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Pedagogical link-making with digital technology in science classrooms: new perspectives on connected learning

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ABSTRACT

Digital technologies, particularly networked technologies, are changing the way we communicate with others and interact with information. Dialogic Theory helps us to understand the new ways in which students and teachers are making meaning with networked technologies, for instance by drawing our attention to the concept of 'dialogic space'. This chapter explores how discursive practices in classrooms are shaped by teachers and students within this dialogic space, by looking at the ways in which networked technologies impact on pedagogical link making in science lessons. We redefine and challenge existing theoretical ideas to construct an interpretative framework that helps us to understand how networked technologies reshape classroom discourse and the teaching learning process. Examples are taken from several research projects over a number of years in two different countries (UK and Catalonia), supporting the feasibility of using our framework in different contexts. Our results show that networked technologies empower students' voices in the educational dialogic space, blur the space and time limits of school and out of school learning, and move the focus of teaching practices towards a competence-based approach, to enable students to establish meaningful knowledge-building links in a wide, digital, dialogic network.

Introduction

Digital technology has changed society and digital tools are rapidly appearing in classrooms all around the world. Digital *networked* technologies in particular, have changed the way in which people learn and what it means to 'be a learner' (Erstad, 2014) and we thus need to expand our understanding of teaching and learning processes in the classroom to include the use of digital, multimodal media, both inside and outside the classroom. Often, learning experiences are visualised as being 'trajectories of learning' in which one experience is chain-linked to other experiences. In education, it is usually the teacher who facilitates the connections between these experiences, since one of the main roles of the teacher is to develop links between learning experiences (see for example Mercer, Dawes & Kleine Staarman, 2009; Scott, Mortimer & Ametller, 2011; Alexander, 2017). However, utilising networked technology in classrooms gives students the opportunity to draw in their own interests and experiences in their learning trajectories in ways that were not possible before.

In this sense, the boundaries of the classroom wall have become permeable and the classroom has changed from being a stand-alone, separate space of learning and teaching, to a node, or 'intersection' (Leander, Phillips & Taylor, 2010, p.336) within a more personalised open-ended and non-linear learning experience, in which teachers help students to create new understanding, by weaving together different elements and new multimodal information, using networked technology. In this new scenario teachers need to put more emphasis on how this links are built in order to create new understanding rather than on providing specific instances of such links.

A key concern in our current connected world is therefore to develop our understanding of how knowledge and learning develops in, and moves between, various contexts. This requires a reconsideration of the way in which we define 'teaching' as an activity and the development of our understanding of learning processes of students across spaces and time. Two important questions in this respect are 'How do students connect one learning experience with another? and 'If learning is seen as weaving together different experiences and information, how are opportunities for learning organized and supported in these trajectories of learning and experience?'. These questions are not only relevant for researchers in education, in order to help to explain what is going on in classrooms, but also for teachers, to help them design valuable learning experiences for their students.

To understand and reconceptualise the role of the teacher in creating links between learning experiences of students, and to enable us to explain the ways in which networked technologies permeate into the teaching experiences of teachers, we need to challenge and refine theories of teaching and learning and develop new ways of theorising classroom practice. For the purpose of this paper, we draw on a dialogic perspective of learning, seeing dialogue as more than the exchange of recognisable utterances but as a "theoretical idea that defines the nature of many aspects of the relationality of language" (Barwell, 2016, p.336). In particular, we explore how the use of new digital technology reshapes dialogic practices in education. We augment a dialogic perspective of learning with the concept of 'pedagogical links', introduced by Scott et al. (2011) to account for the different ways in which teachers connect different learning experiences, elements of classroom activity, and different pieces of information and conceptual constructs during their teaching practice, in order to help students attain a better understanding of science. Thus, this paper explores how this notion of pedagogical links is articulated when interactive technologies are used to support the dialogue and the collaborative construction of knowledge during science classrooms. In this case, it is important to note that we refer not only to the pedagogical links that are created directly with and through technology, but also those that take place because technology is being i*nvoked* in the activity.

