than 50 social academic positions, such as director of the National Demonstration Center for teacher teaching development, director of the MOE Key Lab. of Modern Teaching Technology, director of the Chinese Creativity Research Collaboration Group, deputy director of the National Innovation Center for Assessment of Basic Education Quality, PR China. His research interests are teaching thinking, creativity and science education. In the past 10 years, he has completed 40 national and provincial research projects, published six monographs, 12 textbooks and more than 120 peer-reviewed papers. In addition, Professor Hu has been rewarded by national and provincial agencies 18 times, including the National Teaching Achievement Prize in Basic Education, the National Book Prize, The Natural Science Prize, The Social Science Prize, and so on. He has developed the 'Learn to Think' Activity Curriculum aimed at cultivating the creativity of students, which has been used by more than 400 experimental schools.

Anna Hui is currently an associate professor and also the programme leader of the Master of Social Sciences (Psychology in Education) at the Department of Applied Social Sciences, City University of Hong Kong. Her research interests include creativity development across the lifespan, gifted and talented education, motivation and self-regulation, organisational creativity in industries and educational institutions, and volunteerism in young and old people. She serves in the editorial board of *Thinking Skills and Creativity*, *Creativity: Theories-Research-Applications*, and *Journal of Drama and Theatre Education in Asia*. She publishes in *Developmental Psychology*, *Educational Psychology*, *Journal of Creative Behavior*, and *Thinking Skills and Creativity*.

Phil N. Johnson-Laird was born in Yorkshire, and educated at Culford school. As a supporter of Bertrand Russell's Committee of 100, he refused to do his military service. He spent 10 years in miscellaneous jobs, including giving talks on music on the BBC. He then went to University College London to study psychology. He has held positions at UCL, Sussex University, the MRC's Applied Psychology Unit and the Institute for Advanced Study, Princeton. He is Stuart

Professor of Psychology, emeritus, at Princeton and a visiting scholar at New York University. His research is on human thinking, and combines experiments with computer modelling. His main discovery is of a psychological principle that constrains human rationality: individuals normally represent what is true, but not what is false. This bias seems innocuous, but it leads to systematic errors in reasoning. He thinks that he has also solved the problem of what makes music dissonant.

Amber Johnston is currently Teaching and Learning consultant at the 3e International School in Beijing, China. She is a graduate of the Bank Street College of Education and a PhD Candidate of the Arizona State University Early Childhood programme. Amber was a progressive early childhood educator in Alaska, New York City, Thailand and Cairo. She also prepared teachers in New York, Egypt, Arizona and Liberia. Her doctoral research looks at the role of doctorate programmes in ECE teacher educator preparation. Amber's continuing research interests include: progressive international early childhood education, teacher preparation and play-based learning.

James C. Kaufman is a professor of Educational Psychology at the Neag School of Education at the University of Connecticut. An internationally recognised leader in the field of creativity, he is the author/editor of 30 books, including *Creativity 101* and the *Cambridge Handbook of Creativity*, and more than 200 papers. Kaufman is the past president of American Psychological Association's Division 10, which is devoted to creativity and aesthetics. He is the founding co-editor of *Psychology of Popular Media Culture* and co-founded *Psychology of Aesthetics, Creativity, and the Arts*, both published by APA. He has won numerous awards, including the Torrance Award from the National Association for Gifted Children, the Berlyne and Farnsworth Awards from APA, and Mensa's research award.

Simon Knight is a final year PhD student at the Open University's Knowledge Media Institute. His research explores how people conceptualise knowledge. A core focus has been the relationship between technologies, especially search engines, and both epistemology of assessment, and student's epistemic cognitions. He is particularly interested in the commitments people make to the source, justification, complexity and certainty of knowledge, in information seeking tasks. A consideration of the dialogue used to share and co-construct knowledge is core to this. An aspect of this research has been developing a socio-cultural perspective on epistemic cognition, and analysis of information seeking trace data. He completed his PGCE in Social Sciences and Masters in the Philosophy of Education at the Institute of Education, London, before moving to Cambridge to complete a Masters in Educational Research Methods. He blogs about his work at his website: http://sjgknight.com

Shirley Larkin is senior lecturer in Graduate School of Education, University of Exeter. She has a background in English Literature and Psychology. Since 1999 she has researched metacognition in young children. She worked with Philip Adey and Michael Shayer on the metacognitive aspects of their Cognitive Acceleration programmes before moving to Exeter where she has researched metacognition and learning to write, and metacognition in primary Religious Education classes. She is the author of *Metacognition in Young Children* (Routledge, 2010) and has written a number of book chapters and journal articles on developing metacognition across the primary curriculum.

Li Li is a senior lecturer at the University of Exeter. She specialises in teacher cognition, educational technology, thinking skills and discourse analysis. Li's work on teacher cognition explores teachers' decision making, belief and knowledge and her research in developing thinking skills

in particular looks at how teachers develop thinking skills through classroom interaction. She is also interested in Chinese Confucian philosophy and its contribution to Chinese thinking, with particular attention to its relevance to contemporary Chinese education. Li is involved in several projects exploring learners' thinking skills in China.

Zhaocun Li is currently an associate professor of the Preschool and Special Education School at East China Normal University at Shanghai. He earned his Masters degree in curriculum and teaching theories at Beijing Normal University in 2001. In 2007, he received his PhD in comparative education at ECNU, and joined the faculty the same year. Li's research broadly focuses on curriculum studies, student learning and early childhood education. He is specifically interested in international comparison of curriculum policy, increasing creativity in the classroom, culturally appropriate curriculum reform in Chinese early childhood education. The key book publications include *Study on Curriculum Knowledge* (2009); Find educational meaning behind curriculum policies: based on the international comparison of preschool curriculum guidelines (2012).

Karen Littleton is professor of Psychology in Education within the Centre for Research in Education and Educational Technology. Her research expertise concerning children's collaborative learning and interthinking is recognised internationally. She is the author (with Neil Mercer) of *Interthinking: Putting Talk to Work* (Routledge, 2013).

Elaine Liu-Au is associate professor and assistant head of department of Applied Social Sciences, City University of Hong Kong. She had ten years of experience as a social worker and supervisory social worker to the School Social Work and Youth Counselling services in an NGO before joining the university in 1990. Her primary teaching and research interests are in children, youth and family, and volunteerism. Recently, she has been advocating and promoting youth development and empowerment, youth volunteerism and youth cross-cultural learning both locally and internationally. She has acted as a consultant to a variety of youth related projects in Macau and Hong Kong and she had been a member of the Commission on Youth in Hong Kong for six years. She is now the principle researcher to the City-youth Empowerment Project in the University. She received the Teaching Excellence Award from City University in 2014.

