

Jots: Cultivating Reflective Learning in Scratch

by
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Bachelor of Arts in Psychology
Harvard College, 2002

Master of Education
Harvard University Graduate School of Education, 2003

Submitted to the
Program in Media Arts and Sciences,
School of Architecture and Planning,
in partial fulfillment of the requirements of the degree of
Master of Science
at the Massachusetts Institute of Technology

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ABSTRACT

This thesis introduces the Jots system, a new technology designed to engage children in reflective learning as they work on design projects. Jots enables children to create brief updates, or “jots,” describing their frustrations, achievements and other thoughts and feelings while creating projects in the Scratch programming environment. Later children can look back at their jots to reflect on their own design and learning processes. This thesis introduces an approach to reflective learning in four facets: cognitive, emotional, social and temporal. The design of the Jots system, as well as its development over time, are discussed. An empirical study with three middle school students who used jots in a facilitated context is analyzed in case studies and categorizations. The results of the study are examined in terms of the four aspects of reflection, and ideas for future work are presented.

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Here I am at the end of my thesis, and there you are at its beginning! This is the part where I am supposed to thank everyone. It's hard to imagine giving thanks adequate to the amazing support I've received in so many forms from so many people, but I'll try. In a way, it's an opportunity to reflect on how I've been affected by so many contributions of insight, connections, emotional support, advice, patience, humor, time, food, conversation, books, ideas, and on and on.

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[1] INTRODUCTION

I will begin with two anecdotes that I think capture the spirit of this thesis:

A young girl is learning to knit. She comes to an elder with a problem: she has made a mistake near the start of her work, and a stitch is missing. She asks for help to fix it, but instead, the elder suggests that she leave it the way it is. Perhaps it will help her remember what it was like not to know how. Perhaps one day she will be the elder, and make use of it.¹

A grad student is trying to come up with a thesis topic. He struggles and wonders. He generates ideas, tries things out, reads, and learns through purposeful and chance conversations with trusted mentors and friends. Sometimes he feels frustrated and stuck; other times he feels joy and excitement. Throughout, he carefully makes notes. He uses an editing system that records incremental changes. Writing and observing his own edits helps him step outside own process and question it; later, he can look back in time and see the unfolding story of his ideas as they change. He feels encouraged not just to share his ideas, but to help others see how he arrived at them. He gradually comes to realize where he is going.

There are many facets to reflective learning. It's thinking about your thinking, and it's thinking about your feelings. It's thinking about thinking with other people. It happens in the moment and in retrospect. All these aspects are important for learning, but many tools that help people design

¹ This is a fictionalized version of a story told to me by Eleanor Duckworth.

and create do not support them well. This thesis explores how we can develop environments for designing and creating that support the many facets of reflection.

1 Overview of the Thesis

In chapter 2, “Background,” I give a framework for thinking about four facets of reflection, and describe some approaches for making learning reflective. Then I review a few existing technologies for reflective learning, raise some big questions about the future of reflective learning, and describe the context of the present research in the Scratch programming environment.

In chapter 3, “Design,” I describe my design goals, discuss some preliminary design work, detail the final design of the Jots system for reflective learning that I created for this thesis, and give some details about my own design process.

In chapter 4, “Empirical Study,” I describe my research methods for a study of the Jots system with Middle School students, and then analyze the qualitative data, using case studies and categorization.

In chapter 5, “Reflections,” I discuss the qualitative data in terms of the framework given in the background chapter, and provide some ideas and visions for future work on technologies for reflective learning.

[2] BACKGROUND

In this chapter I describe a view of reflection that takes into account four facets: cognitive, emotional, social and temporal. Then I consider several approaches to making learning reflective in these ways, and some existing technologies for reflective learning. I raise some big questions about how we might reflect using technologies of the future, and then describe the narrower context for the questions addressed by the empirical study in this thesis.

1 Four Facets of Reflection

Here I'll describe four different approaches to describing reflective thinking and learning, emphasizing different facets: cognitive, emotional, social, and temporal.

1.a The Cognitive View

John Dewey, in his book “How We Think,” (1933) articulates a view of reflection as a cognitive process. In reflective thinking, “the ground or basis for a belief is deliberately sought and its adequacy to support the belief is examined. This process is called reflective thought; it alone is truly educative in value.” In this way, the experiences grounding beliefs are synthesized into knowledge.

Bruner (1987) complexifies Dewey's cognitive account of reflection by raising the question of what is gained by reflecting. Is it an ever increasing abstraction? He argues that by distancing ourselves from our knowledge as we reflect, we gain not just increasingly abstract understanding, but new perspectives and alternative stances toward our

knowledge. He writes, “Much of the process of education consists of being able to distance oneself in some way from what one knows by being able to reflect on one’s own knowledge... It is this that permits one to reach higher ground, this process of objectifying in language or image what one has thought and then turning around on it and reconsidering it.”

The approach to reflective learning from cognitive science focuses on metacognitive skills in problem solving. Bruer (1994) defines metacognition as conscious awareness of problem solving strategies, and the ability to monitor and control these strategies. This view positions metacognition as the highest of four levels of thought, which are, in order: automatic processes, recall of stored knowledge, use of thinking strategies, and awareness and control of the three lower levels. Bruer summarizes the metacognitive skills as follows: “Among the basic metacognitive skills are the abilities to predict the results of one’s own problem-solving actions, to check the results of one’s own actions (Did it work?), to monitor one’s progress toward a solution (How am I doing?), and to test how reasonable one’s actions and solutions are against the larger reality (Does this make sense?)”

1.b The Emotional View

The cognitive account of reflection, focusing on the synthesis of experience into knowledge, abstraction and perspective taking, and metacognition, omits the role of affect in reflection. Boud, Keogh and Walker (1985) describe a model of reflective learning in which emotion plays a central role. In the figure below depicting their model, there is a feedback loop between experience and reflective processes, recalling the relationship described by Dewey (they note that the parts shown distinctly in the model are interdependent and difficult to separate in practice). The difference from Dewey’s view is that feelings are included explicitly as

part of the experiences, and considering those feelings becomes central to reflection. Reflection in this model involves making use of positive feelings to help motivate continued action, and attending to negative feelings that are obstructing learning processes in order to work them out. This focus on emotion in reflection also leads to considering emotional change as part of the outcome of reflection, beyond only changes in perspective or development of skills.

