# TALKING ABOUT EVIDENCE IN INQUIRY-BASED SCIENCE: WHAT ROLE CAN SOFTWARE SCAFFOLDS PLAY?

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ABSTRACT
Evidence-based explanations are a core element of scientific reasoning. Nonetheless, the literature reports that middle school students often fail to support their hypotheses with evidence, do not always recognize that there is a need to do so, or try to support their arguments with ideas that are not grounded in the data they are investigating. Software scaffolds can serve as reminders for the need for evidence-based arguments and explanations, and can provide opportunities for students to be reflective in their inquiry-based investigations. This paper reports on the role of software scaffolding in facilitating students' thinking and talking about evidence. We report on a study of two 7th grade classes as they are working on an evolutionary biology, computer-based investigation. Students in one of these classes used the Progress Portfolio, an inquiry-support software tool, to manage their investigation and construct evidence-based explanations, whereas the other class used the traditional paper and pencil method of organization. Our data analysis included groups' videotaped discussions, students' computer artifacts, students' science journals, and process video that followed students' work on the computer. Students in the Progress Portfolio condition were found to consistently engage in self-initiating interpretations of their data, in the light of their hypothesis. We argue that the Progress Portfolio scaffolding helped students to coordinate theory with evidence, as students using the Progress Portfolio engaged in data-specific, evaluative and planning sequences that sent them back to the investigation environment to collect more evidence and back to the Progress Portfolio to synthesize their findings.

KEYWORDS
Software scaffolding, inquiry-based science, coordinating theory and evidence, reflective inquiry, design of learning environments

## INTRODUCTION

As Rutherford & Ahlgren (1990) very succinctly put it “Science demands evidence”. Current efforts to reform the learning of science emphasize the need for enabling students’ understanding of the nature of science and how to help them be goal-directed in making sense of how scientific concepts connect to each other. One of the core ideas in understanding scientific practice is attending to the need for evidence and coordinating theory with evidence to produce evidence-based explanations of scientific phenomena. As the scientific community bases scientific advances around this construction of evidence-based explanations and their acceptance or refutation by peers, it is no surprise that this would be argued by many as one of the most important ideas for middle school students to understand. Nonetheless, this is also one of the biggest challenges of science instruction, as it has been repeatedly pointed out that students often have great difficulty in differentiating between a hypothesis and the evidence for that hypothesis, as well as how to construct evidence-based arguments that connect with their ideas with the data they are investigating (Carey, 1989, Kuhn, 1989, 2001). These results suggest that there is a need for particular types of scaffolding to support students in making the connection between their ideas (hypotheses) and the available data that can support those hypotheses (Sandoval, 2003). Klahr & Dunbar (1988) explain this difficulty as a result of the dual-search space process, with the two spaces being the hypothesis space and experimentation space, each with different representations and search strategies. Klahr (2000) posits that the different representations in each space require different search strategies that isolate the two spaces from each other. Klahr further proposes that the evidence evaluation process is the one that can bridge the hypothesis and the experimentation space.

This paper will discuss how software-based scaffolding can help students evaluate their ideas in the light of evidence, by structuring the task so that such important epistemic features as coordinating theory with evidence are highlighted. Specifically, we will present the findings of a study that looked at how middle-school students used an inquiry-support software tool, the Progress Portfolio (PP), in their task to design evidence-based explanations in an evolutionary biology investigation. The paper begins by describing the context of the study, explaining how the tool was designed to support making connections between theory and evidence. We will then give examples of how students bridged the hypothesis and experimentation spaces in two different contexts: using the PP and using the traditional science journal method. We will end this paper with a discussion of these findings for the design of computer-based learning environments.