Ping-Yu Liu received his first Masters degree in English Language Teaching (ELT) from the University of Essex in 2005. From 2005 to 2008, he worked as a part-time lecturer at the universities of Da-Yeh, Tung-Hai and Ming-Dao in Taiwan, where he taught English and other English language skills such as speaking, writing, reading and listening. In 2009, he received his second Masters degree in education from the University of Exeter. In 2014, he received his PhD in Education from the University of Exeter. He is now an assistant professor to National Chi-Yi University of Technology located in Taichung, Taiwan. His research interests are language learning strategies (LLSs), L2 reading and instruction, and L2 strategic reading comprehension and metacognition.

Haiying Long is currently an assistant professor at the College of Education in Florida International University, Miami, Florida. Her major research interests include creativity assessment, creativity in schools, creativity and motivation, and the development of creativity field. Her works have been published in the *Encyclopedia of Creativity* (2nd ed.), *Creativity Research Journal*, *Thinking Skills and Creativity*, *Journal of Experimental Education*, and *International Journal of Creativity and Problem Solving*.

Nasser Mansour is a senior lecturer in science education at the Graduate School of Education at Exeter University. He is a fellow of the Higher Education Academy (HEA). Dr Mansour got his PhD from Exeter University in 2008. He has published in prestigious education journals such as *Science Education, International Journal of Science Education, Journal of Science Teacher Education, Cultural Studies of Science Education, Research in Science Education, Computer and Education* and *European Educational Research*. Dr Mansour has been awarded the Best Paper Award at the European Educational Research Association conference in 2007 and The University of Exeter Merit Award in 2011. Dr Mansour is currently associate editor of the journal *Thinking Skills and Creativity* and was President of the Junior Researcher JURE 2011 Pre-conference of EARLI European Association of Research on Learning and Instruction (EARLI) Conference held at Exeter. He recently published *Science Education for Diversity in the Knowledge Society: Theory and Practice*, New York: Springer.

Tim Moore is a senior lecturer (academic literacy) at Swinburne University, and adjunct research associate, School of Languages Cultures and Linguistics, Monash University. His research interests include writing in the academy, and the discourses of different disciplines, especially in the humanities and social sciences. Tim has a PhD in Applied Linguistics from the University of Melbourne. His most recent book is *Critical Thinking and Language: The Challenge of Generic Skills and Disciplinary Discourses* (Bloomsbury). Tim is a co-editor of the *Journal of Academic Language and Learning* (JALL), and supervising editor of the recent special issue, 'Key thinkers, key theories: The contribution of theory to academic language and learning practice' (Parts 1 & 2).

Douglas P. Newton teaches and researches in the School of Education of Durham University, UK. His current interest is in the kinds of thinking which some programmes of study say should be fostered in education, such as reasoning, understanding, creative, critical and wise thinking. Going beyond the cognitive strategies for exercising such thought, he has described how moods and emotions interact with cognition in ways which direct and shape these kinds of thought. His very successful book, *Teaching for Understanding*, is now in its second edition (Routledge, 2012), and his latest, highly-praised book, *Thinking with Feeling* (Routledge, 2014) has been very well received.

Mary Oliver is associate professor in Science Education at the University of Nottingham, teaching science PGCE students. She is an experienced classroom teacher and undertakes research on gifted students in science, cognitive acceleration, comparative education and learning science. She is currently a vice chairman of the International Biology Olympiad steering committee and reviewer for a number of education journals. She received 'Best Paper' award from the Australian journal *Teaching Science* for her paper on how students learn about evolution and maintains a research interest in this area.

Jonathan A. Plucker is the Raymond Neag Professor of Education at the University of Connecticut, where he teaches in the Educational Leadership and Educational Psychology programmes. His research interests include talent development, creativity and intelligence, twenty-first century learning and education policy. He is a recipient of the Rudolf Arnheim Award for Outstanding Achievement from the American Psychological Association's Society for the Psychology of Aesthetics, Creativity, and the Arts (Division 10) and the Distinguished Scholar Award from the National Association for Gifted Children, and he is a Fellow of APA and the American Association for the Advancement of Science.

Roni Reiter-Palmon is the Varner Professor of Industrial/Organizational (I/O) Psychology at the University of Nebraska at Omaha (UNO). She also serves as the director of Innovation

for the Center for Collaboration Science. Her research focuses on creativity and innovation in the workplace, cognitive processes and individual difference variables that influence creative performance of individuals and teams, and leading creative individuals, and organisational adoption of innovative processes. Her research has been published in the *Journal of Applied Psychology, Creativity Research Journal, The Psychology of Aesthetics, Creativity and the Arts*, and *Leadership Quarterly*. She is the editor of *The Psychology of Creativity, Aesthetics and the Arts*, an associate editor for the *Journal of Creative behavior*, and for the *European Journal of Work and Organizational Psychology*. She serves on the editorial boards of the *Journal of Organizational Behavior, The Leadership Quarterly*, the *Journal of Leadership and Organizational Studies*, the *Journal of Business and Psychology*, and the *International Journal of Problem Solving and Creativity*.

Ryan Royston is an Industrial/Organizational Psychology graduate student at the University of Nebraska at Omaha. He currently works as an associate with UNO's Center for Applied Psychological Services and conducts research under the direction of Dr Roni Reiter-Palmon. His current research includes creativity within organisations, differences between fixed and malleable mindsets of creativity, goal orientation and emerging leadership in small groups.

Baruch B. Schwarz is the Isadore and Bertha Gudelsky Chair of Early Education at Hebrew University of Jerusalem. His main research interests are Argumentation and Learning, Dialogic Teaching, Computer-Supported Collaborative Learning and Mathematical Abstraction. He also studies dyadic traditional learning in Yeshivas (Jewish Houses of Study) that involve the intensive study of multiple argumentative texts. Among his publications are, *Transformation of Knowledge through Classroom Interaction* (with Tommy Dreyfus and Rina Hershkowitz), and *Argumentation, Learning and Dialogue: Democratic Talk in Classroom Discussions* (with Michael Baker). Baruch Schwarz has coordinated many EC-funded international projects such as Dunes, Escalate, Argunaut and Metafora (FP5, 6 and 7). These projects have in common the development of tools for fostering collaboration and/or argumentation in small groups, and research that shows that these tools afford the intended activities. Baruch Schwarz is the associate editor of the *International Journal of Computer-Supported Collaborative Learning*. He belongs to the editorial board of leading journals in the Learning Sciences.