We will provide some examples of classroom practices from our own research in science classrooms, to show how our interpretative framework can be used to shed light on the ways in which new interactive technologies have helped to make the classroom walls permeable, and the role of the teacher in helping students to weave together new information and ideas into shared understandings. We draw on our own research, undertaken in two different countries with two different educational cultures. Of course, we can see clear differences in pedagogy and teaching practices across these different countries, for instance in discursive practices in the classroom (see also Alexander, 2000). It is important to note that, despite international trends, different cultures and even regional and local differences affect the use of technology in classrooms. However, in our research, we have found it useful to analyse (though not necessarily compare) classroom practices in two different countries and the fact that we see very similar discursive and pedagogic practices around new technology, strengthens our interpretative framework for understanding the role of networked technologies in dialogic practices in schools.

Dialogic Space

Dialogic and dialogue are terms that different people have attached different meanings to, and over the years, these concepts have been approached in various ways. Bakhtin (1981) argued that dialogue is the interplay of voices in the way that every utterance or thought is a response to utterances and thoughts of others. In this sense, the voices of others resonate in our dialogues and conscience and education involves participants to engage with each other's perspectives in classroom dialogues. In contrast to a view of education that sees learning as internalising the knowledge of others, Freire (1986) argued that students and teachers should engage in a joint dialogue about the object of study. In this sense, dialogue in classrooms can be seen as a way of empowering students, by enabling them to bring in their own knowledge and understandings into the dialogue. In the UK, the concept of 'Dialogic Teaching' was developed by Alexander (2017) and others (see for example Mercer et al., 2009) as a pedagogic approach with an emphasis on the active, significant and sustained participation of students in classroom dialogue. In Dialogic Teaching classrooms, tasks are collaborative, involving teachers and students working together and listening to one another, and students are encouraged to voice their ideas without having to worry about giving incorrect answers. From a Dialogic Teaching perspective, the goal for a science educator would not just be to help students to understand the science curriculum, or even to help students to become fluent 'speakers of science' (Lemke, 1990); but to make students fluent, self-aware and reflective speakers of science (Mercer et al, 2009).

The advent of digital networked technology in classrooms has created both opportunities and tensions for student engagement and learning, not in the least because networked technology connects students' identities, voices and discourses with other discourses and voices (Erstad, 2014; Kumpulainen & Mikkola, 2014; Kumpulainen & Rajala, 2017). These connections help to open up and expand the learning space of the classroom, or as Wegerif (2013) puts it, it opens up the 'Dialogic Space' in the classroom. In discussing the meaning of 'Dialogic Space', Wegerif (2013) argues that dialogues may be viewed 'from the outside' as events that are taking place in a specific space and time. However, 'from the inside', dialogues have their own space and time, and in themselves resonate the echoes of the voices of people who are not physically present in the event. Viewed from the outside, a dialogue can take place between two people in a particular place. When viewed from the inside, the same dialogue assumes that participants negotiate multiple positions and perspectives, echoing the voices of others, who are not

physically present in the dialogue. This implies that the notion of ‘Dialogic Space’ is not a static ‘space’ but a dynamic and continuous unfolding of 'meaning'.

When viewed from inside dialogues, 'developing meaning' assumes that there is a tension between the multiple perspectives that exist within these dialogues. When multiple voices interact with one-another, the differences between these perspectives is what Wegerif (2013, p.4) calls a ‘dialogic gap’. Since new meaning cannot arise in an interaction between two voices that say the same thing, it is in this space between different perspectives in a dialogue where new meaning arises. It is important to note that dialogues occur between different voices, not necessarily people. While these may be the voices of actual people talking in an interaction, the dialogic space also invokes the voices of others who are not physically present in the situation, or voices of abstract entities, such as cultural norms and values.

