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Collaborative Practices Using Computers and the Internet in Science Classrooms

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Abstract

Investigations that allow for students to self-direct their inquiries in science classrooms involve building on existing understanding, problem solving and reasoning. The process of explaining complex problems means that students work with multiple sets of data including online resources and information from the Internet. Outcomes of such activities are often in written form, frequently prepared on the computer, representing a collage of negotiated ideas. This article presents primary science classroom investigations about changes of state and landforms and argues that inscription practices were shaped by the functional and social affordances students imbued with the computer and information from the Internet. Findings from the qualitative study with a year 7 teacher, Clara, and her students illustrate how the Internet provided social and collaborative opportunities for scientific meaning making. The argument is made that access to the computer and information from the Internet can open up and constrain opportunities for social thinking and inscription practices. Talking, thinking and composing were observed to constitute the nature of science inquiries as a collaborative effort of meaning making.

Keywords:

Computer, Internet, science classroom, inscription practices, affordances

Introduction

The notion of using the Internet in support of science investigations in classrooms has received considerable interest from researchers, practitioners and policymakers (Cox et al., 2003; Ministry of Education, 2007). Potentially, the Internet offers easy access to multimodal and up-to-date information and more opportunities for interactivity than does a standard text (Cowie et al., 2008; Slotta & Linn, 2000). Students are often encouraged to seek for information from websites identified by the teacher or identified by students themselves. Research on students' web literacy identifies that the effective use of the Internet requires a special set of knowledge, skills and attitudes. Students need to assess and make appropriate decisions about their own information needs and be aware of the limitations of information accessed on the web (Kuiper, Volman, & Terwel, 2009). Several studies have highlighted that despite students being avid users of Information Communication Technology (ICT) in their out-of-school lives, they need support to develop the relevant digital literacy skills. This is particularly the case when the purpose for engaging with information from the Internet is to develop new science understandings as part of student inquiry. Such skills need to be responsive to and analytical of the variety, sources and types of media that make information available. Furthermore, just as is the case with other resources and materials, the processes of working with digital resources from the Internet is shaped by the variety of expertise and practices for collaborative meaning making available in a classroom. When work on the Internet is part of learning activities, traditional classroom norms are often set aside, with students interacting with information displayed on the screen as they talk to each other and the teacher (Somekh, 2007). Such conversations tend to be shaped by a high degree of interdependence with the person/s holding the mouse. It is this person who manages what is displayed and hence is made available for consideration, critique and inclusion in what is newly taken-as-shared and or taken-as-legitimate.

For this article we consider student and teacher practices for accessing and making sense of information from the Internet, as one of the multiple sources of knowledge and knowledge legitimation within a primary science classroom. We propose that knowledge construction during science investigations with the assistance of the computer-plus-Internet is accomplished through social interaction about the legitimation, meaning and implications of the information in much the same way scientists reason and reach social agreement about experimental data (Duschl, 2008). We provide illustrations that demonstrate the ways that students evaluate and make decisions on the nature, quality, completeness and/or significance of information retrieved from the Internet. However, in order to present our considerations about ICT use in the context of "real" classrooms, it is important to consider the social setting and collaborative processes that take place in classrooms.

Meaning making in science as a social and collaborative process

Meaning making in science is a social process where students need to learn how to talk and write like a scientist (Driver, Asoko, Leach, Mortimer, & Scott, 1994; Lemke, 1990). An important aspect of science teaching therefore is to provide for opportunities where students have the chance to practice these skills. That way they can better understand how scientific knowledge is generated and how scientific communities operate and develop "qualitative and quantitative ways of expressing ideas" (Roth & Roychoudhoury, 1992, p. 532). In order to achieve this, science teachers need to include activities in their teaching that allow for students to practice talking, writing and thinking science. However, creating and critiquing science (Duschl, 2008) can be something that is difficult to achieve in an authentic manner. Activities with a purpose that is meaningful for students address this challenge. More specifically, learning activities that involve students as self-directed learners, who investigate, interpret and assess the trustworthiness of information from a variety of sources for the purpose of answering their own questions, provides an authentic learning context. When this learning is positioned within a social framework, communicating and negotiating ideas and explanations amongst group members contributes to authenticity (Dillenbourg & Traum, 2006; Kaartinen & Kumpulainen, 2002). Collaborative learning can be a powerful stimulus for reflection and has been described as being fundamental for conceptual change and meaning making (Anderson, 2002), in particular when contrasting views create a need to resolve issues and create opportunities for conceptual restructuring (Mercer, 1996). The meaning-making process is further promoted when information from others is needed to complete a collaborative task and/or tasks. This is often the case when a task involves the synthesising of multiple sets of data and information sources to understand how patterns are being formed (Mistler-Jackson & Butler Songer, 2000).