Ben Zion (Benzi) Slakmon, PhD candidate, Hebrew University of Jerusalem, trained in philosophy, history and the learning sciences. Slakmon teaches at the Hebrew University and at Kaye academic college of education (Be'er-Sheva). His research deals with the relationship between pedagogical design and students' modes of talk and thinking in the humanities. He has a strong interest in questions of ethics, discourse and cultural change. Slakmon is involved in educational entrepreneurship aimed at reconstructing the relationship between schools, levels of teacher education and university schools of education. He is the winner of the 2014/15 Erasmus Mundus EU Program and is due to spend the next academic year in post-doctoral training at the University of Luxembourg.

Bharath Sriraman is professor of Mathematics at the University of Montana. Among his myriad interests are the use of heuristics in mathematical thinking and learning. He is the founding editor of *Advances in Creativity and Giftedness* (Sense Publishers) and *Advances in Mathematics Education* (Springer). He has edited over 30 books to date and published over 300 journal articles and book chapters in the areas of creativity, innovation, mathematical cognition, history of mathematics and epistemology. His recent books include *Creativity and Complexity: Deconstructing Cliches* (with D. Ambrose and K. Pirece); and *The First Sourcebook on Asian Research in Mathematics Education: China, Korea, Malaysia, Singapore, Japan and India* – a 1782 page tome.

Keith E. Stanovich is emeritus professor of Applied Psychology and Human Development at the University of Toronto. Stanovich's book, *What Intelligence Tests Miss*, received the 2010 Grawemeyer Award in Education. His introductory textbook, *How to Think Straight About Psychology*, published by Allyn & Bacon, is in its Tenth Edition. He is the recipient of the 2012 E. L. Thorndike Career Achievement Award from the American Psychological Association. In 2000 he received the Distinguished Scientific Contribution Award from the Society for the Scientific Study of Reading. Stanovich is the author of over 200 scientific articles and seven books. His 1986 article on Matthew Effects in reading has been cited over 1500 times in ISI Web of Knowledge and he has authored 29 other articles that have received over 100 citations.

Robert J. Sternberg is professor of Human Development at Cornell University. His PhD is from Stanford and he holds 13 honorary doctorates. Sternberg was previously IBM Professor of Psychology and Education and Professor of Management at Yale.

Ai-Girl Tan received her PhD from the Ludwig-Maximilians University of Munich (LMU) under the sponsorship of the German Academic Exchange Program. She has been a faculty member of the Nanyang Technological University Singapore, and a pioneer faculty member of an interministerial team who assisted in constructing a nationwide framework of Singapore's education: Thinking School, Learning Nation (1997). Tan was also a pioneer faculty member at the National Institute of Education Singapore, who designed curricula of thinking and creativity for teachers and graduates. She was a visiting professor at the LMU (2008–2009) and Kansai Gaidai University Osaka, Japan (Jan–June, 2011). In 2007, she edited a handbook of creativity for teachers. In 2013 she edited a book creativity, talent and excellences. To date, Tan has supervised nearly 80 dissertations, theses and higher degree final year critical inquiry research projects.

Keith J. Topping is director of the Centre for Paired Learning at the University of Dundee in Scotland. He has degrees from the Universities of Sussex, Nottingham and Sheffield, and is a fellow of the British Psychological Society and a fellow of the Royal Society of Arts. His research interests are in the development and evaluation of methods for non-professionals (such as parents or peers) to tutor others one-to-one in fundamental skills (such as language, reading or maths) and higher order learning, across many different subjects, contexts and ages. He also has interests in electronic literacy and computer aided assessment and in behaviour management and social competence in schools. He has extensive experience working with teachers, children and parents in a great many school districts, as well as with government and non-governmental organisations, in the UK, US and many other countries. His publications include 21 books, 52 chapters, 173 peer reviewed journal papers, 35 distance learning packages, and other items. He presents, trains, consults and engages in collaborative action and research around the world. Further details are available at http://www.dundee.ac.uk/eswce/people/kjtopping.htm.

Steve Trickey has, for the last five years, been teaching Psychology of Education courses at the American University, Washington DC where he continues to pursue his interest in critical thinking. Prior to this, Steve accumulated considerable experience working with teachers, learners and educational systems in the United Kingdom during a long career as a practising senior educational psychologist. His overriding research interest is in how collaborative dialogue in the classroom can support critical thinking and social outcomes in children. Together with Keith Topping, Steve evaluated the impact of Philosophy for Children in Scottish schools in a four year longitudinal study in a collaborative initiative involving Clackmannanshire Council and the University of Dundee.

Oshin Vartanian received his PhD in experimental psychology from the University of Maine in 2002. He is currently a Defence Scientist at Defence Research and Development Canada, Toronto Research Centre. He is an Adjunct assistant professor in the Department of Psychology at the University of Toronto Scarborough, and a cross-appointed Graduate Faculty member at the University of Toronto. He is the Editor of *Empirical Studies of the Arts*, and serves on the editorial boards of the *Creativity Research Journal* and the *Psychology of Aesthetics, Creativity, and the Arts*. His co-edited volumes include *Neuroaesthetics* (Baywood), *Neuroscience of Decision Making* (Psychology Press), and *Neuroscience of Creativity* (MIT Press). He is the recipient of the Berlyne Award (2005) from APA's Division 10 (Society for the Psychology of Aesthetics, Creativity, and the Arts) in recognition of outstanding research by a junior scholar for his work on the neuroscience of aesthetics and creativity.

Marcel V. J. Veenman studied cognitive psychology and obtained a PhD degree at the University of Amsterdam. For over 20 years, he has been affiliated to both Leiden University and the University of Amsterdam. Currently, he is the director of the Institute for Metacognition Research (IMR) in the Netherlands. His research interests in the field of metacognition concern the nature of the construct, assessment issues, developmental patterns, the application of metacognitive skills across tasks and domains, and instructional effectiveness. Until recently, he was the scientific project leader of a large-scale research project on metacognition and giftedness, which was funded by the Dutch government. From 2006 to 2011, he was the founding editor-in-chief of *Metacognition and Learning*, a journal published by Springer.