Education is a specific context in which dialogues take place and this specificity can be characterised by drawing upon the ‘inside’ and ‘outside’ perspectives of dialogue. In schools, dialogue is often an interactional form, ‘performed’ by learners through language. However, a dialogic perspective emphasises the development of new meaning through openness in the dialogue, addressing one-another’s ideas and building on the various meanings that arise in the dialogue. In this respect, Bakhtin (1981) emphasised the difference between an authoritative voice and a persuasive voice. The authoritative voice is one that comes into a dialogue from the outside, is rich in tradition and authority and “demands our unconditional allegiance” (p.343). It functions as a stable reality or the ‘truth’ or and is not surrounded by an “agitated and cacophonous dialogic life” (p.344). One example given by Bakhtin of authoritative discourse is “acknowledged scientific truth” (p. 343). In contrast, a persuasive voice enters into the realm of a dialogue and changes the dialogue from within (Bakhtin, 1981, p.343). Internally persuasive voices are supported by the power of arguments and centralise the tension between conflicting views and different meanings. In education, especially when critical thinking and an ability to creatively develop new understandings are considered important, a dialogic perspective is particularly important, shifting the importance from actual ownership *of* ideas to having a dialogue *with* ideas, which means not only focusing on authoritative voices, but also on developing children's ability to engage with persuasive voices.

A key challenge for education is to foster these dialogic processes, while at the same time maintaining a focus on curricular demands. Similarly, a challenge is to harness the potential power of technologies to help develop and sustain these dialogic processes, within the

constraints of an educational environment. In our own research on dialogic teaching in science classrooms, we have found that the focus in education should not necessarily be on the technology, but on the ways in which the technology is embedded within the wider dialogues of the classroom; the technology becomes an essential part of the dialogic space, opening it up, bringing in other voices and perspectives and helping to share and consolidate ideas. By following Bakhtin's view, in addition to effective collaborative practice such as building effective collective images for problem solving (Martin & Towers, 2014), seeing a problem 'as if through the eyes of another' is important for emergence and development of collective group thinking and understanding. This includes, for example, recognising multiple 'voices' in mathematical concepts, seeing ideas from an 'outside' perspective, establishing dialogic space, learners' attitudes to each other, laughter, and so on. This is what Wegerif (2011) refers to as dialogic process of conceptual growth.

Pedagogic link-making

As mentioned previously, school-based learning has obvious challenges with relation to increased complexities in the classroom through the use of new digital technologies (Erstad, 2014, p.1). Pedagogical links contribute to develop expanded notions of learning sites, in which classrooms can be seen as intersections (Leander et al., 2010) where different experiences and interests are interwoven through knowledge creation using digital media. In this respect, pedagogical links can be seen as tools to understand and foster dialogic teaching, not only in science lessons but in education more generally. Equally, pedagogic links enable the teacher to draw in a more comprehensive context in the classroom, which questions the place and time in which learning takes place.

Pedagogical link-making is concerned with the ways in which teachers and students make connections between ideas in the ongoing meaning-making interactions of classroom teaching and learning. The original idea of pedagogical links (Scott et al., 2011) is based on the constructivist view that learning involves learners connecting knowledge they already have with new ideas (Larochelle, Bednarz, & Garrison, 1998), and sociocultural perspectives particularly in their conceptualising the reconstruction involved in internalisation (Vygotsky, 1987). Links are also important in dialogic perspectives of education.

These connections across contexts and concepts often require the guide of an expert. Scott et al. (2011) grouped pedagogical link making used by teachers during science lessons into three groups according to their general purpose: 1) links to promote continuity, 2) links to encourage emotional engagement, and 3) links to support knowledge construction. Each of these types of pedagogical links present specific teaching strategies The first two types of pedagogical link making are relevant to any classroom teaching situation, not just in science. When pedagogical link making is used to support knowledge construction, the approach taken by the teacher depends on the nature of knowledge being linked and respond to the epistemic nature of scientific knowledge. In this case, pedagogical links are seen as ways of making explicit the connections between different elements of knowledge that need to be connected in order to construct science knowledge.