Dillenbourg and Traum (2006) have argued that purposeful interactions provide the platforms for forming explanations and reasoning. Most significantly they point out that in order for the members of a group to build and maintain a shared understanding, they need to undergo a *grounding* process. By this the authors mean the progressive process of finding common ground on which the participants agree. This process of establishing a shared understanding or "common knowledge" (Edwards & Mercer, 1987) relies on the commitment of participants to clearly explain their own ideas and to reach a consensus. The social negotiation process of finding common ground through talk requires ideas and information to be discussed and reified by the group members, providing opportunities for information to move from the abstract to becoming more concrete (Wenger, 1998), or what Jewitt (2008) refers to as "leaving one world of experiences for another" (p. 260). The information used for establishing such a shared understanding influences the way meaning is made. While participants make sense of information in the light of their own experiences, their understanding is influenced by the modality of communication. This shapes meaning making on the basis of its material, cultural, social and historical affordances in the context of its use (Jewitt, 2008). For instance, text with images and a video clip provide different insights into the same idea/event through the way they foreground certain (different) aspects whilst at the same time positioning other aspects in the background. Different levels of trustworthiness or importance are attributed to different sources and modes of information by different participants. The grounding process, as discussion evolves, depends on students managing their levels of agreement/disagreement with the information sourced for the purpose of developing new knowledge and reaching consensus. Collaboration can provide for this workload to be shared across the group, facilitating the collective construction of meaning and also creating spaces and artefacts of new understandings.

Meaning making as a process that creates/requires new artefacts and processes in computer-supported environments

As part of the scientific inquiry process, collaborative activity can create new artefacts and practices (Engeström, Engeström, & Suntio, 2002). Often such creations take the form of written *inscriptions* that can readily be shared (Roth & McGinn, 1998). Inscriptions can function as short material records, written accounts of what has just been established as taken-as-shared between group members and then evolve as part of the continuation of the inquiry. In other words, work in modern day classrooms frequently requires students to research and type up information on the computer that has been collected from a variety of sources including the Internet. Such written records evolve through the input from group members and other information sources. Such material manifestations between group members bridge between the different types of information sourced through and from individual group members. The process of creating and managing an inscription connects group members and the information accessed (Bowker & Star, 1999). Inscriptions can be created, reviewed, updated and shaped by the needs of different group members with different expertise to establish how information is being processed, interpreted and shared (Carlile, 2002). This active engagement with inscriptions by members of a group changes the inscription to become what Roth and Roychoudury (1992) describe as *conscription*, which means that it "brings individuals together in a joint task" and serves as "social glue" to sustain conversation amongst group members (p. 552). The practice of using the computer-plus-internet as a conscription device to support collaborative meaning making is one that requires that students "make their actions and products accountable to themselves, their peers, and their teachers" (McGinn, Roth, Boutonné, & Woszczyna, 1995, cited in McGinn & Roth, 1999, p. 17) as new and old information is discussed, melded and discarded so that new material and intellectual artefacts can be generated. This is particularly significant in science where evaluation, critique and reformulation of ideas are shaped by interacting with different communities, their ideas and tools (Hoadley & Enyedy, 1999). ICT-based activities therefore provide students with new and different sources of information and possibilities to interact with this information compared to books or practical work (Kuiper et al., 2009; Slotta & Linn, 2000). Such activities encourage students to justify their ideas, thus offering new opportunities for meaning making and the development of authentic science inquiries (McGinn et al., 1995).

Meaning making and the affordances of computer-supported learning

The way students work together and use computers to access and process information is shaped by the way they conceptualise and use ICTs, and this can be specific to a particular curriculum area (Hennessy, Ruthven, & Brindley, 2005). In order to adequately address and discuss the opportunities and limitations ICT presents for classroom learning, research has considered the particular functional and social affordances computers and the Internet present (Kreijns, Kirschner, & Jochems, 2002; Wallace, 2004). Affordances can be described as the opportunities that ICTs may offer users to achieve certain goals and depend on what users identify as features, both abstract or more concrete, to achieve such aims and the ease at which such tools allow users to operate (Wright, 2010). For example, how effortlessly a website lets its user browse and find information is dependent on how easy it is to navigate as well as the user's knowledge, which enables them to identify certain features that might be conducive to achieving this goal. A user needs to be aware of these affordances in order to use them towards achieving set goals (Nardi, 1996). In the context of this study, it is also important to note that student use of ICTs can be constrained by systemic school and subject cultures, curricular and assessment frameworks (Hennessey, Deaney, & Ruthven, 2003). A consideration for the notion of affordance is of significance when students produce material evidence of their learning in classrooms because it allows researchers to distinguish between technological design features, their intended and enacted uses and what this means for pedagogical practices (Wallace, 2004). In order to consider what it means when students produce written evidence of learning through and with the support of digital tools, it is necessary to consider social processes that influence how students make sense and transform information when they are working on the computer and with the Internet.

This article discusses how the inscription practices of students using the computer and the Internet were defined and constrained by the different affordances the students assumed these ICTs to have, or not have, in order to achieve the task of investigating in groups examples of physical and chemical changes and formation of landforms.

This study

This study is part of a two-year (2009–2010) Teaching and Learning Research Initiative (TLRI) funded project with the aim to investigate the affordances of ICT in support of primary science teaching and learning (SCIAnTICT). The project focuses on student learning outcomes in science in order to trace how individual students and their teachers, through their actions and interactions with ICTs, shape and reshape patterns of social interaction conducive of learning. The project also investigated the relationship between pedagogy and learning in science by identifying how talk and interactions shape the nature of classroom community and the nature of science investigations in two primary classrooms.

This study was guided by several questions relating to the experiences and uses of ICT tools in the science classroom in order to examine the role of ICT and how it mediates students' knowledge production in inquiry-based science learning, namely:

- What are the existing experiences with ICT that students have had?
- How do students think they can use these experiences in the classroom, in particular when learning science? and
- How do these experiences shape students' learning and behaviour?

Qualitative content analysis was employed to examine how existing practices with ICT relate to the nature of knowledge produced. Furthermore, videotaped classroom observations provided for further descriptive analysis of the progression of student and teacher talk. This was conducted on selected video episodes using the analytical software program Studiocode. This software program allowed the research team to examine selected episodes of interest and to "tag" them on a timeline (Otrel-Cass, Cowie, & Maguire, 2010). All names used in the examples are pseudonyms. This article presents findings from one of the two classrooms of 30 year 7 students we have been working with.

Setting the scene

We observed the students in two units in Clara's classroom. Clara described herself as someone who is interested in exploring new ICTs, particularly with support from her colleagues when there are problems. Clara said she would use computers in the classroom as often as possible, as well as other ICTs like the Internet or video cameras. She acknowledged that students needed to have the skills in order to use ICTs effectively.

This article presents episodes from two units that were observed: one investigated physical and chemical changes while the second unit studied the dynamic processes that shape and produce landforms. The selected episodes from the physical and chemical change unit represent classroom work when the students were engaging in independent group work activities after having spent a few weeks developing some conceptual background knowledge. In the landforms unit, the selected episodes occurred when at the beginning of the unit students were researching landforms and how they are formed. As an overarching aim, Clara put emphasis on the Nature of Science strand of the New Zealand Curriculum, which focuses on students exploring and learning about how scientists work, think and ask questions.

Supporting students in a digital environment

The first unit was about physical and chemical changes. After covering some background knowledge for two weeks, students were tasked to conduct their own investigations by experimenting with materials/substances that undergo some physical and/or chemical changes. The teacher used the class blog to post task descriptions, assessment expectations and resources that the students could use in support of their investigations. These items drew attention to the Nature of Science aim of the unit, which was to ensure students experienced something of what it was to work like a scientist. Following is an excerpt the teacher left for her students in the class blog:

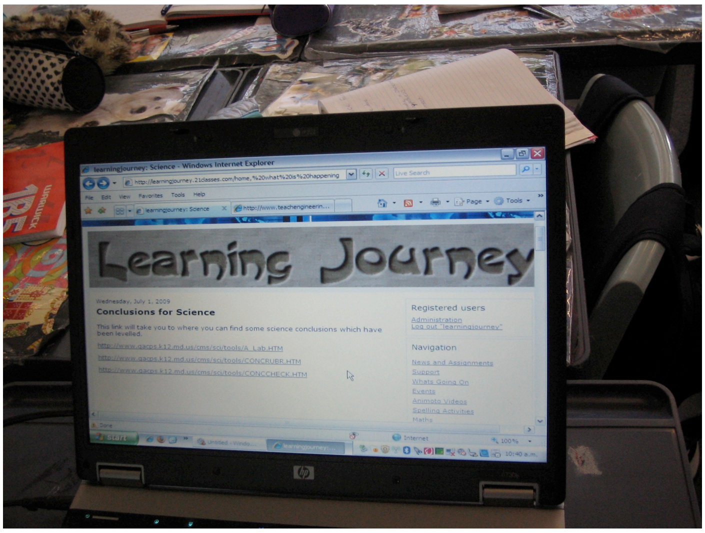
> Group experiments—Please answer these questions when you have completed your experiment, posting the answers as an entry on your blog:
>
> - What does your investigation show about the changes of state?
> - Did a physical or chemical change take place? Explain how you determined this; and
> - How did you work like a scientist?

These instructions were also intended to prepare the students to continue with a science investigation for the annual school science fair.

Clara offered the students a choice between working by themselves or as a group. Some examples of the student investigations were nails rusting in different liquids and liquid milk turning to cheese. Most of the students chose to work in small groups of two to four students. To support their investigations, Clara regularly posted information such as quizzes, revision material and assessment information on the class blog site. This action also meant Clara had easy access to these selected resources while she was teaching about physical and chemical changes.

Clara outlined that as a summative task she wanted each group to present their findings as a poster with a clearly defined structure (see Figure 1). On the class blog Clara detailed that the children needed to include their question, hypothesis, method, graphs, results (including table/chart), conclusion and photographs on their poster. She stressed that the students should use their own words in describing their investigation.

Figure 1. Clara's checklist for students in the class blog for their final presentation



When she explained this in class to her students, Clara referred to websites that she had posted on the class blog where the students could find additional information about how to write up and talk about scientific findings:

> Now this is a conclusion checklist: Re-state the problem, answer the problem, cite the data, extend by evaluating and extend by evaluating lab … this means investigation and apply the findings … then they say what you should have in your first paragraph, your second paragraph and your third paragraph. (Clara)

She continued with a sample conclusion. This framework defined for the students what and how they had to find information and more importantly explained the expected outcome of their investigation whilst leaving them the freedom to decide what to investigate and where to find information.

The computers-plus-Internet were also used to access information Clara had posted there for her students about how scientists ask questions along with content information on physical and chemical change. The information about how scientists ask questions was one of Clara's pedagogical tools to build students' repertoire to prepare for and form arguments (Roth & McGinn, 1998).

Working on the computer and with the Internet

Clara's classroom had several personal computer (PC) workstations the students could use. Each computer had access to the Internet. With a ratio of 10 groups and five computers, students and groups had to share and take turns on the computers. The students used the Internet to prepare for and investigate their questions about physical and chemical change. The situation meant that only some students had opportunities to form identities as inscribers of information that was taken-as-shared by group members.

Students who had access to the mouse or were sitting next to the person on the keyboard could take up the role of the inscriber.

Figure 2. Group work—one inscription handler

Figure 2 shows that those located on the periphery either had to leave the responsibility for information searching up to the student handling the mouse or look up the information in their own time.

Deferring to the authority of the Internet

For their work about physical and chemical change, students had to find background information. In the following example, a group of students were searching for information about dry ice. One student, Barbara, was sitting at the computer with the other two group members sitting behind her looking at the screen. Barbara was typing up the results of her group's investigation, including the additional information they found out about dry ice. When the group was asked by one of the researchers about what dry ice was, the students said:

> Barbara [sitting on the computer]: Basically, dry ice is made up of carbon dioxide.
>
> Zoe [from behind, added]: That's what I said.
>
> Rachel [from behind, says]: I was wrong.
>
> Barbara [continues]: I found that out from the Internet. And it came up with it … that basically dry ice is made up from carbon dioxide.

During the observation of the group and the discussion with the researchers, it appeared that while Zoe had contributed the notion that dry ice was made from carbon dioxide, this answer was not validated until Barbara had retrieved information from the Internet and then typed it into the presentation they were preparing.

By way of another example, Barbara was typing in the group answer to a question about what types of metal stick to a magnet. She added copper to her list and explained she had done this because "it comes up when you look it up on the website". To further support her reason for including copper in the group answer, she keyed the question into her search engine and pointed to the webpage that she selected that showed, amongst a variety of metals, copper. The website Barbara selected was the first on the list the search engine suggested and copper was one of the metals that was hyperlinked on the page, and so stood out by way of being underlined and in a different colour. However, pure copper will not be attracted to a magnet. Careful reading highlighted that the website Barbara was using suggested students test a selection of different metals to see *if* they would be attracted to a magnet. Barbara had missed this information. She recorded the incorrect information because she did not question the validity of, nor cross-referenced, the information.

As these two examples illustrate, students did not always scrutinise or discuss information sourced from the Internet. The next example exemplifies instances when students were observed talking/making sense of/discussing while they had to wait for information to be downloaded from the Internet.

Grounding talk to make sense of information from the Internet

During our observations, we recorded instances of students engaging in grounding practices similar to those described by Dillenbourg and Betrancourt (2006). This talk occurred when there was waiting time as they retrieved information from the web. The following are examples from the physical and chemical changes unit when students came to a shared understanding about what makes metals rust. They also illustrate the degree of authority information from the web exerts. In the first example, Deepti was looking on the Internet for information about vinegar. Her group investigation involved experimenting with different liquids to see which one would cause a metal to rust. The following conversation took place between Deepti and Helen while Deepti was waiting for a website to upload. The words printed in bold were those the girls emphasised in their conversation.

> Helen: Why don't you look at the back of the vinegar container?
>
> Deepti: Oh it's all right. I'm just on here [gesturing at the answer appearing on her PC screen as her search engine loads the response to her question].
>
> Deepti [reads from screen]: Vinegar is mostly water with a small amount of acid … **so its got acid**.
>
> Deepti [frustrated because Internet is slow. She types and says out loud]: **Acid** from the **vinegar** makes metal **rust**.
>
> Helen: So is **vinegar** an **acid**?
>
> Deepti: **No**.
>
> Helen: Has it got **acid** in it?
>
> Deepti: **Yeah**. [She finishes typing] Rust.

Deepti, the inscription handler, dismissed the suggestion of looking at information on the back of the vinegar bottle. It appeared that to her this source was not as useful or valid as what she could read from the Internet. In this case, the wait time for information to be loaded via the Internet provided space and time for the students to talk about the information retrieved and to shape it into an answer that suited their specific task needs.

Similar opportunities to discuss findings from the Internet were observed when students from the same group were sitting side by side to independently search the web for information on two PCs. Both students had the same goal of looking up information about what makes metals rust.

> Deepti: What ingredients in vinegar make metal rust faster? [She types in the question in the search engine.] Let's see if anyone has already done it ….
>
> Helen [working on the computer next to her and reading from the screen]: It's water!
>
> Deepti: What?
>
> Helen: According to Wiki Answers, it's water ….
>
> Deepti: What liquid makes ….
>
> Helen: Iron nails.
>
> Deepti [retrieving new information from her Internet search]: It actually doesn't say fastest. It just says water because water does make it rust but it's just not as fast as some other things ….
>
> Helen: Salt water rusts things.
>
> Deepti: It takes like three days … juice too but I have to say that juice does not taste nice, so don't try that.

In this brief interchange the students retrieved information from two different websites. They then compared what they had found out in the light of their own understanding and experiences. When Helen said, "Salt water rusts things", she was also referring to her own knowledge—in a later conversation with the researchers she explained that she already knew this. When Deepti replied, "It takes like three days … juice too but I have to say that juice does not taste nice, so don't try that", she was referring to the experiment her group had conducted in class. This is another example when students, as they waited for information to be downloaded, took up opportunities to think aloud about and to make sense of information retrieved. While they cannot be planned for and they can be seen as inconvenient, these examples illustrate that delays in website loading can provide time and opportunities for student to think together about a task.

Questioning the authority of information from the Internet

During the observations of the landforms unit, there were two instances where the authority of the information from the Internet was disputed. In the first example, two students, Mere and Jodie, were investigating background information from the Internet about how mountains are formed. The students selected a website they frequently used—Wikipedia. However, the information provided by the website used complicated and jargon-rich language. The information read:

> The formation of mountain ranges occurs by means of lateral movements as opposed to vertical ones. Mountain formation is related to plate tectonics. Folding, faulting, volcanic activity, igneous intrusion and

> metmorphism are all parts of the orogenic processes of mountain building.
> (source: http://en.wikipedia.org/wiki/Mountain_formation)

After reading this, Mere turned to Jodie and said: “That’s not right. Let’s find another site”. The two girls then looked up several other sites until they agreed on a description about mountain building. Later, when talking to the researchers, Mere commented that the information they found “did not seem to be right”.

The second observed instance of this kind was very similar in nature. It occurred when two students were investigating how valleys are formed. As in the first case, the initial information retrieved from the Internet was written in quite complex language and this led to the students doubting the trustworthiness of the information. The students selected and looked up more websites until they found information that made sense to them.

The role of ICTs in students’ lives

In our investigations we spent time talking to students about how they use computers and the Internet at home and at school. Interestingly, students distinguished between using the computer and the Internet at home and at school. Deepti explained:

> When I go home it is mainly the computer I use, and I either play virtual games or email my friends who don’t go to my school. Otherwise I go on the PS2 or watch TV. I like using the Internet because there’s a number of options, there’s millions of options. Without Internet there is only Microsoft Word or PowerPoint or basically nothing. So it gets quite boring without the Internet. In virtual games you can meet up with your friends and talk to them …. When you are blogging—it states one person’s opinion and you can write in your own ideas.

While many students highlighted that the Internet was the fastest way to access information at school, Deepti pointed out that this was not the only or even her first option.

> When I need to find something my first reaction would be to ask other people to see if they knew something about it. If that doesn’t help, I usually go to a book or the Internet if that is available. I think the Internet was just like a second option, something faster that could kinda get a straightforward thing.

This answer was somewhat surprising because we observed very few instances when students accessed information from other resources than the Internet during class time. When the students reflected on their inscription practices, they adopted critical positions regarding the authority assigned to the Internet. However, this position was not necessarily what had been observed.

While the students identified other sources of information such as books or people, the Internet had a distinctive advantage in ease of searching for information.

> Researcher: So why do you prefer to use the Internet? I mean you could have looked at a book for example.

> Lloyd: Because you know where to find it. In a book, you have to find the right books.

When we asked the students about how they worked together to use the Internet, they indicated that different students took responsibility for different tasks. In one group students chose different roles but still had processes to validate what those responsible for searching had done.

> Barbara: Yeah, I've done a little bit [of searching on the Internet]. [But] I was like writing it down and like looking, taking observations while they were searching on the Internet. But I went into the Internet site so I could check if it was good because they told me to come and have a look.

Another girl in this group specified this process of assigning roles:

> Elisabeth: Well, we all did the same kind of role but we just did it differently and then we kind of reported back and then we chose what role was best so we knew for next time.

This group of students had identified that they had to work on separate tasks to do their work while organising ways so they ensured they agreed.

Conclusion

The intent of this article was to illustrate how primary school students used computers and the Internet as part of collaborative science investigations. Specifically it reports an investigation of the affordances of computers and the Internet in relationship to students' inscription practices.

Integration of information from the Internet afforded an active decision-making process in the light of specific learning tasks and goals, which made this type of work highly authentic and agentic. Computers were used to provide a flexible and attractive way to work with and present information such as posters.

However, the inscriptions made on the computer such as written summaries and compositions of information were framed by how work was to be presented and the assessment requirements set. The teacher supported students by utilising the online environment to provide easy-to-access information and clarify her expectations.

Inscription practices were influenced by the physical and functional affordances the computer presented such as who had access to the mouse and to the keyboard. In some cases these functional affordances of the computer limited whose knowledge counted as valid input for the inscriptions. Inscription practices were also shaped by the way students assigned roles, whereby the person being assigned to use the computer decided, in most cases, what information was going to be used in their work unless arrangements were made to share and negotiate findings. In those cases, the computer and the information that was socially constructed on it became a collective conscription device. Such co-construction opportunities were also brought about during times that provided for students to share their inscription practices and when the authority of the information from the web was questioned or when space for collaboration was created, either willingly or unwillingly.

Information retrieved from the Internet required that students had to make sense of it in the light of their questions. Context, goals, web literacy, social context and current knowledge all contributed to what information was sought, selected and how it was going to be processed. In classroom observations and from talking with the students, we found that the information retrieved from the Internet and the inscription practice of producing the findings on the computer typically framed the practices around whose contribution counted. Such practices were to some degree limited by the negotiations amongst the group members.

In our observations, we found that affordances attributed to information from the web also seemed to hold much authority over what the students knew already, and was used at times to validate this knowledge. Even though students reported that the Internet was not the only resource available to them, it seemed that combined with the need to look up information selected by the teacher and the need to create text on the computer, the Internet was a dominating source of information for the students. Work on the computer as a "conscription device" (Roth & Roychouddury, 1992) was shaped by social practices and while information made available through the Internet had the advantage of searchability, it usually came in a format that had to be adjusted so it would suit the needs of the questions asked. As such the co-construction of what was finally selected, reworded and presented was typically shaped by access to the computer. The affordances the students imbued with the Internet highlighted the social dimensions of using the computer and the Internet to access, search, evaluate and create text information in support of their scientific investigations.

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References

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education*, *13*(1), 1–12.

Bowker, G. C. & Star, S. L. (1999). *Sorting things out: Classification and its consequences. Parts II and III*. Cambridge, MA: MIT Press.

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science, 13*(4) 442–455.

Cowie, B., Jones, A., Harlow, A., Forret, M., McGee, C., & Miller, T. (2008). *TELA: Laptops for teachers evaluation—Final report years 7 & 8* (Report to the Ministry of Education). Wellington, New Zealand: Ministry of Education. Retrieved from http://hdl.handle.net/10289/4338

Cox, M., Abbott, C., Webb, M., Blakely, B., Beauchamp, T., & Rhodes, V. (2003). *ICT and attainment: A review of the research literature* (A report to the DfES). London, England: DfES. Retrieved on November 30, 2010 from http://www.becta.org.uk/page_documets/research/ict_attainment_summary.pdf

Dillenbourg, P., & Betrancourt, M. (2006). Collaboration load. In J. Elen & R. E. Clark (Eds.), *Handling Complexity in Learning Environments: Theory and Research* (pp. 141–165). Oxford, England: Elsevier.

Dillenbourg, P., & Traum, D. (2006). Sharing solutions: Persistence and grounding in multimodal collaborative problem solving. *Journal of the Learning Sciences*, *15*(1), 121–151.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23*(7), 5–12.

Duschl, R. (2008). Science education in three-part harmony: Balancing conceptual, epistemic, and social learning goals. *Review of research in education, 32,* 268–291.

Edwards, D., & Mercer, N. (1987). *Common knowledge: The development of understanding in the classroom.* New York, NY: Methuen.

Engeström, Y., Engeström, R., & Suntio, A. (2002). Can a school community learn to master its own future? An activity-theoretical study of expansive learning among middle school teachers. In G. Wells & G. Claxton (Eds.), *Learning for life in the 21st Century* (pp. 211–224). Malden, MA: Blackwell.

Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution, and change. *Journal of Curriculum Studies, 37*(2), 155–192. doi:10.1080/0022027032000276961

Hennessey, S., Deaney, R., & Ruthven, K. (2005, September). *Developing pedagogical expertise for integrating use of the interactive whiteboard in secondary science.* Keynote paper to the British Educational Research Association (BERA) Conference 2005, University of Glamorgan, Cardiff, Wales.

Hoadley, C. M., & Enyedy, N. (1999). Between information and communication: middle spaces in computer media for learning. In *Proceedings of the 1999 Conference on Computer Support for Collaborative Learning* (p. 30). Palo Alto, California: International Society of the Learning Sciences. Retrieved from http://portal.acm.org/citation.cfm?id=1150240.1150270

Jewitt, C. (2008). Multimodality and literacy in school classrooms. *Review of Research in Education, 32*(1), 241–267. doi:10.3102/0091732X07310586

Kaartinen, S., & Kumpulainen, K. (2002). Collaborative inquiry and the construction of explanations in the learning of science. *Learning and Instruction, 12,* 189–212.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2002). The sociability of computer-supported collaborative learning environments. *Educational Technology & Society, 5*(1), 8–22.

Kuiper, E., Volman, M., & Terwel, J. (2009). Developing Web literacy in collaborative inquiry activities. *Computers & Education, 52*(3), 668–680. doi:10.1016/j.compedu.2008.11.010

Lemke, J. L. (1990). *Talking science: Language, learning and values*. Norwood, NJ: Ablex

McGinn, M. K., & Roth, W. (1999). Preparing students for competent scientific practice: Implications of recent research in science and technology studies. *Educational Researcher, 28*(3), 14-24. doi:10.2307/1177252

McGinn, M. K., Roth, W.-M., Boutonné, S., & Woszczyna, C. (1995). The transformation of individual and collective knowledge in elementary science classrooms that are organized as knowledge-building communities. *Research in Science Education, 25,* 163–189.

Mercer, N. (1996). The quality of talk in children's collaborative activity in the classroom. *Learning and instruction, 6*(4), 359–377.

Ministry of Education. (2007). *The New Zealand Curriculum.* Wellington, New Zealand: Learning Media.

Mistler-Jackson, M., & Butler Songer, N. (2000). Student motivation and internet technology: Are students empowered to learn science? *Journal of Research in Science Teaching, 37,* 459–479.

Nardi, B. A. (1996). *Context and consciousness: Activity theory and human-computer interaction*. Cambridge, MA: The MIT Press

Otrel-Cass, K., Cowie, B., & Maguire, M. (2010). Taking videos into the classroom. *Waikato Journal of Education, 15*(2), 109–118.

Roth, W., & McGinn, M. K. (1998). Inscriptions: Toward a theory of representing as social practice. *Review of Educational Research, 68*(1), 35–59. doi:10.3102/00346543068001035

Roth, W.-M., & Roychoudhury, A. (1992). The social construction of scientific concepts or the concept map as conscription device and tool for social thinking in high school science. *Science Education, 76*(5), 531–557.

Slotta, J. D., & Linn, M. C. (2000). The knowledge integration environment: Helping students use the Internet effectively. In M. J. Jacobson & R. B. Kozma (Eds.), *Innovations in science and mathematics education: Advanced designs for technologies of learning* (pp. 193–226). Mahwah, NJ: Erlbaum.

Somekh, B. (2007). Pedagogy and learning with ICT: Researching the art of innovation. New York, NY: Routledge.

Wallace, R. M. (2004). A framework for understanding teaching with the Internet. *American Educational Research Journal, 41*(2), 447–488.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, England: Cambridge University Press.

Wright, N. (2010). *E-Learning and implications for New Zealand schools: A literature review* (Report commissioned by Ministry of Education). Wellington, New Zealand: Ministry of Education. Retrieved from http://www.educationcounts.govt.nz.ezproxy.waikato.ac.nz/__data/assets/pdf_file/0006/77667/948_ELearnLitReview.pdf