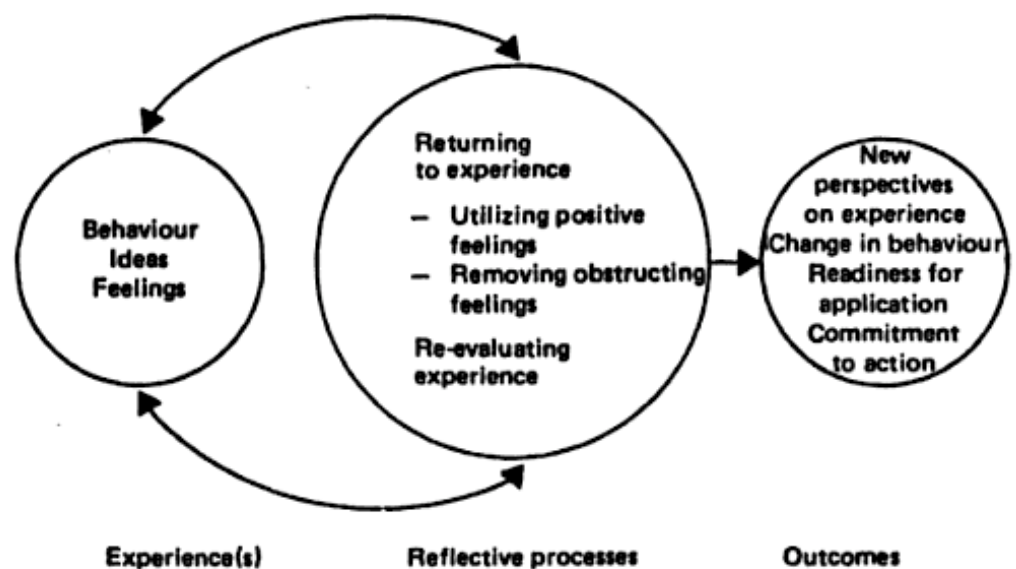


Figure 1: A model of the reflection process, from Boud, Keogh and Walker (1985)

1.c The Social View

These cognitive and emotional accounts are still lacking the crucial role of other people in reflecting. Surely we are limited in our ability to reflect as individuals. As Habermas writes,

“The self-reflection of a lone subject... requires a quite paradoxical achievement: one part of the self must be split off from

the other part in such a manner that the subject can be in a position to render aid to itself... [furthermore] in the act of self-reflection the subject can deceive itself.” (Habermas, 1974, cited in Boud, Keogh and Walker, 1985).

The support and encouragement of others can help us go beyond our limited abilities to reflect as individuals. Conversation with a mentor can play a crucial role in helping a learner develop more reflective thinking processes. Bruner (1987) writes, drawing on Vygotsky:

“...conceptual learning [is] a collaborative enterprise involving an adult who enters into a dialogue with the child in a fashion that provides the child with hints and prompts that allow him to begin a new climb, guiding the child in next steps before the child is capable of appreciating their significance on his own. It is this “loan of consciousness” that gets the child through the zone of proximal development.”

Children may not yet have access to the ability to make, as Habermas puts it, one part of the self split off from another part, in order to reflect on their own thinking. The mentor can serve this role of the other. The “loan of consciousness” that Bruner describes is a loan of an alternate perspective to provide feedback to the self.

But how can we “loan” our consciousness to another person? My interpretation is that a mentor must work to understand the mental state, both cognitive and emotional, of the learner, in order to mirror their thoughts and feelings empathically. The mentor can then use their own more highly developed reflective abilities to imagine reflective moves that the learner could make, carefully suggesting them, such as drawing the learner’s attention to their own thoughts and feelings. Boud, Keogh and

Walker (1985) describe this type of mentorship as follows: “The single most important contribution facilitators can make is to give free and undivided attention to the learner... If facilitators are more experienced and more confident they can also draw the attention of the learner to his or her behaviour: the non-verbal signs which betray emotions, the missing elements of a description, and the repetitions which appear to punctuate the recollection.”

It is worth raising the question of the extent to which reflection processes can be learned by children from a mentor, such that they are internalized in a way that the child can continue to reflect on their own. Reflection is difficult to measure, so this type of transfer is difficult to demonstrate. Scardamalia et al (1984) show some provocative results with six-graders learning skills in written composition. They found that after some teaching, the students could continue reflective processes about their writing on their own, but in a limited way. Students could reflect on individual ideas on their own, but could not reflect at a higher level of rhetorical thinking.

Beyond the relationship of an individual learner and a mentor, reflective learning can benefit from a larger social context, such as a community of learners. For example, a classroom formulated as a reflective community of learners can involve its students in reflecting on each other's thought processes. Bielaczyc and Collins (1999) describe a scenario in which “students are frequently asked to explain what another student is thinking or to articulate the idea one is arguing against, prior to making a proposal of one's own. Such activities require students to examine the ideas of the community, to compare proposals, and to talk about knowledge and understanding.” This social environment enables and amplifies reflective learning.

1.d The Temporal View

The accounts of reflective learning reviewed so far, cognitive, emotional and social, are generally agnostic of the details of how reflection plays out over time. For example, a learner's trajectory through Boud, Keogh and Walker's (1985) model in the figure above might take them from experience to reflection and back over the course of a minute, a day, or a year. The final piece I would like to add to this integrative approach to reflective learning is a view that takes into account differences between the ways reflective processes unfold over time. Schön (1995) distinguishes between two types: reflection-on-action, which occurs after an experience has concluded, and reflection-in-action, which evolves along with the flow of experience.

Describing reflection-in-action, Schön (1995) writes about expert practitioners approaching complex and uncertain situations. First they must frame or re-frame the problem, placing it in a context that bounds it. What follows is what Schön refers to as a "reflective conversation with the situation."

"Each practitioner tries to adapt the situation to the frame. This he does through a web of moves, discovered consequences, implications, appreciations, and further moves. Within the larger web, the individual moves yield phenomena to be understood, problems to be solved, or opportunities to be exploited... the practitioner's moves also produce unintended changes which give the situations new meanings. The situation talks back, the practitioner listens, and as he appreciates what he hears, he reframes the situation once again."