Grady Venville is Winthrop Professor and dean of Coursework Studies at the University of Western Australia. She is responsible for the quality and structural integrity of the curriculum across all coursework within the University. She is currently a member of the Australian Research Council College and is known internationally for her research in science education. Her research interests focus on curriculum integration, conceptual change and cognitive acceleration. Grady has published more than 50 papers in scholarly refereed journals and is co-author of the book, *Knowledge that Counts in a Global Community: Exploring the Contribution of Integrated Curriculum* (Routledge, 2012). Grady received the NARST (a worldwide organisation for improving science teaching and learning through research) Early Career Research Award in 2004 and was associate editor for the *Journal of Research in Science Teaching* from 2005 to 2009. She is currently on the Editorial Board of the *International Journal of Science Education*.

Michael Waring is director of MSc (QTS) PE and PESP programmes and senior lecturer in the School of Sport, Exercise and Health Sciences at Loughborough. His research interests focus on the development of a Personal Learning Styles Pedagogy and the use of learning technologies as part of blended learning in higher education and initial teacher education contexts. Generally and as part of the exploration of this personalised learning agenda, he is interested in the use and innovative development of qualitative research methodology.

Rupert Wegerif is a professor of education at the University of Exeter. His research focus is dialogic education for the emerging Internet Age. For Rupert dialogic education is education for creative thinking. He has led several major research projects and published nine books as well as over 40 peer-reviewed articles and over 30 book chapters. He heads the Centre for Teaching Thinking and Dialogue at Exeter and edits the international journal Thinking Skills and Creativity.

Richard F. West is emeritus professor in the Department of Graduate Psychology at James Madison University. He is the author of over 80 scientific articles in various areas of psychology and cognitive science. Thirty-three of his articles have received over 50 citations, 19 articles over 100 citations, and nine articles over 200 citations. He is the co-author of a target article in *Behavioral and Brain Sciences* that has been cited over 700 times in ISI Web of Knowledge and over 1700 times in Google Scholar. West is one of only two faculty at James Madison University to have received the University's Madison Scholar Award twice.

Yu-chu Yeh is a distinguished professor of Institute of Teacher Education as well as a researcher at the Research Center for Mind, Brain & Learning and the Center for Creativity and Innovation Studies at National Chengchi University, Taiwan. Her research interests include critical thinking, creative thinking, cognitive psychology, e-learning, educational psychology and positive psychology. She has won the Outstanding Research Award from the Ministry of Science and Technology, Taiwan; she has also obtained 10 research awards from her university. Her research findings have been published in well-known journals, such as the *Creativity Research Journal*, the *Journal of Creative Behavior*, *Instructional Science*, *Teaching and Teacher Education*, *Educational Technology & Society*, *Computers & Education*, the *British Journal of Educational Technology*, *Thinking Skills and Creativity* and *NeuroImage*. She is currently on the editorial board of *The Open Education Journal* and the *International Journal of Educational Research and Technology*.

Li-fang Zhang is professor of Psychology and Education in the Faculty of Education at The University of Hong Kong, where she served as associate dean (Research Higher Degrees) from 2007 to 2010 and is currently head of the Division of Learning, Development, and Diversity. Professor Zhang is the author of over 100 peer-reviewed journal articles and encyclopaedia entries as well as dozens of academic book chapters and books. Her most recent book is *The Malleability of Intellectual Styles* (2013, Cambridge University Press). The title of her forthcoming book is *The Value of Intellectual Styles* (Cambridge University Press). Apart from publishing on intellectual styles, she has also published in such research areas as creativity, giftedness, personality, student development, teacher education, higher education, multicultural education and the academic profession. She is associate editor of *Educational Psychology* and serves on the editorial boards of the *Educational Psychology Review*, the *Journal of Cognitive Education and Psychology*, and *PsyCh Journal*.

Anat Zohar is a full professor at the School of Education, Hebrew University, Jerusalem, Israel. Her main research interests are the development of students' higher order thinking, metacognition, inquiry teaching and learning, teachers' knowledge and professional development in the context of teaching thinking and metacognition, and gender issues in science education. She served as Director of Pedagogy at the Israeli Ministry of Education and was a member in the Institute for Advanced Study in Princeton, NJ. Among her publications are the books *Metacognition in Science Education: Trends in Current Research* and *It's Not All About Test Scores: Reviving Pedagogical Discourse*. Her article 'Fostering Students' Argumentation Skills in Genetics' was nominated in the fiftieth anniversary special issue of the *Journal of Research in Science Teaching* as one of the most influential papers that had been published in that journal.

Introduction

Rupert Wegerif, Li Li, James C. Kaufman

Introduction

Teaching thinking is important. Policy reports from around the world stress that education for higher level skills, such as problem solving, creativity and learning to learn, is crucial for future economic growth (e.g., World Bank, 2011). This policy push is influenced by social science research that strongly suggests a causal relationship between the level of cognitive skills in a nation and the level of economic development (Rindermann and Thompson, 2011; Hanushek and Woessmann, 2008). Beyond these familiar economic arguments there is also widespread recognition that dispositions required for good thinking such as resilience, tolerance, creativity and reasonableness are all also essential to personal and collective well-being in an increasingly globalised world (OECD, 2014).

In China the curriculum has been changed in recent years to focus more on promoting critical and creative thinking. In the USA and UK many colleges include Critical Thinking as part of their general core curriculum. In Malaysia the government has declared that every school will engage in teaching thinking training in order to become a 'thinking school' within three years. Similar initiatives can be found in other developing economies including Thailand, Mexico, Russia and Brazil. Teaching thinking is very much on the agenda for education in the twenty-first century, but how good is the research base for all these practical initiatives?

This book offers the background theory and summaries of research evidence required by policy makers and teachers who have to make decisions about teaching thinking.

The interest in teaching for thinking and creativity around the world has led to a great many publications of practical recipes. However, given that anyone can publish a book and claim whatever they want to, much of this practice is not informed in a rigorous way by research. Teaching thinking as a field of research has been damaged by the commercial success of teaching thinking packages. Each package claims to be based on research but these claims are almost always based on cherry picking the research findings that seem to fit the approach adopted rather than on building an approach that comes out of a serious review of the research findings.