Methodology, methods and data analysis

The examples presented in this paper are drawn from a number of research projects that we have been engaged in over the years, both in the UK and in Catalonia. While the projects have been slightly different in scope and context, they have in common that they are all collaborative, classroom-based studies, in which research teams have been working with teachers to jointly develop new understandings about dialogue in science classrooms (see for more information on the specific projects: Scott & Ametller, 2007; Mercer et al., 2009; Grimalt, Pintó & Ametller, 2013; Grimalt, 2016). In our projects, a range of data has been collected, including classroom video observations and interviews with teachers and students. We made video and audio recordings in more than one, often three consecutive lessons, both of the teacher and of any group work that takes place, to be able to capture both the teaching practice and the emerging understanding of the topic.

The analysis of data is mainly concerned with identifying characteristics of the interaction process, within and across a series of lessons. Our methodological framework for this can be best described as Sociocultural Discourse Analysis (Mercer 2005; 2008), which is a methodological approach that foregrounds the historical, contextualised and purposeful nature of classroom dialogue and involves both quantitative and qualitative methods of analysis of classroom dialogue. The qualitative analyses were done using NVivo and AtlasTI and involved the development of detailed analysis maps, outlining the most important features of the lessons to capture emergent understandings and themes in the data. Quantitative analyses of transcript data are then used to draw out patterns of interaction, which are subsequently analysed in detail

using discourse analytic methods. The end result of this combined approach are detailed case descriptions, including close analysis of key moments of dialogue, and contextual notes about. for instance, the content of the lessons, use of technology and pedagogical aims of the teacher.

Pedagogical link-making with new technology

Our analysis of science lessons in which new digital technology is used, initially revealed the same three broad pedagogical aims for pedagogic link making, but at the same time, has led us not only to focus on approaches that seem specific to the activity in which technology is being used but in particular on the process of making these links. It seems to us that, just as pedagogical link making can support knowledge construction by modelling the connections students need to build during their process of internalisation, pedagogical link making mediated by networked technology can model the ways in which students will have to develop understanding, in and between contexts where technology is used to engage with new information. This represents a very commonplace context for students nowadays, and engages with what has been recognised in the literature as an urgent issue in relation to digital literacy.

The following example of classroom dialogue illustrates the way in which a UK Secondary School teacher is encouraging students to engage with technology to expand their understanding of a particular science phenomenon; in this instance related to the concept of 'energy'. This lesson takes place at the beginning of the lesson series on the topic of 'energy' and the teacher invited the students to submit questions about energy that they would like to ask and answer in the lesson series. In the example, she is collecting their responses.

Example 1: *Energy*

T: No let's try – I understand that these questions are interesting; trust me, I would love to have a conversation with gravity with you, but can we leave that for about 2 months, and then we'll have a conversation about gravity? Because I'd really like to concentrate on energy today? K?

[...]

S4: Does that mean that ultimately everything will lose energy? Because ultimately the sun's either going to explode or implode.

T: Yeah everything will lose energy, because all energy comes from the sun, so we will actually have no energy

[...]

S5: Um you know when it blows up, how long will until we know because, my brothers told me like it will be like over 1,000 years before we actually know because its so far away?

T: Some questions that people ask, we don't actually know the answers to, and that is a brilliant example, of a question that I do not know the answer to. If you want to know the answer, try look it up, exploding sun, and you come back and tell me where you found an answer, you have a look for it.

[…]

S3: Um everything might stop but a battery won't stop.

T: A battery won't stop? Let me tell you what - H's come up with a brilliant point. Wait a minute, lets deal with H's point first and then I'll come back to you. H said a battery won't stop, and I agree with you, alright, until it runs out. Right when all the batteries on this earth have run out, where are we going to get the energy from to make more batteries?

S1: From the sun.