In summary, he writes that “the process spirals through stages of appreciation, action, and reappreciation.” This spiral recalls the feedback loop in Boud, Keogh and Walker’s (1985) diagram, but it is clear from Schön’s description that the process takes place in rapid continuity from moment to moment, with no sense at any given time of being in a single phase.

In contrast, Schön’s reflection-on-action takes place after the experience has concluded. In this case, there is a clear separation of the direct experience itself from the time of reflection on it. This type of reflection is the one more typically thought of, and we see it in activities such as journal writing or reflective discussions after an event.

Looking at the temporal aspects of reflection also allows us to focus on important understandings that can be lost in reflection-on-action. When we look back on a learning experience, it is easy to forget how the moments of insight, including all their messy or difficult parts, actually occurred, or even that they happened at all. We often conveniently leave them out of our stories to ourselves of how we arrived at an understanding, but those challenging moments may be very fruitful material on which to reflect. Bamberger and Schön (1983) refer to the loss of these moments as a “wipe out” phenomenon:

Unexpected insight evolves in the work of making, but makers tend only to see it when, through the evolutionary process of making, itself, they can recognize it. And when they do, the transitional objects, the moves on the way, seem to disappear. Practicing a kind of “historical revisionism,” they attribute insight to the moment when it occurs, even finding in the moment a sense of certainty—of course, “we knew it all the time!”... A finished product—a computer program that works, a proof that matches the

canonical one—tends to “wipe out” in its clarity and logic especially when expressed in conventional symbolic notations, the conversations with the materials through which they evolved.

This wiping out of the moves along the way to understanding is an important problem to focus on in the temporal view of reflection.

1.e Putting It Together

A fully nuanced view of reflective learning should take into account all four of these facets: the cognitive, emotional, social, and temporal. Reflection involves metacognitive skills such as awareness and control over one's own problem-solving processes; it also involves awareness of and control of one's own emotions. It can occur individually but benefits from thoughtful and empathic mentorship, or participation in a reflective learning community. Finally, we can make a distinction between reflection-in-action, which is a reflective process with a tight feedback loop that occurs rapidly in the flow of events, and reflection-on-action, that occurs after an experience has ended. A potential hazard in reflection-on-action is the “wiping out” of the messy transitional stages in our memory after the experience.

2 Making Learning Reflective

Given this view in several facets of reflective learning, what are some approaches to making reflective learning happen? Here I review three approaches: helping children see their own thought processes in their creations; the spiral of creative thinking as children design and create, leading to reflection; and rich documentation by adults of learning processes.

2.a Children As Epistemologists

Seymour Papert, father of the LOGO programming language for children, wrote that learning to program could help children think about their own thinking. A program is itself like a particular kind of thought process, proceeding logically and sequentially. When a child writes a program, in a way she is creating a concrete instantiation of a thought process in her own mind. By studying the behavior of the program, she is studying her own thinking. Papert (1980) writes, “I began to see how children who had learned to program a computer could use very concrete computer models to think about thinking and to learn about learning, and in doing so, enhance their powers as psychologists and as epistemologists.”

One example of an epistemological discovery, a discovery about the nature of thinking and knowing, that a child might make, is in the relationship between debugging and knowing. Papert explains that children typically learn in school that knowing is black and white: you either know something or you don't. As they begin to develop their own complex programs, though, they see that a program can be partly correct, necessitating a “debugging” process that iteratively isolates and fixes the problems. The child can then make the leap back to their own thinking, seeing that understanding can also be partial, and that thought processes sometimes need debugging. The programming environment which brings to the surface this similarity between programming and thinking, especially along with mentorship to help the child see the similarity, becomes a powerful tool for reflective learning along the cognitive dimension.

2.b The Creative Thinking Spiral

Resnick's (2007) spiral of creative thinking describes an iterative, cyclic process that people go through as they design and create (see the figure

below). We begin by imagining an idea for something to make, then we create it, play with it, share it with friends, and finally step back to reflect on its meaning. Reflecting leads to imagining again, and the cycle begins anew. While this spiral recalls the feedback loops described above, it specifically describes the role of reflection within a creative design process: not just experiencing something, but making something.

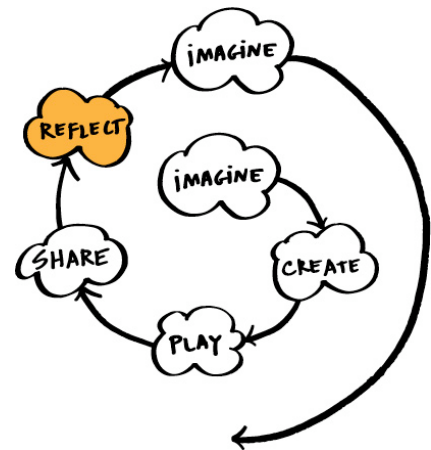


Figure 2: Resnick's creative thinking spiral

The creation of an artifact has important consequences for reflection. To see how this plays out, we can apply Schön's notion of reflection-in-action to each of the phases of the spiral. The concept of a reflective conversation with a situation can become focused into a reflective conversation with materials. The creation process involves working with stuff, which talks back: the building blocks respond as you build with them, telling you about the physics of the world. Similarly, as we play, we are reflecting on the affordances of what we have made, to see what we can do with it: maybe my doll can live in this house of blocks, or maybe it can represent a ship. And sharing involves feedback from our friends: they may see the house as a castle, or want build an addition, leading to new ideas. In this way reflection in action can happen throughout the stages of the spiral of creative thinking, in ways that are unique to the process of designing. The

cognitive and the social aspects of reflection thus appear in the spiral, and a temporal analysis illuminates it.

2.c Documenting Learning

Even when learning involves designing and creating, the learning process is generally not visible. How can we make learning visible, in the way that Papert showed that children could reify their thoughts as programs? The Reggio Emilia schools for young children place a high importance on this aspect of learning, creating rich documentation that serves as material for reflection:

Careful consideration and attention is given to the presentation of the thinking of the children and the adults who work with them. Teachers' commentary on the purposes of the study and the children's learning process, transcriptions of children's verbal language (i.e. words and dialogue), photographs of their activity, and representations of their thinking in many media are composed in carefully designed panels or books to present the process of learning in the schools (Caldwell and Rinaldi, 2002).