## DESIGNING A DEMAND FOR EVIDENCE

The PP tool (Loh, B., Radinsky, J., Reiser, B. J., Edelson, D. C., & Gomez, L. M., 1997) is a domain-general, inquiry-support software tool that can be customized by the teacher to scaffold students as they organizing and making sense of their data. Using data camera tool students can easily capture investigation data, which they can then organize by creating pages in the PP. The basic structural components of these pages are data boxes, in which students can paste and store the captured information, text boxes or tables which can serve as repositories for students' written articulation, and prompts that can accompany the text or data boxes to remind students of the task they are asked to do. The user also has the capability of adding sticky notes (similar to paper-based post-it notes) to further annotate the data they import in the PP and draw arrows from these sticky notes to point to issues they wish to highlight.

For the study described in this paper we designed six types of templates. The templates relevant to this discussion are two: the "Data page" template (see Figure 1), intended to provide space for students to record their data and create opportunities for interesting, data-grounded discussions, and the "Explanation Page" (see Figure 2) where students were asked to record their hypothesis, construct an explanation about what happened and provide evidence for it. The Explanation Page design was based on prior design efforts in another software environment, the ExplanationConstructor (Sandoval, 1998). Students can rename the data pages so that they more accurately describe the contents of the page. Figure 1 demonstrates one of these student-created data pages, renamed "Weight" to illustrate that the content of this page was about the weight feature of the population under study.

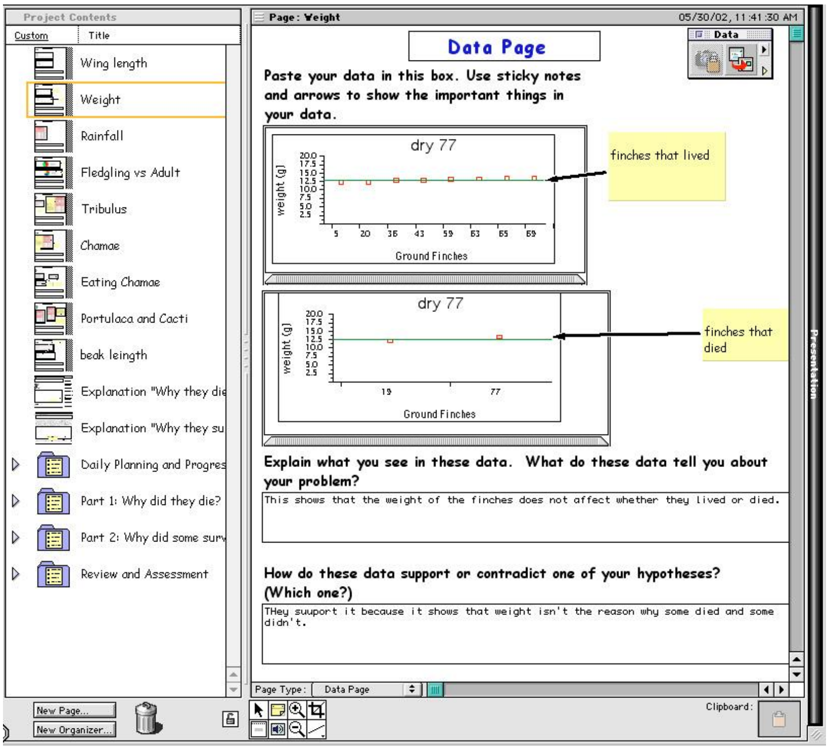


Figure 1. An example of a Progress Portfolio data page (the "Weight" data page)

The design of these templates was the product of an iterative process, with the goal to help focus students' attention on important epistemic aspects of their investigation, especially those ones past research has pointed to as problematic (e.g. Sandoval 2003). In the case of the Data Page template, we wanted students to make explicit connections between the data they identify as important and how these data actually support their ideas. We designed for this by automating the movement between the investigation environment and the investigation management environment (the PP) and by providing students with a space to record their selected data. We also put in place text boxes with guiding prompts to help students reflect on the data while they were still visible to them. Finally, we provided two prompts, one asking students to describe the data ("Explain what you see in these data. What do these data tell you about the problem?"), and the other one asking them to explain the link between these data and their ideas ("How do these data support or contradict your hypothesis? Which one?"). The design of these two prompts aimed at distinguishing between first reporting and interpreting the data and then coordinating theory and evidence.