T: But the sun's been switched off, and all energy – wait a minute. I can only listen to one person at a time, J?

S3: We could switch the, uh we could switch the sun back on.

T: Yeah I agree with that, this is a mind game that we're playing. T?

S2: But Miss it says on the Ford Ka advert, there's 5 billion years of the sun left, make the most of it.

As we can see in Example 1, students are providing a multitude of possible questions, and in the first turn, the teacher can be seen to make a conceptual link to the notion of 'gravity' and immediately after that, she makes a link to promote continuity, by stating that this is a topic that the class will address in two months' time. The students keep submitting potential questions that they would like to answer over the coming period, and one student brings up the idea that eventually (when the sun will explode), everything will lose energy. This prompt gives the teacher a starting point to discuss the concept of 'conservation of energy'. In Example 1, we first see that the student makes a link between something that was mentioned in the home context, to which the teacher replies that she does not know the answer to that question, and actively encourages the student to 'look it up' and report the answer back in a later lesson. The key here is, that because of the dialogic nature of the classroom interaction, the students were able to make their own connections between ideas discussed in the classroom and other information, that they gained from out-of-school experiences. We also see that, while

networked technology is not actively used in this particular instance, the technology is invoked by the teacher, freeing her up to focus on the particular content of this lesson series, while enabling students to follow up on the content with their own interests and questions. It is interesting to note that she does not ask the student to come back with the answer, but to tell her *where* the student found the answer, possibly as a way to discuss later the validity of information found on the internet.

We see the teacher using pedagogical links to manage students wanting to steer the dialogue towards a topic that is not the one the teacher wants to focus on. On the one hand, when students mention "gravity", the teacher has used a continuity link to show the students when they will discuss this topic. On the other hand, when in the course of discussing energy, students ask how long it will take for people on Earth to find out about the end of the Sun when it "blows up", the teacher chooses a different strategy. This is neither a topic that is going to help with the aim of this lesson, nor is a topic that the teacher plans to cover in the future. The teacher asks students to find the explanation themselves, accessing the internet outside the school. In this case, the knowledge construction pedagogical link was made in the classroom by S4 when it connects the death of the Sun with the end of energy sources on Earth. S5 asks for an expansion of the information related to this link and the teacher asks students to complete this part of the link.

Later on, the teacher uses the prompt of the student who mentions that 'batteries won't stop' as a starting point for a discussion about sources of energy and energy degradation (lose of energy). In the way in which she positions herself as a participant in the dialogue, rather than a source of knowledge, the dialogue opens up and the students draw the wider context into the classroom, expanding the place and time in which learning takes place.

One of the specific approaches to pedagogical link making presented by Scott et al. (2011), referred to linking different types of representations. This is of particular importance in science classrooms, where knowledge is multimodal in nature and hence linking across representations is essential to construct scientific understanding. This kind of linking benefits greatly from the use of digital networked technology in classrooms, something that was acknowledged by secondary school science teachers in a study by Grimalt (2016). The affordances of digital networked technology for this kind of pedagogical link making are not restricted to bringing together different media representations of the knowledge but actually make possible the

construction of knowledge through different media. In this sense, interactive and networked technology can play an important role in redefining how students build a rich network of representations which provide a more dialogic scientific "text".

An illustration of this can be found in the following example (Example 2), in which a science teacher in a Catalan Secondary school, teaches about different mechanisms producing the collapse of a terrain.

Example 2: Ground subsidence and collapse

In this class all students use tablets to access the digital teaching material that has been designed by the teacher. This material includes links to text, picture and video files as well as embedded science modelling applets. The classroom has two whiteboards, side by side. The teacher uses one of them to project the digital material and the other one to write (see Fig. 1). These differentiated uses are replicated by the students who access the digital information with their tablets but take notes with pen and paper. The teacher couples this "technological diglossia" with pedagogical links across different modes of representation to support knowledge building. In doing so the teacher models for the students how to look at images of a phenomena (like a picture of a geological formation) and how to make a scientific representation of this phenomena through a multimodal text including visual representations of the salient features and processes as well as written language information such as labels and short explanations.