This Reggio Emilia style of documenting the learning process in many media provides rich benefits for reflective learning. It generates a whole new set of material to have conversation with, in Schön's sense, about learning. It can incorporate both cognitive and emotional aspects of learning. The documentation can engage a broad community in the conversation, and extend it across time. If it is rich enough, this documentation may become a way to address the wipe-out phenomenon described above.

3 Technologies for Reflective Learning

The three approaches to making learning reflective reviewed above are difficult to achieve, but technology can be used to facilitate them. Here I review three technological approaches: capturing of process, collaborative inquiry, and the sharing of reflection artifacts.

3.a Capturing Process

In 1986, Collins and Brown envisioned that the computer would become a new tool for reflective learning. They pointed out that process information is typically lost, but that computers are uniquely capable of capturing, processing and displaying it. For example, as a student works through a math problem on a computer, the computer can record each step that they take, and then present these later for study. They write:

The students' problem-solving processes—their thrashings, false starts and restarts, and partial successes—should not be left implicit. A major value in solving problems occurs when students step back and reflect on how they actually solved the problem and how the particular set of strategies they used were suboptimal and might be improved.

They go on to describe a set of ways that recordings of process information might be used reflectively. A novice could compare their performance with that of an expert; processes can be represented in new concrete visualizations, highlighting otherwise hidden aspects; and process can be abstracted and generalized in powerful ways. This vision represents a highly cognitive view of reflection, lacking emotional or social elements. It captures process in a much narrower sense than, for example, the rich documentation at Reggio Emilia described above. Nonetheless, if the

“thrashings” and “false starts” are indeed captured, that may be one way to regain the understanding of process lost in the “wipe-out” phenomenon.

3.b Collaborating On Inquiry

Scardamalia and Bereiter (1991) describe a system called CSILE, the computer-supported collaborative learning environment, that uses computers to support reflection in a different way. Rather than capturing process information, CSILE is designed to give students agency in posing and answering their own questions as they learn. At the heart of CSILE is a database of knowledge generated by a community of students, who enter it in from networked computers. They enter notes, which can contain text and images, in the form of questions, answers and other thoughts related to inquiry processes about school curricula (such as astronomy, biology, history, etc). The explicit goals of the project included supporting reflective thinking processes, and making these metacognitive activities into social activities. To support reflective thinking, the software includes “thinking types” with which students can categorize their notes: “what I know,” “high-level questions,” “plans,” and “new learning.” Students might start by creating notes about what they know, and posing high level questions. Then, they formulate plans and note what they learn; as new questions arise, students continue the cycle of inquiry, documenting it with notes as they go. They can see and respond to each other’s notes, providing answers to each other’s questions and also critiquing each other’s thinking.

CSILE focuses on cognitive aspects of reflection, but situates them in a powerful social context. The act of creating notes, with scaffolding for high-level thinking, seems to support reflection in action, while the searchable persistent database of notes affords the opportunity for using it as documentation to support reflection-on-action.

Gardner and Kolodner (2007) developed a tool for reflecting on scientific inquiry in their Kitchen Science Investigators (KSI) project. They created activities for fifth and sixth graders that combine science inquiry with cooking and baking. Groups of children completed scaffolded writing activities on computers in the kitchen as they cooked and experimented. The writing activities were in the form of a cooking magazine, for which the children created annotated recipes, stories, explanations, and an advice column. The authors write: “we found that with computers in the kitchen and an online magazine to contribute to, participants were stopping and reflecting as part of their finishing-up activities in ways that we had only seen previously when a facilitator was prompting them.”

The KSI project focuses, like CSILE, on cognitive aspects of reflection, but takes into account the emotional aspect by using writing activities designed to feel authentic to the children, encouraging their excitement rather than interrupting it. The groups may have provided a social context, but without any special support for reflection within the group. As in CSILE, the writing activity was integrated in the activity in such a way that it could support reflection-in-action, for example by writing and annotating recipes, as well as reflection-on-action. The authors make a provocative claim in saying that the reflection afforded by the computer-based activities was comparable to that seen with a facilitator’s prompting; more data and an explicit comparison would be needed to support this claim.

3.c Sharing Reflection Artifacts

Chapman’s (2004) “Pearls of Wisdom” system is a technological tool for integrating reflection into the practice of a community learning informally. In this case, the learners were focused on design processes using multimedia technologies such as software for creating images, animations,

and music. The software enables people to create and share “intentional-reflective artifacts,” Pearls, which document learning and design processes. Each Pearl consists of an image or other media artifact such as a sound or animation, a how-to area describing how the artifact was made, and a space for reflections and other comments. The Pearls are collected in an online database for other community members to browse and comment on.

Pearls of Wisdom provides open-ended space for both cognitive and emotional reflective learning, and supports the social aspect of reflection strongly through its integration with a specific community of learners. Constructing a Pearl is fairly easy, but not quick enough to be done in a rapidly iterative fashion; for this reason I would say the system mainly supports reflection-on-action. It is geared specifically toward the design process, and potentially results in rich documentation of learning processes.

3.d Comparing facets

Each of the technologies for reflection described above emphasizes some facets of reflection over others; none of them support all facets. Collins and Brown’s (1986) vision of process capture focuses on cognitive and temporal reflection, and lacks the emotional and social. Scardamalia and Bereiter’s (1991) CSILE supports all but the emotional facet. Gardner and Kolodner’s (2007) KSI, on the other hand, supports all but the social facet. Finally, Chapman’s (2004) Pearls of Wisdom supports all the but the temporal facet. Apparently it is a difficult design problem to develop systems that support all the facets of reflection.

4 As We May Reflect

So far in this chapter, we have seen a four-part view of reflection, in its cognitive, emotional, social and temporal facets. We have examined three ways of making learning reflective, through externalizing thoughts in code, through design processes, and through documentation. And we have looked at a few of the existing technological tools for reflection. It would appear that none of the existing tools fully lives up to the promise of a fully nuanced view of how learning can be made reflective. At this point I would like to raise some big questions.