Commercial packages in the field of teaching thinking have a real vested interest in not learning from research. Research implies constant reflection, refinement, and development, whereas

packages need to stay the same to establish and expand their brand penetration of the market. Edward de Bono's well known 'six thinking hats' approach is a good example of this problem. This approach has many positive virtues, but it is important to note that it has not changed in the last thirty years. There have been a few small evaluations designed to demonstrate that the hats approach is effective but there has been no serious research to help us find out why these are exactly the hats that we need and what would happen if we had different hats or if we used seven hats or five instead of the given six.

Just pulling packages, like the six hats approach, off the shelf and applying them without questioning why they work is the opposite of thinking. Yet it is exactly such a poor choice of action that many misguided policy makers and teachers believe is all that is needed in order to 'teach thinking'. At world conferences on teaching thinking the voices of gurus with commercial solutions drown out the more modest voices of serious educational researchers. This is why we need this volume. All the contributors to this volume are university researchers or based in research laboratories. The chapters are not promoting packages or any commercial product but are instead exploring the principles that underlie the success or failure of different approaches to teaching thinking.

Another reason why we need this volume is to report on the changes and developments in the field of research into teaching thinking. Our choice of the term 'teaching thinking' to describe this research field already says something significant about how we think that the field has developed.

What is 'teaching thinking'?

Some people might find that the term 'teaching thinking' sounds a little vague. They might prefer something that sounds more precise like 'cognitive skills' or 'Higher-Order Thinking' or 'critical thinking'. However, we find that the practice of teaching thinking takes many forms, from electrical brain stimulation (Snowball et al., 2013) to group drama (Anderson, 2004). All of these approaches are united by the desire of practitioners and policy makers to improve the quality of thinking of students. In conducting research in support of this practice we need to question and develop notions of what counts as good thinking but we are not yet in a position to define the field through our theories. If we claim that we are teaching 'cognitive skills' for example then we exclude approaches with good results that are not obviously cognitive or obviously skills such as working on emotions (Newton, this volume) or working on the self image of students (Burden, this volume). There is a long tradition of separating the teaching of critical thinking from the teaching of creativity, but most research indicates that creativity is crucial to all types of effective real-world thinking. Now teaching for creative thinking tends to be seen as a key part of teaching good thinking in any context (Tan; Cropley, both this volume). The separation of 'Higher Order' thinking skills such as 'evaluating' from supposedly 'Lower Order' skills such as 'remembering' is not grounded on good neurocognitive research evidence. The use of phrases such as 'Higher-Order Thinking Skills' sounds technical and precise but in practice means simply 'the kind of thinking that is highly valued in this culture at this time and that we think students do not do enough of and really ought to do more' (Wegerif, 2002). So by using the inclusive phrase 'teaching thinking' we avoid the potential trap of prematurely claiming a settled consensus as to what good thinking is and how it can be taught. On the other hand we are clearly delineating a field of research: this is research into the underlying structures and causal processes behind the widespread cultural practice of teaching thinking.

Lauren Resnick's insight into the field of teaching thinking, expressed nearly thirty years ago, remains true today (Resnick, 1987). Although we might not be able to explain what we mean by good thinking in advance, we recognise it when we see it. It cannot be completely defined in

advance because it is not algorithmic but always surprising. This is another way of saying that the field of teaching thinking is founded on the intuitions and practical expertise of educationalists who want to teach for more than repetition and exam success and who know from experience that this is possible.

Developments in the field

Resnick's definition of good thinking as always surprising implies that creativity is an essential component of good thinking. Creativity was once marginal in the field of teaching thinking, yet now it has become central. The scholarship on creativity is a rapidly increasing juggernaut that has brought academic rigour to a field that is often thought to be 'soft'. There are more academic journals devoted specifically to creativity research than ever before, and the impact factors of these journals have uniformly increased (sometimes more than doubling) over the last decade (Long et al., 2014). The question of how creative thinking can be improved has been studied by a multitude of fields, from education (Beghetto & Kaufman, 2010) to neuroscience (Vartanian et al., 2013) to business (Paulus & Nijstad, 2003). This shift is reflected in the Handbook not only with a section of six chapters on research on teaching for creative thinking but also through the fact that creativity features as a significant theme in most of the chapters. Beghetto considers challenges and new opportunities in teaching creative thinking in K-12 schools in the USA; whereas Li and Johnston explore what it means to teach creativity for teachers in China. Craft discusses possibility thinking for creativity to suggest that it helps us to understand how children inhabit the world of imagination that allows them to pose 'what if' questions as well as engaging in 'as if' behaviours. Creative thinking is not a stand-alone concept but something that everyone needs to have and it can be embedded in various learning environments (Yeh, this volume) and can be nurtured across the lifespan with various methods appropriate to the developmental needs of individuals (Hui, He, Liu-Au, & Ching, this volume). Creative thinking can be and should be linked to other aspects of learning, such as motivation and goals (Kaufman, Reiter-Palmon & Royston, this volume). The shift of teaching thinking towards fostering creative thinking also is evidenced by the approaches of assessing creative thinking (Long & Plucker; West & Stanovich, both this volume).

When David Perkins surveyed developments in the field of teaching thinking in his valedictory address at Harvard (in 2011, available on YouTube) he stressed a particular shift from a focus on teaching skills to teaching for the development of enduring dispositions. Research suggests that cognitive skills often do not transfer from the context in which they are taught. A focus on teaching for positive thinking dispositions is an answer to this challenge. Dispositions are tendencies to act in certain ways that people carry with them across different situations. Dweck's work (2012) has been particularly influential in demonstrating a) the importance of having a positive disposition towards learning new skills and b) that this disposition can be taught. This shift from understanding teaching thinking as teaching skills or abilities to understanding teaching thinking also in terms of teaching for positive thinking dispositions is implicit behind many of the chapters in the Handbook, particularly the two chapters on research into cognitive styles (Zhang; Evans and Waring), Doug Newton's exploration of the significance of emotional responses and Robert Burden's chapter on assessment (all this volume).