The design of the Explanation Page was a response to the realization that even though students may create several data pages noting interesting observations in each one of them about fragments of the data (e.g. a weight graph), they oftentimes fail to synthesize their ideas into a coherent explanation telling a story about what happened while providing evidence to support this story. The design of the Explanation Page reflects these important aspects of forming evidence-based explanations: as you can see in Figure 2, we have provided a text box where students record their hypothesis, including prompts above this text box. The prompts' intent is to serve as a reminder of investigation-specific important concepts, which students need to consider as they are constructing their explanation but which they may easily ignore if not reminded, because they are novices to this domain. The design of several smaller data boxes on the side of the explanation box, where students can drag and link evidence previously stored and interpreted in data pages, facilitates making connections between theory and evidence more explicit.

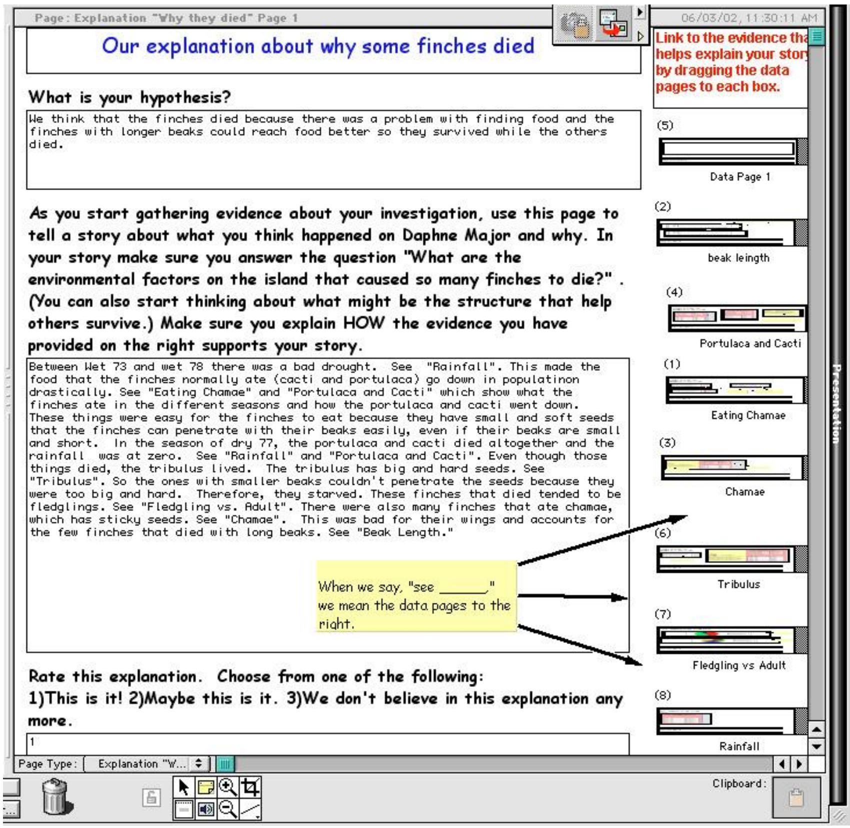


Figure 2. An example of a Progress Portfolio Explanation Page

Thus, our intent as the designers was to structure the task in such as way so that it is easy for students to notice the need to connect theory with evidence as well as provide the impetus for them to engage in discussions about what to include in each box, ideally culminating in rich, documented articulations of their ideas which help students understand the connections between their hypotheses and the available data. Following, we will describe an empirical study set out to test this hypothesis and to further investigate the role software scaffolding can play for students' inquiry.

## METHODS

### Research Design

The goals of this study were to test the hypothesis that the PP environment facilitated students' focusing on issues of coordinating theory with evidence. In particular we were interested in finding answers to such questions as whether students used the PP scaffolds we designed to reflect about evidence. Furthermore, if students did use the tool for this purpose, we wanted to examine the role scaffolding played, especially as compared to using traditional paper and pencil methods of helping students engage in sense-making during their inquiry.