In his astonishingly prescient 1945 essay, “As We May Think,” Vannevar Bush imagined technologies that would one day enhance and amplify human thought and memory. In this thesis I would like to ask, how may we reflect, using technologies of the future? Which of our mental capacities and human experiences will we choose to amplify and enhance? Can we develop tools for the process of designing and creating that help people reflect in cognitive, emotional, and social ways? Can we address the multiple time scales at which the feedback loops of reflection occur? Can we address the wipe-out phenomenon, preserving the messy moments of learning as rich material for reflection?

5 Scratch

In this thesis, I will address these big questions in a somewhat narrower and more focused way, by presenting a tool for reflective learning in a particular environment called Scratch. Here I will introduce the Scratch application and Scratch website.

5.a The Scratch Application

Scratch (Maloney et al, 2004; Resnick et al, in press) is a programming environment for children that lets them create their own interactive stories, animations and games, and share them on the web. To create programs in Scratch, you snap together graphical blocks, each representing a command that can make something happen. The commands control characters on the screen, which in Scratch are called sprites. You can make your sprites do things like move, change color, or play a sound. You can also create interactivity in your program, enabling input from the keyboard or mouse.

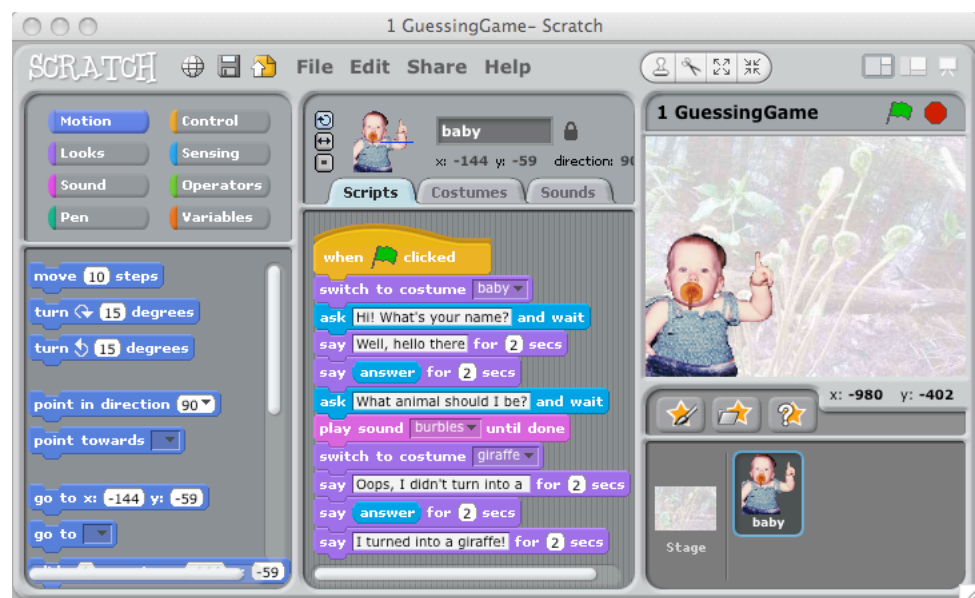


Figure 3: A screenshot of the Scratch application

Scratch is designed to bring powerful computational ideas close to the surface, in the tradition of the earlier LOGO programming language (Papert, 1980). Its design emphasizes a “low floor” and a “high ceiling.” The low floor means a low barrier to entry. It is very easy to get started making things happen in Scratch, thanks to numerous design features. For example, you can try out the blocks by clicking on them, and it is impossible to cause a confusing compiler error, as it is in other programming languages. The high ceiling refers to the fact that it is also

possible to build up to quite complex projects, using the expressive and powerful syntax and the carefully chosen generative lexicon of the language.

In addition to the low floor and high ceiling, Scratch is designed to have “wide walls,” supporting a variety of pathways and styles of use, and providing ways to connect to a variety of different interests. It includes functions like the ability to easily create drawings, import photos, images and animations, and record and play music and sound effects. Children using Scratch can make their own mashed up versions of the media they enjoy, building elaborate projects full of media uniquely meaningful to them, or create something entirely new of their own imagining. Scratch is designed to empower children to create and remix media, taking control of it as producers rather than consumers.

5.b The Scratch Website

A key feature of Scratch is the ability to easily share your projects on the Scratch web site (Monroy-Hernández, 2007), so that others can view and interact with them, comment on them, and press buttons to “love” or “favorite” them. On the web site you can also download any Scratch project, and open it up to see how it works. If you modify it to make your own version and then share it online, it shows up on the website as a “remix,” crediting the original creator. Each user on the web site has a “My Stuff” page, showing a picture they have chosen to represent themselves, their collection of projects, and their collection of favorite projects by others.