<insert Figure 1 about here>

In this session, the teacher also asks students to visit a newspaper website to find news related to the scientific topic they are working on. In this case the teacher guides the students to a particular piece of news that students access individually with their tablets. The teacher then asks the students to read the news and to interpret the text and the accompanying graphs using the geological concepts they have been discussing. The teacher opens up the dialogic space of the classroom by inviting an external frame of reference into the classroom dialogue. During the dialogue that ensues, the teacher and the students link scientific concepts with everyday explanations and real phenomena, as well as linking the scientific representations that have been built during the lesson with media outside the classroom.

Overall, the teacher is using the technology to bring into the dialogue a realistic context for a competence-oriented science education. We argue that the technology mediation is not just convenient here it actually brings into the classroom the media that students use outside of school to access information and, hence, it becomes a realistic exercise on linking classroom constructed knowledge to out-of-the-school reasoning. The teacher is helping to expand the learning space and dialogic space of the classroom, in effect permeating the walls of the classroom, both from the outside in and from the inside out. We would argue here that the expansion of the learning space happens not only because more ideas are being introduced by the students, but also because, critically, the teacher is integrating and using these ideas within the trajectory of the curriculum to develop the students understanding of science. The end result is a linked text, not dissimilar to a hyperlinked text on the computer, although while in the computer the links are physical links, in a dialogue, the links are integrated as the voices of others.

The previous two examples illustrate the different pedagogical links generated by teachers invoking the use of networked technology to foster students' extension of the classroom dialogue after school and the use of this technology in the classroom to open up the dialogue with out of school inputs. We have seen similar examples in different schools in our data from UK and Catalonia. However, it proved much less common in our data to find examples of students bringing unfiltered voices co-opted through networked technology, into the classroom dialogue. We argue that while, on the one hand, networked technology affords students to bring into the dialogue information that is closer to their interests and helps to reinforce their arguments, on the other hand, it implies that the teacher must give up more control of the dialogic space. Even though teachers who engage with technology in their practice usually have a positive view on how it affects students' learning, they look for ways to channel students' inputs, so that these actually rarely enter the classroom dialogue as unfiltered voices. The following example (Example 3) presents two vignettes that exemplify ways which teachers enabled this 'channelling' in two different schools in Catalonia, drawn from interviews with teachers in one of our projects.

Example 3: Students' "unfiltered" voices in the classroom dialogue

The first teacher does not always plan for the students to use laptops or tablets in her lessons, but she prepares a lot of material for the students in the school virtual environment and makes extensive use of the interactive white board. Her rationale seems to be that students should

work collaboratively as a group in her lessons but have the chance of following a more personalised path when working outside the classroom. To include the students' inputs from their own searches in the class dialogue she uploads some of them to the virtual learning environment, making sure to identify the student that has made the contribution (pedagogical link to encourage emotional engagement) as well as explaining how it relates to the rest of the information they are using (pedagogical link to support knowledge building). While the student's voice is incorporated "unfiltered", the teacher does select what she considers to be relevant contributions.

The second teacher has a different approach to the use of networked technology. He sees this technology as allowing him to develop a more personalised practice in the classroom. In the sessions we observed, his students used laptops to access information and to write down notes during a series of lab sessions on chemistry where they worked in small groups. For most of the sessions, students were following what the teacher had prepared and the dialogue was focused on the information provided in the digital book. The last part of the activity, however, required students to contrast their results with information they had to find on the internet. The teacher then discussed with each small group to analyse both their results and the process of finding, selecting, critically appraising and linking to the classroom activity, the information each group had found. In this case, the students' voices entered the dialogue completely unfiltered and the teacher had to help them, not just to establish links with scientific knowledge, but to reflect on the validity of the information they had found.