The increasing roles given to creativity and to dispositions are perhaps part of a broader movement away from a focus on discrete cognitive skills of the kind that can be measured in a laboratory and towards an understanding of thinking as always embedded in complex real-world contexts and so needing to be taught in a way that takes context into account. In the theory section of the Handbook for example, Robert Sternberg argues for the importance of

ethical thinking as part of effective thinking in social contexts, Yoram Harpaz draws out some of the implications of understanding approaches to teaching thinking as ideologies, supported by Steve Higgins who looks at the factors and motives that have influenced the history of teaching thinking. In the STEM (Science, Technology, Engineering and Mathematics) section, we look at teaching thinking embedded within particular curriculum contexts, in relation to cognitive acceleration (Oliver & Venville), developing science teachers' epistemic practices and thinking (Erduran & Garcia-Mila), teaching and learning of probabilistic thinking (Chernoff & Sriraman), and problem-based learning (Adel El Sayary, Forawi, & Mansour).

In real life, thinking is something we usually do using tools and together with others, so to many people it makes sense to also teach it that way. The use of tools such as argument maps or concept maps and other visual scaffolds is widespread in teaching thinking practice (e.g., Hyerle, 2009) and it is perhaps a weakness of this volume that we do not have more research into how such tools work. However Johnson-Laird (this volume) offers a fascinating study of the impact of using diagrams of possibilities to support thinking.

Traditionally teaching thinking has focused on individuals. It is only quite recently that there has been clear research demonstrations that collective or group thinking is a real separate phenomenon with its own unique features that can be measured and can be taught (Woolley, 2010). Group thinking depends upon communication and research on group thinking is often linked to research on tools that support group thinking (e.g. Stahl, 2006). This very new approach to teaching thinking is brought out in the final section of the Handbook, 'Collaboration and New Technology' where several chapters explore how we can teach thinking together mediated by tools. This new development follows the logic of the general shift towards more situated approaches to thinking and teaching thinking.

While the developments outlined above all fit with the overarching theme of moving from discrete skills to studies of thinking in context, there is one very exciting development that can at times appear to be pushing in the opposite direction. This is the recent expansion in neurocognitive research relying on brain-scanning techniques. Vartanian and Beatty (this volume) review the impact of training on the working memory and so on more general thinking ability. Many other chapters in the book refer to this new and expanding line of research, the findings of which will have growing significance in the field of research on teaching thinking.

Finally there is another prominent development in the field of teaching thinking which we take account of in this Handbook: globalisation. Previous handbooks, such as Baron and Sternberg's (1987) excellent volume *Teaching Thinking Skills*, have been largely limited to researchers in North America. The three editors of this volume are citizens of three continents (North America, Europe and Asia) and this geographical spread is reflected in the contributions. For example in the theory section Li explores the cultural issues that arise around the meeting of Western ideas of teaching thinking and Confucian traditions of education. The rise of interest in education in the Asia-Pacific region is particularly reflected in this Handbook with chapters from Hui; Li and Johnston; and Cheng (all this volume) surveying developments there in teaching thinking and in the assessment of thinking, as well as several other chapters reporting on studies of teaching thinking conducted in Asia.

These are just a few highlights of developments in a complex and multi-faceted field. In focusing on new and emerging themes we do not mean to obscure other, more established areas that continue to develop. The Handbook also has a section on research developments in metacognition and critical thinking research for example. Metacognition is closely examined in specific subject areas, such as second language learning and science eduction. Zohar and Barzilai point out the central role of metacognition in teaching higher order thinking skills in science, and argue that metacognitive skills should be taught explicitly more often. Liu and Li review the research in metacognition in second language reading and consider think-aloud protocols

in tapping into second language learners' metacognition. They also offer practical guidance for developing metacognitive awareness in second language classrooms.

Although we have done our best to include all relevant strands of research inevitably some important and exciting research in the area of teaching thinking has been left out. This Handbook is not intending to be either exhaustive or final. The dynamic field of teaching thinking research cannot be contained in one book or summed up in one narrative.

Some tensions that help to define the field

Ideology or science?

Harpaz (this volume) lays down the challenge that teaching thinking is based upon ideology although it often presents itself as if it was science. The very idea of teaching thinking seems to depend upon a notion of good thinking that is culturally specific and so inevitably disputed. Li (this volume) brings out that ideas of good thinking and of good ways to teach thinking are different in China than in the West and this has implications for pedagogical interventions. Wegerif (this volume) refers to evidence that how we think and also how we value thinking, varies across cultures and across time. Many of the chapters in this Handbook actively advocate a particular approach to teaching thinking which implies a particular view of what good thinking is. Just to give three examples, Sternberg advocates teaching ethical thinking; Baumfield advocates teaching thinking as a way to engage teachers in reflecting on their practice; whereas Hogan advocates the value of teaching a particular kind of systems thinking. Other chapters, such as Veenman and Topping and Trickey, limit themselves to the more neutral voice common in natural science research, reporting the results of research.

This apparent tension between styles of writing in the field, some articles reading like political advocacy while others read like neutral scientific research reports, indicates a tension at the heart of all educational research. Education inevitably involves decisions about what to teach and how to teach it and these decisions imply values. From its inception, the field of teaching thinking research has been about political advocacy for the need to teach for more than transmission of knowledge (Higgins, this volume). That advocacy might be grounded on 'ideology' according to Harpaz's definition of this term, but that does not mean that it is incompatible with good science. Good science is needed to tell us the effects of different approaches to teaching and to help us understand the learning and teaching processes that lie behind those effects. Education is always an arena for political debate and no more so than the field of teaching thinking. Researchers in the field of teaching thinking propose or imply so many different models of good thinking, and so many different ways to teach good thinking, that they cannot all be right. It is best to be honest about this. However, that is precisely why we need good scientific research. Research might be motivated by social concerns (or 'ideologies') but in pursuing these it needs to provide persuasive evidence based on reliable methods. In the process research helps us to understand what lies behind the different approaches to teaching thinking not only so that we can choose between them but more importantly, so that we can better understand what good thinking is and how best to teach for it.

Can we teach good thinking in general or should we teach thinking in a way that is specific to different subject areas?

Moore (this volume) raises the long-standing debate between those who claim that good thinking has general features that can be taught and those who claim that good thinking is specific

to context, especially disciplinary context. He looks at what is meant by 'critical thinking' in different areas of the university curriculum and concludes that it takes distinct forms and requires subject knowledge. This is not an argument against teaching thinking but in favour of teaching thinking skills within curriculum areas in ways that are specific to those areas. Higgins (this volume) looks at what the evidence of research studies tells us about the debate between teaching thinking skills as extra 'enrichment' outside the curriculum and teaching thinking in a way that is 'infused' within each area of the curriculum. He concludes that the evidence points clearly to the need to do both. Teaching thinking skills outside contexts can leave students unclear as to how to apply them whereas teaching skills only within contexts can lead to a limited awareness of how to apply the same skills in new contexts.