With these questions in mind, we selected a comparative approach for our study, collecting data from two seventh-grade classrooms both engaging with the Galapagos Finches (GF) investigation environment (Tabak, I., Smith, B. K., Sandoval, W. A., & Reiser, B. J., 1996), as they were enacting an evolutionary biology curriculum, the "Struggle for Survival" (Reiser et al., 2001). In the GF investigation students investigate the reasons leading to the death of many finches on the Galapagos island of Daphne Major during the late 1970's. Through the use of the GF software students collect data to support their hypotheses on why many finches died and why some survived during the crisis years on Daphne Major. As the design of the PP aimed at helping students manage complex, data-driven investigations we selected this computer-based investigation because of its complexity, in that it presents students with four different kinds of data that can support several different hypotheses.

Prior to the GF investigation, students in both classes did a two-day investigation on the foraging behaviour of marine iguanas, during which one class used the PP to get acquainted with the use of the software whereas the other used paper-and-pencil journals to help them with the investigation. Both classes worked with the Struggle for Survival curriculum and the GF investigation during the same time of the year, spent approximately the same amount of time investigating the problem and were taught by the same teacher. The teacher had several years of experience teaching science and had taught the Struggle for Survival unit once before, but without using the PP tool. The instruction of the unit was identical in both classrooms. Students worked primarily on their own, supported by the teacher periodically. They were introduced to the same activities, progressed overall with the same pace and were allowed to work on the investigation the same number of days in both classes. After the teacher introduced the GF software and the task to the students, the groups conducted the investigation mostly independently of the teacher, seeking the teacher's advice only periodically. What differentiates the two classes is whether they used the PP as a way to organize their investigation or not, as only one of the classes did, whereas students in the other class used paper and pencil. Students who finished their investigation early proceeded to preparing their final presentation to the class. Other than emphasizing several times during their investigation that students need to support their ideas with evidence, the teacher did not set up a specific number of PP pages or data they needed to collect to finish the investigation.

**Data collection**

We closely followed three pairs of students in each class for the whole period of their work with the GF investigation. With the help of the teacher we selected academically homogenous pairs, representing a range of academic abilities, to observe the range of inquiry activities and discussions. Students were of comparable academic achievement respectively in each class.

The data for the current analysis come from the videotaped interactions of these pairs of students as they worked on the computer, process video from the students' work with the two software programs (Krajcik, Simmons, & Lunetta, 1988), and daily records of students' artifacts in the PP and their science journals. Students in both conditions worked on the GF investigation for a total of ten, 40-minute investigation days. A researcher was present each day of the investigation in both classes to set up and collect the video data and also collect the students' work from the PP each day. At the end of the unit we conducted exit interviews with each pair of students, and also interviewed the teacher.

**Data Analysis**

Videotaped interactions were transcribed verbatim. In addition to students' discourse, these transcripts included all actions the students took on the computer as well as when they decided to write something in their science journal. The written text was then subsequently coded for discussions regarding coordinating theory with evidence, such as attending to the need for evidence, and examining the data to find evidence needed, and interpreting/evaluating the data in the light of the hypothesis pursued. After collecting all examples belonging to this category, we then revisited them to examine the relation between software and other scaffolding and this talk. During this analysis our goal was to understand what triggered students' discussion, whether a software or paper-based prompt was involved and what, if any, actions were elicited because of this discussion.

## FINDINGS: COORDINATING THEORY & EVIDENCE IN ACTION

In this section we report on preliminary findings based on four groups of students, two groups in each condition (PP vs. non-PP). We will first describe how students used the PP or their science journals to manage their inquiry and then report on the role of software and paper-based scaffolding in facilitating students' thinking and talking about evidence.

**General mode of work**

Students in both conditions generated and talked about many pieces of data as they worked with the GF investigation, something that correlates with the complexity of the task. Since the PP was designed to help students make sense of their data and reduce their cognitive load by helping them manage their investigation, one of the first things we looked at was how students use the tool, how many data students produce in the GF environment and what portion of these data end up in their PP files. On average all four groups generated forty-nine pieces of data in the GF, with the minimum number being twenty-seven and the maximum number being eighty-five pieces of data. Both PP groups generated fewer pieces of data in their GF data log than the non-PP ones.

After an initial exploration of the GF software the PP using students worked interchangeably with the two tools, alternating between the two environments as they found more information that they felt was important to record. The latter is corroborated by what the students said in their exit interviews and by the fact that they used almost all the data pages they created in their final presentation. The PP groups moved back and forth between the PP and the GF on average nine times each investigation session. While working in the PP both groups generated several data pages. Group 1 created nine data pages and responded to 85% of the prompts within these pages. They also created one explanation page that included their response to both investigation questions (Why did many finches live? Why did some survive?) and which they linked to eight data pages, all including relevant data. The group also renamed all their data pages, since upon creation each PP data page has a generic name “data page #”. On the other hand, Group 2 created eight data pages and two explanation pages. At the same time, this group gave responses to only 38% of all the possible prompted boxes. In their two explanation pages they linked three and four data pages respectively. In respect to the percentage of written responses to the prompts in the PP further analysis showed that these students engaged in most discussions about evidence in the context of the PP and, moreover, when they move to the GF environment they show an awareness of the task of constructing an evidence-based explanation in the PP but nonetheless, these discussions do not always lead to a written response in the PP.

Towards the end of their investigations both groups spent more time in the PP where they were constructing their explanations and looking for data they had collected in their data pages to link as evidence for their claims. An analysis of their PP artifacts shows that students included no information they did not eventually use for backing up their explanation. With the exception of one graph that did not explain their claim, the groups used evidence from their data pages to back up their claims which reflected an understanding of important conceptual distinctions of the domain.

The non-PP groups took notes in their science journal. These notes were at the best of a summary nature or more often, a recording of specific information for specific data (for instance, gf 8: foraging, dry 77, referring to the number of finch, its observed behaviour and season when this behaviour was recorded). Students often expressed the desire to take notes in their science journal and returned to these notes when they had to respond to a handout their teacher gave them as well as when they were putting together their final presentations. Nonetheless, even when students had consulted their notes during their investigation looking for a particular problem, on several occasions they did not resolve the question that sent them to their notes in the first place.

**Use of the Progress Portfolio Data Pages**

Since we are interested in understanding the role of the scaffolding in the two Progress Portfolio pages discussed in this paper, we will now turn to a discussion of how students used the PP Data and Explanation pages and what this might meant for their investigation.

The analysis of the identified episodes showed that the two PP pages, whose design explicitly focused on providing opportunities to coordinate theory with evidence, elicited patterns of action, which are in line with the PP design intent. The task set-up of the Data Page of articulating what is seen in the data always elicits a discussion about what other data students need, with the exception of one episode. Following these discussions in the PP, students deliberately return to the GF to look for that type of data. The following excerpt is an example of such a discussion as students are working with one of their data pages. My comments about actions they were taking at the time are shown in brackets.

This group is working on a PP page that they have titled “Weight”. Students have already recorded data about the finches’ average weight during the dry and wet seasons and just finished pasting another piece of data in a data box showing the rainfall for the same period of time.

| | | |
|---|---|---|
| 1 | Joni: | Okay. Now let’s go back to the rain thing… wait, wait, wait, let’s look at the data. |
| 2 | Annie: | Measurement of rainfall. Rainfall in dry, wow! There’s really no rain at all in the dry season. |
| 3 | Joni: | I know. I know. |
| 4 | Annie | [Reading the prompt towards the end of the page.] “So how do these data support or contradict one of your hypotheses?” |
| 5 | Joni starts typing in the first box that asks students to explain what they see in the data. | |
| 6 | Annie: | [Repeating the prompt.] “How does these data support or contradict your hypothesis?” These charts… [She types for some time.] That there is a lot, like any rain in the one season? |
| 7 | Joni: | [Typing as she speaks]: That there is 0 to 12cm in the dry season? … |
| 8 | Annie: | Two hundred, twelve in the dry…oh, sorry, I’m looking at the wet. |
| 9 | Joni: | Twelve…[She continues typing their response.] |
| 10 | Annie: | [Pointing to where Annie is now typing.] That the rain ranges from... |
| 11 | Joni: | I wonder why. |
| 12 | Annie: | That’s what we got to figure out. |
| 13 | Joni: | Which is nothing compared to the wet season. |
| 14 | Joni: | From 162-200 cm. |
| 15 | Annie: | No, from 25 to…Oh yeah. To 200 cm. |

As lines 1-6 indicate, instead of immediately going back to their investigation environment, students stop and take the time to reflect on what the data show, explicitly prompted by the reminder prompt on the text box to which they are responding. These prompts helped them externalize the relationship of the new data to their working hypothesis on why so many finches died. As a result of reflecting on the meaning of the new data, the group realized that they needed to figure out why there was such a big seasonal variation in the rainfall and decided to look for the answer in the GF data (lines 10-12). Tracing students’ subsequent actions we saw that, in fact, they returned to the GF investigation to pursue the questions that rose from the above discussion. This episode shows that the Data Page template structured the task so that students were reminded and encouraged to make connections to the data and also provided opportunities for them to reflect on the information they still needed to explore.

**Use of the Explanation Pages**

The structure of the Explanation Pages requires a slightly different mode of work than the Data Pages. Even though the teacher had asked the students to hold off writing their explanation until they had explored some of the data, all groups waited until they gathered all the data they perceived as needed in order to proceed composing their argument. As such, their engagement with the Explanation Page does not elicit the pattern of often going back to the GF to look for additional data, but it does elicit a pattern of re-evaluating and re-organizing their information so that they can present an evidence-based argument to their audience, as students were expected to present their argument to their peers at the end of their investigation. Even though students worked on their Explanation(s) towards the end of their investigation, they were aware of the structure of these pages early on since they had to record their hypothesis there at the beginning of the investigation (see Figure 2 for a snapshot of an Explanation page). The following is a sample explanation, given by Group 1:

> [Why the finches died] “Between Wet 73 and wet 78 there was a bad drought. See "Rainfall". This made the food that the finches normally ate (cacti and portulaca) go down in population drastically. See "Eating Chamae" and "Portulaca and Cacti" which show what the finches ate in the different seasons and how the portulaca and cacti went down. These things were easy for the finches to eat because they have small and soft seeds that the finches can penetrate with their beaks easily, even if their beaks are small and short. In the season of dry 77, the portulaca and cacti died altogether and the rainfall was at zero. See "Rainfall" and "Portulaca and Cacti". Even though those things died, the tribulus lived. The tribulus has big and hard seeds. See "Tribulus". So the ones with smaller beaks couldn't penetrate the seeds because they were too big and hard. Therefore, they starved. These finches that died tended to be fledglings. See "Fledgling vs. Adult". There were also many finches that ate chamae, which has sticky seeds. See "Chamae". This was bad for their wings and accounts for the few finches that died with long beaks. See "Beak Length."”

Students highlighted the references to the data pages linked by repeating the word “See…” followed by the title they had given to that page (see Figure 2 to see how their completed Explanation page looks like).

The analysis of students’ discourse around evidence indicates that the scaffolding provided through the Explanation Page template worked in two ways: a) before they even started constructing their explanations, as they were evaluating their progress and sufficiency of evidence for their claims in the PP Data pages students seemed aware of the scaffolding in the Explanation page, which then sent them back to the GF to engage in more inquiry, if they decided that they needed more evidence; b) after collecting all data, we saw both PP pairs spend at least one 40-minute session working in their Explanation page, re-evaluating and re-organizing their information (deciding on an order of presentation) so that they could present an evidence-based argument to their audience. The following is an example of how students worked with the Explanation page.

Group 1 is working on composing their argument in the Explanation Page for the first time:

| | | |
|---|---|---|
| 1 | Alicia: | We should drag all these data pages to...? [Pointing to the empty boxes where they are expected to link their evidence on the side of the Explanation text box.] |
| 2 | | They read the prompt “What is your hypothesis”. |
| 3 | Sydney: | Okay, so this is our hypothesis. [Pointing to the "What is your hypothesis" text box.] |
| 4 | Alicia: | [Reading another prompt.] “What are environmental factors…” Okay, we'll just explain our theory. How about between, which season, 73 and wet 78 there was a bad drought. This made the food the finches normally ate die and, what is that called? |
| 5 | Sydney: | Portulaca. |
| 6 | Alicia: | Portulaca, go down drastically. In the season of dry 77, the portulaca and cacti died all together. |
| 7 | Sydney: | Can you go to data page 4? [They go to data page 4 and take a look at it]. |
| 8 | Alicia: | Yes, let's put this in box #1 and tell them to go see it. Cause this is where we can say that they eat this. Wait where's the one where it says that they eat that stuff? This one? [Pointing to one of the data pages on the left]. No, it's that one [pointing to another data page]. Let's put 5, 4, and what was 3, was that any use? No that was graphs. Five and four. [5, 4, 3 are Data Pages numbers.] |
| 9 | | They return to their Explanation Page. They continue typing on why the finches died, and say "see data page 1". Then they drag their first data page, which shows what the finches eat. |

The design of the Explanation Page template targeted three things: articulating a hypothesis, telling a story about what happened that provides answers to the questions addressed in the prompt, and providing the evidence for the claims they make in their story. The above discussion shows a fairly typical example of how students notice these three things. Students scanned the page reading the prompts, noticing what each one is asking them (lines 1-4) and proceeded working as encouraged by the prompts: agreeing on which story to tell and finding the evidence to support it by linking the relevant data pages. The example above shows that not only students are being careful to coordinate their theories with evidence, but that they are doing it reflectively: that is, that is they revisit their data pages (line 8), re-evaluating them in respect to the claim they are making and returning to the Explanation Page to compose their explanation.

**The science journal condition: A different kind of talk about Evidence**

We have discussed thus far how the PP scaffolds helped focus students' conversations and subsequent actions. The analysis of the comparison case, which is of those students who did not use the software scaffolds to help manage their investigation, enables a grounded discussion about what the added value (or the limitations) of the tool might be. Our comparison class also engaged with the GF using the traditional paper and pencil based science journals to manage their investigation instead of the PP. In particular, the teacher asked students to divide each of their science journal pages into two columns and write the main ideas in one of the columns and the more specific ideas in the other column. Students were free to record any ideas they thought interesting.

We identified discourse episodes about evidence in a similar way as those identified for the PP groups. In this environment, which did not include the PP prompting, students also talked about evidence but quite differently. Even though non-PP users also talk about evidence and the need to verify their hypothesis by examining the investigation data, these discussions are more general in nature. For instance, students may say, referring to whether they will keep a stated hypothesis, "we'll have to see", meaning that whether they will keep this hypothesis depends on whether later they will later find data to support it or not. Furthermore, these discussions were less extensive and did not, most of the times, lead to the planning of specific next steps, with students making general statements of the kind "we need to find more information" and sometimes even supplementing this by saying "by I don't know what".

The first of the non-PP groups discussed the need for evidence on several occasions. The most frequent pattern of action triggered by these discussions was writing down the piece of information identified as important in an abbreviated form (i.e. gf15 mating, meaning that they had read some information about the mating behaviour of Finch #15), with no other extended conversation about what the data might mean or how exactly all connect together. We observed the same pattern with the second non-PP group too, that is of writing down observations of the finches which seemed interesting without any further elaboration of what these might mean for the problem at large, with the exception of the students' initial discussions of their hypotheses. The second of the non-PP groups was prompted by the teacher to talk about their evidence the most of the four groups.

Examples of the PP based discussions, most of which happen in the context of responding to prompts interpreting specific data, show students engaging in discussions about data which end up sending them back to the investigation environment to look for a piece of data they may be missing. For instance, one PP group was developing the hypothesis that strength was the deciding factor for the finches' death or survival. As they were discussing this and recording their hypothesis in the PP in the "What is your hypothesis" box, they engaged in a discussion of how weight might be a contributing factor. At that point, realizing that they needed evidence for this, they interrupted the recording of their hypothesis, switched to the investigation environment to investigate the weight of the finches, and then returned to the PP to complete their hypothesis, emphasizing in their discussion that this new elaboration of their hypothesis was based on data by starting their sentence with the phrase "after looking at some information we saw…". Another difference between the two conditions is how they judge the sufficiency of evidence; specifically we saw arguments regarding how much evidence they should gather between the group members in only the non-PP condition. The following discussion illustrates the tension:

Students are reading a field note about finch GF5 spending a considerable amount of time searching for food and engage in a conversation on what that means.

1 Lilly: So they are looking for food and not mating. How can we prove it?
2 Lydia: We just did.
3 Lilly: Yeah, but we need to prove it more. Is this a gf…GF5.
4 Lydia writes down that information "gf5 searching for food and not mating".
5 Lydia: That's really...we figured it out.
6 Lilly: Not necessarily.

As demonstrated by this discussion one of the students felt that this single piece of evidence was enough to solve the problem of why finches were dying (lines 2 and 5), whereas the other student felt that they needed more information to be able to say so (lines 1, 3, and 6). Nonetheless, there is nothing else to support Lilly's intuition that they need to provide more evidence and the discussion never moves beyond this level. In contrast, the two PP groups provide several pieces of evidence supporting their claims in their data and explanation pages and do not argue about how much evidence they need, even though often times they will say that they need to find more evidence to prove their ideas.

## CONCLUSION AND FUTURE WORK

Several of the findings of our current analysis merit further attention. For instance, when it came to evaluating the data and deciding what next steps to take, the non-Progress Portfolio groups were more vague than the students in the Progress Portfolio condition. Along the lines of epistemic forms and games (Collins & Ferguson, 1993) one possible explanation for this is that the PP templates help students understand the game of scientific explanations by visually communicating expectations for these. The game in this instance is filling out this explanation template, which creates a demand for students to attend to important domain-specific conceptual distinctions and provide evidence, guiding them towards the coordination of theory and evidence. This idea is supported by the observation that often the discussions of the non-PP groups, even when students were apprehensive of the need to provide evidence, were derailed by the fact that there was no structure about the nature and form of evidence needed. The absence of a structure clearly communicating expectations about what it means to prove an idea inhibited students from further pursuing connecting their ideas with evidence, something that the prompts and placeholders for the evidence in the PP tried to guide against. In the best-case scenario, one could hypothesize at this point that if the students were working with a PP Explanation page, they might have noticed the multiple data boxes that are supposed to be linked to evidence, helping them to move past this issue of how much evidence is needed and into looking for more related pieces of evidence.

To summarize, the goal of the analysis was to examine the role of the PP scaffolding in helping students coordinate between theory and evidence. Results indicate that students in the PP condition engaged in qualitatively different discourse about evidence, connecting their ideas to the observed data, and engaging in cycles of locating, interpreting and evaluating their data as they related to their hypothesis. Most of these episodes happened in the context of working in the PP environment and, in many occasions, as students were specifically responding to the PP prompts. In addition, students constructed explanations supported by several pieces of data, reflecting an understanding of important principles in the domain. This evidence suggests a positive relationship between the PP scaffolding and students' cognitive engagement. These findings challenge research suggesting that students cannot connect theory and evidence, by arguing that students can differentiate between hypothesis and evidence with the appropriate kinds of support. This support, in this case a system of software scaffolding, can make the epistemic game of constructing evidence-based explanations more transparent to students, thus helping them to attend to the necessary aspects of coordinating between the often distinct spaces of theory and evidence. Our future work will be focusing on understanding how this scaffolding system contributed to students' inquiry in more detail by looking at more groups of students and characterizing how students interact with different kinds of scaffolding, both software and non-software based, trying to understand the value-added as well as the limitations of this type of scaffolding in promoting students' reflective inquiry.

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