Implications for theory and practice

Networked technology has the potential to change the scope and process of learning at both social and cognitive levels. Nevertheless, it is not the introduction in the classroom of the technology itself that will bring about these changes. "It is in the combination of technology with reflection and dialogue that students learn to think." (Wegerif, 2015, p 438). This potential is closely related to the affordances of this technology for opening the dialogic space, for making the space and time borders of school and out-of-school education more permeable.

As we have seen from our examples, students make links between information gathered in the home context and new information presented by the teacher and these links become resources

for learning in educational dialogues (Silseth, 2018). While there has been much research on the ways in which learning takes place across a variety of contexts (see for example Barton & Tan, 2009; Bronkhorst & Akkerman, 2016), there has been a dearth of research on the ways in which digital technology introduces a new context for the teachers and students to engage with and in particular, how the networked technology, in the form of mobile networked devices, becomes an unlimited context to draw on in the classroom.

Networked digital technology provides a common medium through which information found outside of school and presented in school can be brought together; a medium which brings information that resides both in and out of the school into the thinking processes and dialogues around a particular problem. These dialogues themselves reside both in and out of the school and from within the school, the technology serves as a door to open classroom discourse to outside voices. Networking technology is thus not just about opening students to new information but rather adapting formal education to be part of the "windows" from which students interact with the (hyper)culture they inhabit (Han, 2018). It is about making the information in the classroom meaningful, and connectable, to the outside world, as the students experience it. On the one hand, it helps to position the students as expert; on the other hand, the information directly co-opted from digital media can foster the participation of students that might have been stopped by not being able to present their views in a more "professional" form. This increased capacity to bring into the dialogue and to work with richer multimodal information is very important for science, due to the multimodal nature of the knowledge it generates (Lemke, 1990). This has a direct effect on enriching the pedagogical links that can be enacted, by teachers and students, to connect different modes of representation.

The blurring of the space and time boundaries in school/out-of-school learning, which is closely connected to the life-long learning paradigm, means that students are expected to engage in more competence-oriented learning, closely connected with their capacity for learning using networked technology. This provides new challenges for teachers, and involves pedagogic link making of a more generic kind than described by Scott et al. (2011). Where normally, teachers would model specific connections between two pieces of knowledge, they now have to help students understand how to make their own connections between ideas discussed in the classroom and other information, which has not been specified or selected beforehand by the teacher. One of the consequences of this may be, that the focus of teaching should shift from the content to be linked, to addressing *how* content can be linked and how

students should engage with the linked content. In our examples, we see the teacher inviting students not only to draw on their own everyday experience, thus expanding the dialogic space of the classroom, but also integrating the students' ideas within the science curriculum and, importantly, helping students to establish the validity of the information by modelling and filtering the external voices. This implies that the teachers have to consider a learning process that they cannot map completely since it might branch out into networks that are, in part, personal to each student. Hence, teachers need to model continuity and knowledge building links for students to be able to navigate that network. At the same time, we need to acknowledge that the navigation itself is a learning activity, for it asks from the students to establish those links. For students, to be able to engage with web-based materials and to be able to link with what they already know and what they hear in the classroom becomes an essential skill.

This shift towards competence learning is possible because information is readily available to students via interactive technology and hence, teaching time can be freed up to focus more on fostering these essential learning skills by focusing on how to select, evaluate and connect information in everyday contexts. However, it is important to focus on where information is coming from, as students are bringing in unfiltered voices into the classroom dialogue. While this element of unfiltered voices creates dialogic opportunities in the classroom, as it allows each individual to engage with the information in different ways, at the same time it also creates new challenges, both for the teacher and the students. Future research should therefore aim to focus more on the different types of pedagogic links with new technology; how they affect the quality of learning (both the skills needed for life-long, out-of-the-school learning and the learning of specific topics), and how they affect the engagement with learning dialogues, for instance by exploring the sense of agency derived from a more active role, on the definition of the dialogic space.

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