This debate will continue because it depends not just on research evidence but on what we mean by thinking and on our purpose in teaching thinking. Thinking as metacognitive awareness of the kind advocated by Larkin (this volume) is not obviously the same as the critical thinking activities that Moore considers. It might be that the demands of teaching thinking in the primary school contexts looked at by Larkin are less constrained by disciplinary boundaries than the thinking in college subject areas explored by Moore. Butler (this volume), appears to take the opposite point of view to Moore, claiming that generic critical thinking can be successfully taught and successfully assessed. It is noticeable that she begins her chapter with a reference to the need to teach for twenty-first century real-world skills, referring to a kind of thinking perhaps different from the thinking in the context of college teaching of History, Philosophy and Cultural Studies referred to by Moore.

Is thinking individual or social?

The mainstream tradition in the teaching thinking movement has always been to focus on improving the thinking of individuals. Even when practical approaches use the language of 'thinking schools' (Burden, this volume), 'thinking classrooms' (McGuinness, 1999) and thinking communities (Harpaz & Lefstein, 2000) it is often clear that they are assuming that thinking is really located in the neural processes of individual brains. However, as we mentioned above there has recently been much interest in research on collective thinking suggesting that this has unique features (Woolley et al., 2010). Knight and Littleton (this volume) and Wegerif (this volume) both refer to the direct teaching of better collective thinking through interventions that address the shared culture of communication and the means of communication including communications technology. Schwartz and Slakmon (this volume) illustrate how teaching can change the culture of a classroom in the direction of improving collective thinking. Of course, focusing on teaching thinking at the individual level and at the social level are not incompatible. It is likely that better group thinking will transfer to individuals within that group (Wegerif et al., 1999) which is perhaps one reason why the community of inquiry approach is a popular way to teach thinking (Topping & Trickey, this volume). However, whether the focus is on thinking understood as a property of a shared culture or thinking understood only as the property of individuals is another tension that can be seen in the field of research on teaching thinking.

Towards the future of teaching thinking research

Teaching thinking is driven by the desire for a kind of education that goes beyond the transmission of existing culture towards providing students with the skills and dispositions that they need to face new challenges in the future. Understood in this way the drive to teach thinking is as old as education itself but this drive takes different forms in different contexts (Higgins, this volume). The contemporary teaching thinking movement has already seen waves of enthusiasm

followed by periods of controversy and retreat (Harpaz, this volume). We are at the beginning of a new wave of interest in teaching thinking fueled partly by the challenge of new technologies and partly by developing countries interested in education that will lead to more economic innovation. Key to this new wave is the kind of rigorous research into teaching thinking that this Handbook exemplifies. Teaching thinking has lost some academic respect in the past because of the influence of champions who were long on persuasive rhetoric and short on the kind of convincing argument that can be backed by research evidence. This Handbook is part of a movement to overcome that weakness. Although there are many approaches and many methods represented in this Handbook they all participate in a serious attempt to understand what teaching thinking is and how we can best take this movement forward.

References

Anderson, C. (2004). Learning in 'As-If' worlds: Cognition in drama in education. *Theory into Practice, 43*(4), 281–286.

Baron, J. B., & Sternberg, R. J. (Eds.) (1987). *Teaching thinking skills: Theory and practice*. New York: Freeman.

Beghetto, R. A., and Kaufman, J. C. (Eds.) (2010). *Nurturing creativity in the classroom*. New York: Cambridge University Press.

Dweck, C. S. (2012). *Mindset: How you can fulfil your potential*. London: Constable & Robinson.

Hanushek, E., & Woessmann, L. (2008). The role of cognitive skills in economic development. *Journal of Economic Literature, 46*(3), 607–668.

Harpaz, Y., & Lefstein, A. (2000). Communities of thinking. *Educational Leadership, 58*(3), 54–57.

Hyerle, D. (2009) *Visual tools for transforming information into knowledge* (2nd ed.). New York: Corwin.

Long, H., Plucker, J. A., Yu, Q., Ding, Y., & Kaufman, J. C. (2014). Research productivity and performance of journals in creativity sciences: A bibliometric analysis. *Creativity Research Journal, 26*, 353–360.

McGuinness, C. (1999) *From thinking skills to thinking classrooms: A review and evaluation of approaches for developing pupils' thinking*. London: DfEE (Research Report RR115). Retrieved from: http://www.dfes.gov.uk/research/data/uploadfiles/RB115.doc (accessed 9 February 2015).

OECD (2014). ESP International Report: Skills for social progress. Retrieved from: http://www.oecd.org/site/espforum2014/IssuesPaperESPForum2014.pdf (accessed 9 February 2015).

Paulus, P.B., & Nijstad, B.A. (2003). *Group creativity: Innovation through collaboration*. Oxford: Oxford University Press.

Resnick, L.B. (1987). *Education and learning to think*. Washington, DC: National Academy Press.

Rindermann, H., & Thompson, J. (2011). Cognitive capitalism: The effect of cognitive ability on wealth, as mediated through scientific achievement and economic freedom. *Psychological Science, 22*(6), 754. doi: 10.1177/0956797611407207.

Snowball, A., Tachtsidis, I., Popescu, T., Thompson, J., Delazer, M., Zamarian, L., Zhu, T., & Cohen Kadosh, R. (2013). Long-term enhancement of brain function and cognition using cognitive training and brain stimulation. *Current Biology, 23*(11), 987–992. Retrieved from: http://www.sciencedirect.com/science/article/pii/S0960982213004867 (accessed 9 February 2015).

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge* (pp. 451–473). Cambridge, MA: Mit Press.

Vartanian, O., Bristol, A. B., & Kaufman, J. C. (Eds.) (2013). *The neuroscience of creativity*. Cambridge, MA: MIT Press.

Wegerif, R. (2002) *Literature review in thinking skills, technology and learning*. Commissioned by Futurelab. Retrieved from: http://archive.futurelab.org.uk/resources/documents/lit_reviews/Thinking_Skills_Review.pdf (accessed 9 February 2015).

Wegerif, R., Mercer, N., & Dawes, L. (1999). From social interaction to individual reasoning: An empirical investigation of a possible socio-cultural model of cognitive development. *Learning and Instruction, 9*(6), 493–516.

Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (2010). Evidence for a collective intelligence factor in the performance of human groups. *Science*, 29 October, *330*(6004), 686–688. doi: 10.1126/science.1193147.

World Bank (2011). *Learning for all: Investing in people's knowledge and skills to promote development. Education sector strategy 2020*. Washington, DC. The World Bank. Retrieved from: http://siteresources.worldbank.org/EDUCATION/Resources/ESSU/Education_Strategy_4_12_2011.pdf (accessed 9 February 2015).

Cazden, C. (2001). *Classroom discourse: The language of teaching and learning*. Portsmouth: Heinemann.
Chin, C., & Osborne, J. (2010). Supporting argumentation through students' questions: Case studies in science classrooms. *Journal of the Learning Sciences, 19*(2), 230–284.
Dewey, J. (1933). *How we think*. Buffalo, NY: Prometheus Books (Originally published in 1910).
Dillon, J. T. (1984). Research on questioning and discussion. *Educational leadership, 42*, 50–56.
Dillon, J. T. (1988). The remedial status of student questioning. *Journal of Curriculum Studies, 20*(3), 57–74.
Engle, R. A., & Conant, F. R. (2002). Guiding principles for fostering productive disciplinary engagement: Explaining an emergent argument in a community of learners classroom. *Cognition and Instruction, 20*(4), 399–483.
Graesser, A. C., Lu, S., Jackson, G. T., Mitchell, H., Ventura, M., Olney, A., & Louwerse, M. M. (2004). AutoTutor: A tutor with dialogue in natural language. *Behavior Research Methods, Instruments, and Computers, 36*(2), 180–193.
Graesser, A. C., McNamara, D. S., & VanLehn, K. (2005). Scaffolding deep comprehension strategies through Point&Query, AutoTutor, and iSTART. *Educational Psychologist, 40*, 225–234.
Habermas, J. (1984). *The theory of communicative action*. Boston, MA. Beacon Press.
Hardman, M., & Delafield, B. (2010). Philosophy for Children as dialogic teaching. In K. Littleton & C. Howe (Eds.), *Educational dialogues: Understanding and promoting productive interaction* (pp. 149–164). London: Routledge.
Henderson, B., & Moore, S. G. (1979). Measuring exploratory behavior in young children: A factor-analytic study. *Developmental Psychology, 15*(2), 113–119.
Koppa, K. J., Britt, A. M., Millis, K., & Graesser, A. C. (2012). Improving the efficiency of dialogue in tutoring. *Learning and Instruction, 22*(5), 320–330.
Lipman, M. (2003). *Thinking in education* (2nd ed.). Cambridge: Cambridge University Press.
Lipman, M., & Sharp, M. (1978). *Growing up with philosophy*. Philadelphia: Temple University Press.
Lipman, M., Sharp, A. M., & Oscanyan, F. S. (1980). *Philosophy in the classroom* (2nd ed.). Philadelphia: Temple University Press.
Ludvigsen, S., Rasmussen, I., Krange, I., Moen, A., & Middleton, D. (2011). Intersecting trajectories of participation: Temporality and learning. In S. Ludvigsen, I. Rasmussen, A. Lund & R. Säljö (Eds.), *Learning across sites: New tools, infrastructures and practices* (pp. 105–121). New York: Routledge.
Passmore, J. A. (1970). *Philosophical reasoning* (2nd ed.). London: G. Duckworth.
Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.
Sanders, N. (1966). *Classroom questions: What kind?* London: Longman.
Schwarz, B. B., & Asterhan, C. S. C. (2010). Argumentation and reasoning. In K. Littleton, C. Wood & J. Kleine Staarman (Eds.), *International handbook of psychology in education* (pp. 137–176). Bradford, UK: Emerald Group Publishing.
Schwarz, B. B., & Asterhan, C. S. C. (2011). E-moderation of synchronous discussions in educational settings: A nascent practice. *The Journal of the Learning Sciences, 20*(3), 395–442.
Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.
Topping, K. J., & Trickey, S. (2007). Collaborative philosophical enquiry for school children: Cognitive effects at 10–12 years. *British Journal of Educational Psychology, 77*(2), 271–288.
Wong, B. Y. L. (1985). Self-questioning instructional research: A review. *Review of Educational Research, 55*, 227–268.
Zuckerman, G. A., Chudinova, E. V., & Khavkin, E. E. (1998). Inquiry as a pivotal element of knowledge acquisition within the Vygotskian paradigm: Building a science curriculum for the elementary. *Cognition and Instruction, 16*(2), 201–233.

38

Thinking, interthinking, and technological tools

Simon Knight

KNOWLEDGE MEDIA INSTITUTE, OPEN UNIVERSITY, UK

Karen Littleton

CENTRE FOR RESEARCH IN EDUCATION AND EDUCATIONAL TECHNOLOGY, OPEN UNIVERSITY, UK

Introduction: the development of individual and collective thinking

The pictures here (see Figure 38.1) will be familiar to most who have had any contact with educational settings in the last 20 or so years. Indeed, one of our most recent books (Littleton & Mercer, 2013) reflected on one of the first pieces of research into school-classroom based dialogue from that time. There, it was noted that in many cases group work around computers was conducted not due to any underlying pedagogic strategy, but because of a lack of resources. For many this will be a familiar story, but along with colleagues, we have spent considerable effort in investigating what constitutes effective learning in group activity particularly that mediated by technological devices. Of course, many educators – as was the case in that original research – will have had the experience of frustration in some such situations, finding occasions when group work seemed to be ineffective and suspecting that a better use of resources would be to set students on individual tasks. Indeed, what is so potent about many new technologies is their ability to open up new worlds of learning for individuals. Yet, in this chapter we will argue that to see technology as primarily an *individual* pursuit is to miss out on two important considerations: firstly, many modern technologies vastly expand the potential for inter-textual and inter-active elements (Wegerif, 2013) through our interaction with which we are exposed to the thoughts and arguments of others and, secondly, technology can be an invaluable aid in resourcing and supporting both co-located and remote small group activity.

Throughout this chapter we aim to highlight the ways in which shared use of technology can be seen as both an individual and collective resource, and foreground the importance of dialogue as being of fundamental importance in such contexts.

Language and thinking

The Russian psychologist, Lev Vygotsky, highlighted the importance of language for thinking, emphasising that: