Trajectories of inquiry learning

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Introduction

The contributors to this volume make a compelling case for the potential, value and significance of inquiry-oriented learning and instruction. The debate then is not so much whether sciences should be taught via inquiry, but rather how to do so (see Hickey and Filsecker 2012, p.x). There are of course considerable challenges to be faced in supporting and resourcing inquiry learning – a process that involves learners asking questions about the natural or material world, collecting data to answer those questions, making discoveries and testing those discoveries rigorously (de Jong 2006). Pupils may, for example, experience difficulties in engaging with inquiry learning, forming appropriate investigations, designing and running experiments, and interpreting data. A key issue, then, is how to resource and support processes of inquiry learning within and beyond the classroom. Whilst recognising the multiplicity of challenges facing those of us committed to fostering inquiry-based learning, our chapter focuses on one specific challenge – namely, the need to ensure that young people have a coherent, cumulative experience of the diverse activities, ideas and settings that are implicated in the process of inquiry. The focus in this chapter is on understanding how connections are made between ideas and events over time. Specifically, we will explore how connections, between known and new (Rogoff 1990) and between everyday and scientific understandings (Mortimer and Scott 2003), are negotiated in talk and interaction between learners and learners and their teachers and how this process is
mediated by representations and technologies. In both cases the focus is on how connections are made to previous activities and interactions. A key concern is how time is harnessed as a pedagogical resource - not only in the sense that the students’ understanding progressively develops over time, but also in the sense that the teacher draws upon past understandings and points to the future, in the present.

Making connections

*Learning is a process that happens gradually over time and, given this, one of the critical functions of classroom interaction is ‘connection building’* (Gee and Green 1998).

‘Most learning does not happen suddenly: we do not one moment fail to understand something and the next moment grasp it entirely’ (Barnes 1992: 123). From the pupil’s perspective, then, it is vital that school-based inquiries have a connected, cohesive and cumulative quality in which activities and their goals become construed in ways that constitute a purposeful educational journey. That said, coherent knowledge and new understandings will not naturally emerge for students simply from their extended immersion in classroom life (Lemke 2001; Mercer and Littleton 2007). Rather such understandings have to be pursued actively, with teachers orchestrating tools (including language) and technologies such that activities and ideas become connected and aligned to broader pedagogic goals. The emphasis is not only on ensuring continuity (whereby the teacher explicitly makes connections between new knowledge and concepts or topics learned earlier) but also on resourcing the progressive deepening or expansion of a concept or topic to be explored and investigated (Nurkka, Viiri and Littleton submitted).

In this chapter we present extracts drawn from analyses of an extended technology-mediated
scientific inquiry learning activity concerning micro-climates undertaken by 11-12 year olds, as part of the Personal Inquiry project (described earlier in Chapter 1) to both exemplify and explore how progressive ‘connection building’ is accomplished multi-modally over time through a multiplicity of semiotic resources. Such progressive connection building is not, as we shall see, a narrow and unidirectional process. Rather, the effective co-construction of mutual, cohesive understandings makes use of multiple representations and interactions and involves revisiting and (re)negotiating ideas and understandings.

The metaphor of ‘orchestration’ sits at the heart of our exploration as this metaphor draws attention to the subtle interweaving of activities, ideas and resources and the ways in which a teacher may make (what are often moment-by-moment) shifts between what is fore-grounded and what is back-grounded in an on-going inquiry. It also captures the sense in which a teacher, or more knowledgeable other, encourages, and works with, learners’ contributions in the context and pursuit of overall goals as part of a longer trajectory of meaning-making (Rasmussen 2005; Baldry and Thibault 2006).

**The inquiry context and analytic approach**

The analytic extracts presented in this chapter are derived from the detailed analysis of observations made as a mixed-ability, mixed-sex class of 28 students, supported by their teacher and researchers, undertook an inquiry on microclimates spanning four lessons over 2 weeks. Lesson one was classroom-based and initially involved a whole class teaching session on the topic of microclimates. An initial design for an inquiry on micro-climates was also scoped as
part of this whole-class session. This required the students to design an inquiry to explore the existence and nature of microclimates within their school grounds so that they could recommend where to locate a new picnic bench. Whilst this provided an initial frame and contextualization, it was intended that the inquiry could be adapted, personalised and refined by the students themselves. Following this initial orientation to the purpose and nature of the inquiry, the students were then divided into small groups of four to five, and a netbook was given to each of the groups. Each group was then shown (by the teacher and researchers) how to use ‘Activity Guide’, an instantiation of nQuire - a web-based application developed to guide secondary school students in designing, conducting and evaluating their inquiries (Collins, Mulholland and Gaved 2012) (see also Chapters 1 and 5). The students were then asked to work in their groups to discuss the data they wanted to collect (a discussion that was resourced with reference to the relevant Activity Guide screen). Each of the small groups subsequently fed back their decisions in a whole class plenary, and the class members collectively agreed which data they were to collect. The students then worked in their small groups to discuss which locations within the school grounds they wanted to collect data from and once again they then fed their decisions back to the whole class so that the locations from which to collect data could be agreed. Towards the end of the first lesson each of the groups worked on developing their own hypothesis. They were advised to structure their hypothesis as follows: ‘I think the best place to put a picnic bench would be X because Y’. The second lesson began in the classroom, with the distribution of equipment to the groups of pupils. The whole class then moved outside into the school grounds. The students walked around their selected data collection locations as a class, supervised by their teacher, and they collected data in groups. During the third and fourth lessons, the students worked in an ICT suite. Here they focused on writing a report consisting of an introduction about
microclimates, a description of their methodology, representations of their data in bar graphs and some written analysis of their findings. This report was completed as homework.

Qualitative analysis of the data involved repeated consideration of all video-recorded whole class data and the recordings made of focal groups (who gave consent for their group-work sessions to be recorded and analysed) together with the associated transcriptions and observation notes in order to trace the ways in which connections were built, using language and other semiotic resources. We built upon the sociocultural discourse analytic approach (Mercer and Littleton 2007) to focus on the ways in which shared understanding is developed, in social context, over time. The analysis thus necessitated an iterative process of moving backwards and forwards through time, trying to make sense of episodes and events as linked chains of interactions. The extracts we present here are drawn predominantly from detailed analyses of the first two lessons and as such they are not intended to be representative of the totality of the lessons observed, but are rather used as exemplifications and vehicles for exploring the issues of interest outlined above. As our focus is on how ideas are chained and how knowledge is co-constructed using language and other semiotic resources, the presentation of findings and their discussion is necessarily interwoven.

Making connections between known and new: from climate to microclimate

Prior to commencing the microclimate inquiry, the students had been taught about weather (e.g. clouds, anticyclones and depressions) and climate. The teacher therefore initiated the inquiry process with a whole class teaching session in which she mobilised and revisited the students’
prior work. She made explicit reference to shared, common knowledge, previously established during earlier lessons, using this as an ‘anchor’ (see Littleton, Twiner and Gillen 2010), an initial starting point, upon which to build, expand and extend the students’ understanding into the new realm of microclimates. She thus works to ‘bridge’ students’ understanding from what they already know (climate) to the new (microclimate). In Extract 1 we see how the establishment of this anchor was constructed multimodally - in dialogue mediated crucially through the use of a slide deck displayed on the interactive whiteboard.

*Extract 1: From weather and climate to microclimate*

Teacher: So, first of all, let’s quickly recap on the difference between weather and climate. So there’s two different definitions that are gonna come up (on the interactive whiteboard), you need to tell me which is which. X means the day to day changes in the atmosphere. What is x? Weather or climate?

(students then raise their hands and give their answers as requested by the teacher)
Teacher: Very good. So (reads statements on interactive whiteboard), deserts are always dry, is this weather or climate?

Pupil: Weather

Teacher: Deserts are always dry, is this weather or climate? Hands up. Hand up first

Pupil: Climate.

(pupils then continue to give their answers to the remaining statements on the interactive whiteboard)

Teacher: So this is what you need to write in your books. (reads from interactive whiteboard) ‘A microclimate is the ______ state of the ______ close to a very ____ area of the earth’s _______. Generally, we take a ______ to be the climate of a small ______ such as a town, forest or ______.’ Now all the words you need are at the bottom. Fill them in and we’ll
Through focused questioning the students are asked to ‘recap’ what they already know about the difference between weather and climate, and then are encouraged to extend their understanding of climate to complete the missing words of a paragraph which describes a microclimate (all of the terminology is familiar except for ‘microclimate’). In this way, the trajectory from previous lessons into the current lesson is contextualised for the students as being a cumulative development - building on and progressively extending prior knowledge, a process which Wells (1999) describes as the “development of expertise through participation in activities in which…knowledge is progressively constructed, applied and revised” (p 138).

The concept of a microclimate is initially presented to the students as a theoretical construct, through a scientific definition (see ‘What is a Microclimate’ slide in Extract 1). However, the concept is gradually re-contextualised such that it is made personally relevant to the students by the teacher, as she alerts them to the fact that their own school grounds consists of different microclimates. She thus initiates the crucial process of grounding scientific content and process in students’ existing points of view and activities, thereby working to enable them to see the
intellectual relevance of their learning activities, helping learners to reframe their everyday experiences in empirical and scientific terms.

Throughout lesson 1, the teacher continually reminds the students that their investigation will be carried out in their school grounds and that microclimates can be found there. She repeatedly grounds the students’ inquiry in the familiar. In one of her very early utterances addressed to the whole class she said “we’re gonna be looking at what a microclimate is, what affects a microclimate and what the microclimates of [our] school are”. Similarly, following the activity presented in Extract 1 above, in which the students were supplying the missing words of a definition of microclimates, the teacher added that the last word could indeed in their case be “school” (i.e. ‘generally we take a microclimate to be the climate of a small area such as a town, forest or school’). Personal inquiry cannot simply be equated with personal interest – rather it crucially entails personal relevance. Thus the simplistic use of the ‘everyday’ in classroom contexts is problematic not least because it trivialises the complex processes involved in meaning making and falls far short of the authenticity that is essential to engage young people and support learning (Murphy, 2000). As Scott, Ametller, Mortimer and Emberton (2010) suggest, grounding scientific content in students’ existing points of view needs to enable a student see the intellectual relevance of their learning activities. However, as we will go on to show later in the chapter, it can be difficult for learners to reframe their everyday experiences in empirical and scientific terms.
Making connections between known and new: from microclimate as an abstract definition, to investigating microclimates in the school grounds

Later in lesson 1 the teacher gradually dialogically transforms the familiar context of the school grounds into a site for inquiry and investigation, making purposeful shifts between scientific and everyday perspectives. Earlier in the lesson she had worked to help the students understand the definition of a microclimate. She subsequently focuses on enabling the students to understand that they can investigate microclimates in the context of their school grounds, a process that will involve them in hypothesis testing and taking salient measurements. In Extract 2 we can see how she foregrounds prospective scientific activity, building a connection to work they will undertake in the future, simultaneously introducing key scientific vocabulary and inquiry concepts (indicated in italics).

Extract 2: Re-contextualising the school grounds as a site for inquiry

1. Teacher: Our enquiry question is gonna be ‘where shall we put the new picnic bench?’ OK so we’re gonna be trying to find the place around school to put a new bench.

2. Pupil: MUGA (Multi-Use Games Area)

3. Teacher: First, to start off our research we need to come up with a hypothesis. Now (reads statement from IWB as in Figure 1a) ‘a hypothesis is a suggestion or guess, suggestion or a guess, that tries to explain something but has not yet been proved’. So you’re gonna write a hypothesis, and then you’re gonna go out, and that’s what you’ll be doing next lesson, you’ll be trying to prove it, or disprove it. So we’re gonna write our
hypothesis and then we’ll go out and measure...(T changes slide to that shown in Figure 1b) So for an example, you might say, the best place to put the picnic bench would be outside the canteen, because

4. Pupil: there’s too many there

5. Teacher: it is warmer. OK, you might decide the best place to put the picnic bench would be

6. Pupil: MUGA (Multi-Use Games Area)

7. Teacher: by the MUGA, because there might be more sunshine there. OK. But you’ll be working this out in your groups in a minute.

8. Pupil: In the middle of the field.

9. Teacher : So, we’re gonna be looking at places to measure, and then we’ll also be looking at what we’re gonna measure.

Firstly we need to write our hypothesis

- A hypothesis is a suggestion or a guess that tries to explain something but has not yet been proved to be true or false.
- We will write a hypothesis and then go and measure the weather to try to prove or disprove our hypothesis.

We need to decide where to measure

- Use the map of Oakgrove school to think about the places where you might like to put the bench
- You will go round the school to the places you have chosen as a group.

Figure 1a and b: The slide deck in use
It is evident that here the teacher serves as an influential discourse guide, modelling in her own talk the use of the new scientific discourse she wishes the students to appropriate - enacting scientific ways of thinking and talking in classroom contexts (Mercer and Littleton 2007). Crucially, she models the kind of critical reasoning and thinking that is critical to learning through inquiry, by placing an emphasis on the need to explicate the reasons that underpin the hypothesis to be tested. She does this by emphasising the word ‘because’ (see Extract 2: 3 and 7). Thus, as the students call out some suggested locations for the bench the teacher elaborates on these suggestions, reformulating and recasting them through offering a possible rationale, based on the types of data that the students would be collecting. So through her talk she begins to recontextualise the school grounds as a site for future scientific inquiry and prefigures the work they will be undertaking in subsequent lessons.

Making connections between everyday and scientific: the challenge of reframing the familiar school grounds in terms of scientific variables

In the group-based session at the end of the first lesson, the students needed to decide from where in the school grounds they would collect their data. In Extract 3 a focal group of four students were sitting around a table using nQuire on a netbook and were discussing where the class should undertake their data collection (see Figure 2).
**Figure 2:** Students’ grouped around their netbook discussing where the class should collect their data, pointing to the photographs of the lockers in nQuire

**Extract 3: Where to collect data?**

Beth is operating the netbook. She has clicked on the ‘lockers’ tab (See Figure 3)

1. Dan: I think lockers
2. Beth: I think lockers too because everyone hangs around there when it rains
3. Beth: Everybody. So do you want it in the lockers?
4. Dan: Yeah, lockers. That’s one
5. Beth: So that’s one. So keep that in mind Dan
6. Carl: But you don’t get very much light (points to photo. See figure 3)
7. Beth: Yes you do. These bits here (points to photo) you do, you get a lot of light
8. Angela: The lights come on don’t they (points to photo)
9. Beth: Yeah, so lockers, keep that in mind
10. Carl: So lockers are one

(Beth clicks on ‘football pitch’ tab)
12. Dan: Yeah football pitch
13. Beth: because of the boys. Yeah around here (points to photo)
14. Dan: Yeah
15. Beth: So keep football pitch in mind
16. Angela: Yeah it’s not very sheltered is it
17. Dan: Lockers, football pitch
(a few seconds later)
18. Beth: Yeah. Car park. Yeah cos how about if somebody’s waiting for their mums, they sit on the floor most of the time.
20. Carl: So car park

What is evident is that photographs of key school locations, presented in nQuire, provided an important multimodal focal resource and common representational reference point that mediated the students’ classroom-based discussions. Key considerations, such as whether a location was in light or shade, could be discussed with reference to specific features of individual photographic resources. What is also significant is that both everyday and scientific frames of reference were interwoven and juxtaposed in the students’ discussions regarding the choice of locations. Thus, they wanted the picnic bench to be near the lockers so people could sit on it when it was raining and because it is light there (they have previously discussed the possibility of ‘light levels’ as being one of the types of data the class collects). They also thought the picnic bench would be well positioned near the football pitch as the boys who play football could use it, but Angela
argues that it is not very sheltered there (they have previously discussed wind speed and wind
direction as potential measures). Similarly, they think the car park would be a possible location
as it would be somewhere to sit whilst waiting to be collected by parents at the end of the day. In
the case of the lockers and football pitch, suggestions are justified with reference to an everyday
and an empirical rationale. However, the car park is suggested solely on the basis of an everyday
argument. It was this argument which they subsequently decided to use to construct their initial
hypothesis. So one can see here the very real challenge the students faced in disambiguating their
everyday knowledge regarding the use of physical space around the school and the empirically
rooted inquiry question regarding the appropriate siting of a picnic bench given the micro-
climatic conditions in the school grounds. Given their orientation to everyday reasoning, later in
the same lesson the teacher encouraged the students to reframe their hypothesis. They found this
challenging and needed prompting with examples before they understood that their hypothesis
needed to be based on empirical measures and not on needing ‘somewhere to sit’. In terms of
the development of the students’ learning trajectory throughout this lesson, the process of re-
contextualising and reconceptualising the everyday and familiar context of the school grounds as
a site for scientific inquiry proved to be a challenge for the students. This indicates that teachers
cannot rely upon mobilising prior understandings and experiences as a pedagogic strategy.
Rather, they also need to pay close attention to how bridging (between the everyday and the
scientific) can be resourced and supported. Whilst the students used the photographs in nQuire as
a crucial, valuable resource to help navigate this bridging process, they were continually
juxtaposing empirical and everyday perspectives, and found it difficult to acknowledge that there
was indeed a difference between the two.
Figure 3: Screen shot of the hypothesis entry screen in nQuire (A) with the content of the ‘lockers’ information tab enlarged in (B) and the hypothesis text later created by the group enlarged in (C).

4. Making connections between the everyday and the scientific: collecting scientific data
from familiar (but newly ‘empiricised’) school grounds

Some of the ways in which instructors encourage students to make purposeful shifts between the everyday and the scientific are exemplified in Extract 4. Here a second group of students are collecting data from different locations in the school grounds. They are engaged in an activity that necessitates them characterising the school grounds in a new, scientific way, namely in terms of measurable variables.

Extract 4: It is windy

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<tbody>
<tr>
<td>1.</td>
<td>Researcher: What are you doing for your temperature?</td>
</tr>
<tr>
<td>2.</td>
<td>Tina: I’m taking that</td>
</tr>
<tr>
<td>3.</td>
<td>Researcher: Hold it up. Otherwise you get it right by you.</td>
</tr>
<tr>
<td>4.</td>
<td>Tina: (holds sensor up high. On the right of photo opposite) 8.4</td>
</tr>
<tr>
<td>5.</td>
<td>Clare (typing, centre of photo): What’s the light level? Put it up!</td>
</tr>
<tr>
<td>6.</td>
<td>Tina: 2700</td>
</tr>
<tr>
<td>7.</td>
<td>Clare: What do you say cloud cover is? I can’t see no clear sky.</td>
</tr>
<tr>
<td>8.</td>
<td>Matt (left of photo): Seven still.</td>
</tr>
<tr>
<td>9.</td>
<td>Tina: Eight</td>
</tr>
</tbody>
</table>
10. Researcher: You decide amongst yourselves

11. Clare: Seven. Right and now I need to do a comment. I need to sit on something that’s dry (goes to a dry area nearby).

12. Researcher (out of shot): So what do you think’s special about the environment here?

13. Clare (sitting on the ground): Like there’s not a lot of, like the buildings are in the way of the sun so

14. Researcher: What do you think guys about…

15. Matt: It’s windy
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<tr>
<td>16.</td>
<td>Researcher: It’s windy. Why do you think it’s windy?</td>
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<tr>
<td>17.</td>
<td>Ben (left in photo): It’s windy because it’s quite open</td>
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<tr>
<td>18.</td>
<td>Researcher: Quite open, yeah. When you were out here, just coming through, do you think the buildings have any effect?</td>
</tr>
<tr>
<td>20.</td>
<td>Researcher: So the buildings would block it in some direction</td>
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<tr>
<td>21.</td>
<td>Ben: it depends which way the wind is coming from (gestures wind directions, as in photo)</td>
</tr>
<tr>
<td>22.</td>
<td>Researcher: Yeah, does it always come in different directions here, or does it always come in one direction when you’re out here?</td>
</tr>
<tr>
<td>23.</td>
<td>Ben: (inaudible but gesturing a wind direction)</td>
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In lines 12-23 in particular the researcher, through prompts and open questioning, works to support the students encouraging them to look at the buildings around them and to think about how they might impact the wind speed. In terms of the orchestration of inquiry, he is working to help the students make an important shift in terms of what is foregrounded for consideration and discussion. He encourages them to think of causal explanations as to why a specific location is windy and to draw upon their prior experiences in doing so. In lines 18 and 22 he asks them to think back to when they have been in this location before (when they were “just coming through”) and whether the wind always blows in the same direction as it was blowing during their data collection activity. At first Ben (line 19) asserts that he does not think that the buildings have an effect on the wind speed, but the researcher encourages him to revisit this assumption. Ben begins to think about how they might do so and then uses gesture to mediate an explanation to his friend Tina regarding the typical wind direction and how the buildings may affect this. This short extract evidences how the students are beginning to characterise and explore this familiar school environment in new ways: in terms of wind speed, wind direction, and how the buildings (their classrooms) may affect these variables. The emergent dialogue constitutes the cumulation of all the new understandings which have been “progressively constructed, applied and revised” (Wells ibid) across the previous lesson, and this lesson.

Making connections between known and new: the role of nQuire in supporting a coherent learning experience.

Our analyses of the inquiry-based teaching-learning interactions have thus far underscored how through a complex series of multimodally mediated recaps, elicitations and reformulations and
careful lines of questioning, the teachers and researchers supporting students’ inquiries continually work to create cohesion and continuity from what might otherwise be seen by learners as no more than a series of disparate events. They strive to help students build bridges, between established and new understandings, whilst developing ‘common knowledge’ and new shared understandings (Edwards and Mercer 1989). In doing so it is evident that a range of discursive, physical and technological resources are orchestrated to revisit, reframe and (re)contextualise the class’ shared experiences and knowledge (of climate, weather and the school grounds) in ways that render these salient and relevant to the new topic of microclimates. It is also apparent that bridging between familiar and new ideas is a complex pedagogic achievement – something to be actively resourced, supported and accomplished rather than simply assumed. It is here that we would suggest that the nQuire toolkit that runs on an ultra-mobile netbook has a distinctive role to play. This is because the toolkit has been designed in ways that mean that facets of students’ everyday knowledge become recast and reframed in ways that recontextualise and situate it in the context of a scientific inquiry – in this case within a scientific investigation of micro-climates.

We have already explored how the use of photographic images of familiar locations embedded in nQuire can resource detailed discussions in respect of scoping and planning the data collection phase of an inquiry. However, this is not the only relevant affordance of nQuire. Our observations indicate, for example, that the teacher harnessed the functionality of nQuire in ways that encouraged students to capture their unfolding and shared understanding of the aim of their inquiry. In lesson 1, for instance, the teacher encouraged the students working in groups to record their hypothesis and key methodological choices by entering them into nQuire. The
recording of the hypothesis and methodology choices in nQuire represented the culmination of a process of dialogic negotiation and created a textual record that bridged between lesson one and lesson two. The outdoor activities to be undertaken in the following lesson would build-upon the classroom-based activities in the current lesson thus creating a coherent and cumulative learning experience that contributed to meeting the longer term goal of addressing the hypothesis. In this way, nQuire supported the students in building connections between past, current and future activities across the contexts of the classroom and the school grounds. As nQuire is web-based, the group’s inquiry had at this stage become mobile across contexts; the hypothesis and methodology referred to plans to carry out an inquiry outside the classroom. Similarly, the net book could be physically carried outside in the next lesson and used to access nQuire in the field (for a detailed discussion see Kerawalla et al, in press). nQuire thus distinctively entered into and resourced the processes of connection building across phases of activity. From the learner’s perspective, the work they were undertaking began to develop a cumulative quality in which specific activities, and their goals, began to form part of a greater whole - a purposeful educational ‘journey’ through which they came to understand the nature and processes of the inquiry learning cycle. Consider as a further example, the students’ use of the qualitative free text ‘Comments’ boxes that were aligned with the numerical and categorical data entry boxes.

The ‘Comments’ boxes were designed to enable students to capture, during the data collection phase of their work, important contextual information that would assist them in the interpretation of their data during analysis. Initially the students could use these boxes to ‘record’ data. Subsequently, however, as they moved towards the individual reporting of their investigation, they could also rework and refine and continually edit and save the text within the boxes. In
doing so the text can become an ongoing work in progress. It can be an iteratively refined aide memoire and repository for capturing emerging ideas and thinking, over time, in respect of the interpretation of data and key findings. So the initial contextual information recorded in the comments boxes provides an ‘anchor’ from which to build knowledge and understanding. This process of reworking using the comments boxes can support students’ in making connections across different phases of the inquiry cycle – work undertaken as part of the data collection phase can become connected to and can resource further work in respect of interpretation and reporting.

So rather than moving through a sequence of prepared screens, with the associated dangers of fragmenting and compartmentalising learning, the students’ iterative use and re-use of the comments boxes can constitute a kind of ‘narrative trail’, somewhat akin to the workings of a problem, which can be saved, remaining visible to the learner, their former group-mates and the teacher who might then offer reflections, reactions and comment. The material is thus available for working on in the present, using material generated in the recent past and in anticipation of future use.

When it comes to attempts to engage in sustained, cumulative knowledge building, spoken discourse has some particular limitations, and as Wells suggests: ‘Chief among these is the evanescence of the understandings achieved in speech’ (1999, p 115). Recognizing this, teachers often encourage children to either collectively or individually construct texts or representations which capture something of what has been said or discussed. Wells has suggested
that such texts can serve as ‘improvable objects’, and by this he means that such an object ‘provides the focus for progressive discourse and simultaneously embodies the progress made’ (p 115). All forms of meaning making which give permanence to, or capture something from the ephemerality that is talk have the potential to serve as improvable objects. In each case, ‘it is the material permanence of the form in which the semiotic artefact is embodied that enables it to support the recursive reflection and revision that is so important a characteristic of knowledge building’ (p 116). The creation of brief but highly salient textual comments within nQuire, clearly served as such improvable objects as the texts generated as part of this process typically became valuable resources for iterative reflection, revisiting and re-versioning over time.

**Concluding Remarks**

As Gee has argued: ‘It is the connections or associations that people make among their experiences that are crucial to learning, thinking and problem-solving’ (2003, p 73). Given this, we chose to explore and underscore the significance of the processes of connection-building for inquiry learning. In doing so we have highlighted both the complexity and the necessity of building correspondences between ideas and experiences - both within and between lessons. The analytic extracts presented here show how, in the context of inquiry-based learning experiences, instructors work multi-modally to support learners in developing trajectories of meaning making through the orchestration of diverse resources. The metaphor of orchestration is an apposite one - capturing the sense in which instructors’ work to harness pupils’ knowledge, experience and contributions and weave together (and connect over time) ideas, themes and sub-themes in pursuit of overall pedagogic goals. Orchestration happens in the subtle interweaving, backgrounding and foregrounding of multi-faceted guided activities. Our work also indicates that
the affordances of an ICT-mediated inquiry tool-kit, can in the hands of a teacher skilled in the pursuit of inquiry, may be of considerable use in this orchestration, enabling coherent connection building to be successfully pursued.

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