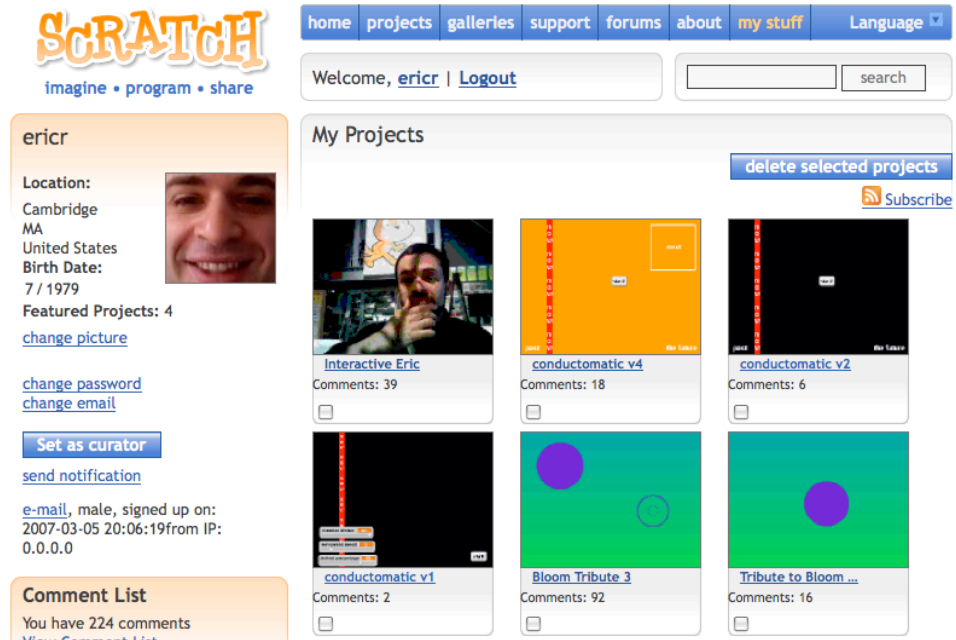


Figure 4: The Scratch website displaying the My Stuff page

5.c Scratch and Reflective Learning

As they design and create with Scratch, people move around the spiral of creative thinking (Resnick, 2007) described above. The design of the Scratch software and web site supports creation, play and sharing quite well, as we have seen from the active community of people around the world who have created and shared an incredible diversity of projects. But what about that other crucial part of the spiral, reflection?

Surely, many people using Scratch are reflective as they work, and reflect afterward on their experiences with it. For example, one person wrote “I made this swirly effect by accident, whilst experimenting with pattern making.” Thinking back on their design process, they realized they had made a mistake that became useful and interesting, which is a valuable thing to learn. Another person wrote “I heard about [Scratch] at school. I downloaded it at home, and I taught myself everything I know, using logic, trial and error, and the ‘Here's how all the blocks work’ page. No

help!” This person is reflecting on the self-guided learning process they have gone through, and concluding that they are able to learn Scratch, and probably many other things, on their own.

Of course, these examples make up only a tiny number of anecdotes, out of the tens of thousands of people using Scratch. I give them mainly to point to the potential benefits of reflection for the Scratch community. There is a huge amount of room to support and cultivate reflection as people use Scratch to design and create.

1 Overview

In this chapter I present the design process and the resulting design of the Jots system for cultivating reflective learning in Scratch. I summarize the design briefly here, review my preliminary design work, and then describe the design in more detail. Then I return to the design process to reflect on some of the learnings along the way.

The Jots system consists of a pane added to the Scratch application's user interface (see figure below), allowing you to write a brief note about what you are doing, thinking or feeling as you work in Scratch, and post it along with a screenshot to your My Stuff page on the Scratch website.

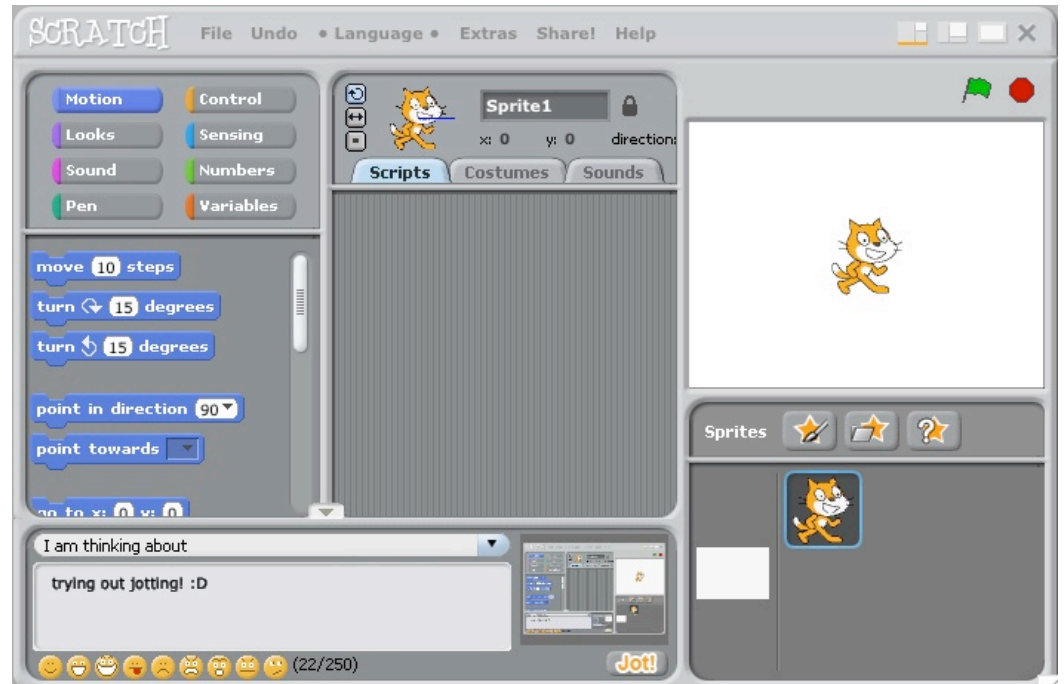


Figure 5: A screenshot of the Scratch application with the Jots pane at the lower left

2 Design Goals

Three goals guided the design of the Jots system:

- **Cultivate Reflection:** Support and scaffold inquiry into the process of constructing a Scratch project, at a cognitive and an emotional level, in the moment and after the fact
- **Make Reflection Constructive:** Enable the creation of “reflection artifacts” that document learning processes, persisting over time for later review and re-construction
- **Make Reflection Social:** Enable sharing and social interaction around reflection artifacts.

Cultivating reflection involves, ideally, supporting each of the aspects of reflective learning described in the background section: cognitive, emotional, social, and temporal. Also, ideally we can make learning reflective in each of the three ways discussed: making thinking visible in programs, enabling reflection through the design process, and documenting reflection through reflection artifacts. Scratch as an application already allows children to program and to some extent make their thinking visible as programs; that aspect is not a focus of this thesis. Scratch also is already a carefully designed tool for designing and creating, so my design can take advantage of that fact. This leaves me with the goal primarily to create a system for children to document their reflection as they design and create.

The first design goal, to cultivate reflection, focuses on reflection in the cognitive, emotion and temporal aspects I have described. The second design goal, making reflection constructive, draws on the notion of rich documentation for reflection described in the background section. Making reflection social draws on the social aspects of reflection, both in

relationships between a child and a mentor, and in a larger community of learners.

3 Preliminary Design Work

In my thesis proposal, I presented several design ideas that addressed these goals in different ways. Aspects of each them showed up in my final design. I referred to them as the “reflection toolkit,” and they included the “process trace visualization,” the “process narrative creator,” and “process microblogging.”

3.a Process Trace Visualization

The process trace visualization records detailed information about a learner’s interactions over time with the Scratch application. It includes a tool that allows learners to interactively explore and annotate the “trace” of their interactions.

I considered two ways to record process information: “event recording” and “process snapshots.” The idea of “event recording” is to record user actions in the software at the level of user interface events, such as clicks, drags, and key-presses. Done rigorously, this would make it possible to “play back” a sequence of interactions in the software, and recreate the exact state of the project at any moment in the process. It would also as a side effect make possible an infinite undo system. There are at least two major problems with this approach. One is that it is brittle: as the trace is played back, if the initial conditions vary even a tiny bit, or if a single event is incorrect, the entire state of the project could be distorted (for example, if a sprite is supposed to be created but this event is missed, all future events related to this sprite will create errors). Another is that it would be heavy: the amount of data required to store every action would be quite large, especially if it includes graphics and sounds, and it would

be processor intensive to record all the data. I learned that there is already a system implemented for Squeak Etoys called the “event recorder” and “event theater.” These are designed for creating and editing tutorials to show people how to use EToys. I looked at briefly at the implementation and confirmed my intuition that the problems I mentioned would make it difficult to integrate this system with Scratch.

“Process snapshots” would be a somewhat lighter-weight way to record process information, by storing periodic snapshots of the screen (at intervals of a few seconds, and triggered by user actions so as to capture changes), and selected higher-level data about user events (e.g. block assembly events vs. paint editor events). This version would not have the useful property of being able to reconstruct the exact state of the software, but the problem of brittleness is not an issue, and the data should be somewhat lighter-weight with a good image compression algorithm.

Assuming I would go with the “process snapshots” version, I imagined two modes for the interface that lets learners explore their process, “annotation mode” and “abstract mode.” In the annotation mode, learners can see a view like a film-strip of the snapshots of their Scratch screen over time, and add comments to moments they consider significant. For example, they might see some new blocks appear in their script and write a note about figuring out how to use them.

Annotate your timeline

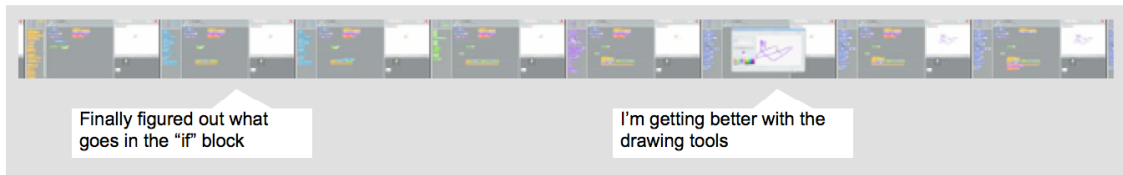


Figure 6: A mock-up of the “annotation mode” process trace visualization

The “Abstract mode” of the process trace visualization combines the periodic screen snapshots with a graphical representation of different types of user events at high level. The horizontal bars in orange in the figure, for example, might represent times during which the person was assembling scripts; the blue ones might represent times the user was interacting with the paint editor. This view could include a zooming functionality, to enable the user to view their process at different time scales, looking closely at one minute during which a discovery was made, zooming out to see the progress during a whole session, and then out again to see the patterns in a whole week of work at once.

Multiple time scales, abstract view



Figure 7: A mock-up of the “abstract mode” process trace visualization

3.b Process Narrative Creator

The process narrative creator is a tool for telling a visual story about your learning process. It would allow you to create something like a comic book, with a customizable character representing the learner narrating in

speech balloons. There would be templates for different layouts for each frame, into which you could drag and drop information from the process trace visualization such as screenshots and text annotations. The templates would also provide scaffolding for the representation of different types of moments in the learning process, such as inspirations, discoveries, and frustrations.

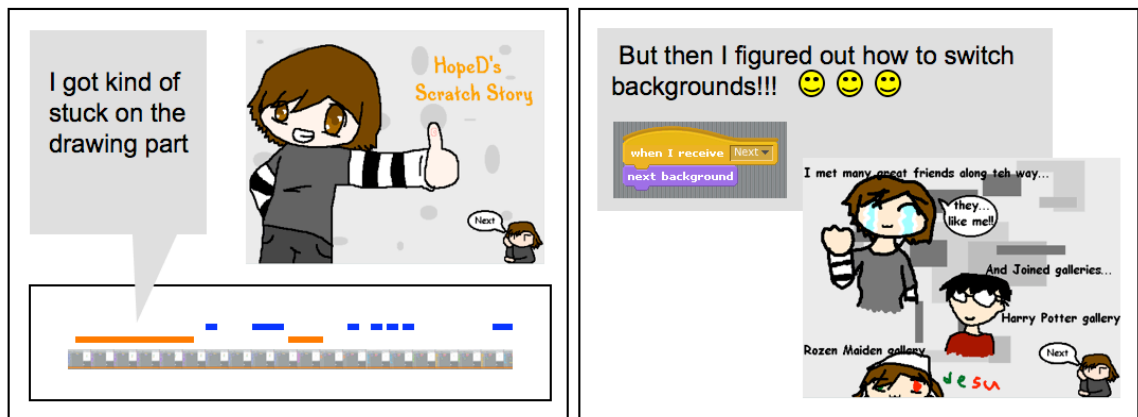


Figure 8: A mock-up of a process narrative comic

3.c Process Microblogging

Process microblogging is the design idea that was closest to what became the Jots system: a system for writing brief textual updates about your progress as you work, with prompts to scaffold writing reflectively, optional image capture of the screen, a way to share these updates on the Scratch website, and a way to view the history of previous updates.

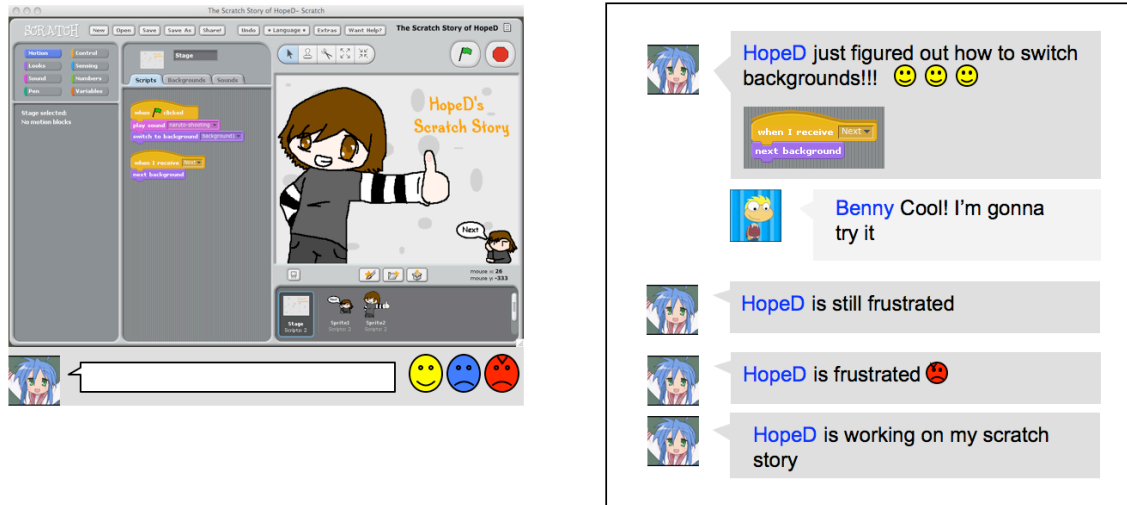


Figure 9: A mock-up of process microblogging

3.d Experiment in Process visualization

I was interested to learn what it would be like to use even a very simple version of one of these tools with a person learning Scratch, as a way of trying out the ideas before doing the technical work to develop a new tool. I was able to do this as part of one of the assignments in Professor Duckworth's course at Harvard Graduate School of Education, "The Having of Wonderful Ideas." The assignment was to practice our skills in field work using Professor Duckworth's Critical Exploration method.

Critical Exploration is an open-ended way for a teacher to work with a learner as they engage with a task, question, puzzle or set of material. The role of teacher is non-traditional, more like that of a mentor or facilitator. They ask questions rather than giving answers. They are careful not to evaluate or judge the learner, mainly providing encouragement for the learner to continue inquiring and finding their own value and meaning. They place a high importance on the learner's own agency in guiding their path through the inquiry process, using their own curiosity as a guide. Critical exploration is not about guiding the learning along a set path,

toward a fixed set of learning goals. Instead its emphasis is on helping the learner feel ownership and empowerment about their own learning.

For my critical exploration field work assignment, I worked with another student (who I will refer to as Katie), in an exploration of Scratch, over three sessions, each about an hour in length. The primary motivations for me were to learn more about critical exploration by trying it in depth, and to learn what it would be like to use Scratch in this way. I was also particularly interested to try an experiment related to the design ideas above, using some simple means to visualize the learner's process, and see if it is useful for them to look at it as they work.

Rather than develop a new software design to record process information, I decided to simply record "screen capture" video, showing everything that happened on the screen as we worked, along with audio of our conversation. I recorded each session in this way, and at the beginning of the second and third sessions, we looked together at the video of the previous session.

I'll focus here on an excerpt from my report about our second session that describes what it was like to review the video of the first session, focusing on a single incident. In the incident we are discussing, Katie had been playing in Scratch with a cat and a purple scribble. She wanted the cat to meow if it was touching the purple scribble. I had noticed at some point that, among the other conceptual issues Katie was exploring, one problem was that the color on the "touching color?" block was not exactly the same purple as the purple on the purple scribble. This caused her program (in the figure below) not to work as she expected. Up until this point, I had been carefully resisting my impulse to explain to her several things about Scratch that seemed to be stumping her in various ways, and was rewarded by seeing her figure them out on her own or work around them. In this

case, I gave in, thinking the very subtle difference between the two purples would be very hard for her to discover on her own. I pointed out very briefly that she could change the color on the “touching color?” block by clicking on the color, which would change the cursor to a dropper, which she could use to select the color of her purple scribble. Here’s the excerpt of my report:



Figure 10: A screenshot showing Katie's Scratch program that plays a meow sound if the cat is touching the purple scribble

At the beginning of our second session with Scratch, I started by putting the video of the first session on the screen, for Katie to investigate as much as she liked before diving back into Scratch. I was very interested to see what would happen. Would she be interested, even? What would she (and I) see that we hadn't noticed as it happened? How would this inform the rest of our session?

There was a very interesting moment, after a few minutes of skipping through the video, when we watched a brief segment...We were watching the moment when I “gave in” to my impulse to explain, and told Katie how to change the color on the “touching color?” block. I think we both learned something from watching ourselves and talking about it.

Here is our conversation while we watched the video of the previous session, right at the moment where I am explaining about

the “touching color?” block and Katie starts experimenting with setting the color:

K: Oh, my purple wasn't actually that color purple.

E: I think that's right

K: Oh. I did not catch that when you said that before. I really thought you didn't understand what was going on [laughing]. I knew you did but I-

E: That's interesting.

K: I was just kind of ignoring you and playing around with it.

E: Well, all the better, like, you may as well figure it out yourself, rather than my telling you... And you did, you-

K: I was like, 'you idiot, it IS purple!'... no not really.

Katie's first remark here is the key one: by setting the color on the block to the correct purple, she eventually makes it work correctly. I'm still not sure exactly when she understood that first. Was it during the first session, after she got it working? Or was it not until the moment, watching herself in the second session, that she said that?

It's fascinating to me that she thought I didn't understand what was going on. At that moment (during this conversation in session two) I remember feeling a bit frustrated: why would she not trust in my understanding of Scratch? Aren't I the expert? I want to be trusted in that way! I did recall at some points expressing my own puzzlement about things that we were seeing on the screen, and these were always honest confusions. And those I expressed in order to empathize with her process of exploration, and show her that she was investigating puzzles that were real in many cases for both of us- not just trying to figure out something that I already

easily understood. So maybe my expressing my puzzlement in those cases undermined my “expertness” for her?

Actually, I think what was happening was not so much that. I think her thinking I didn’t understand resulted from her simply not being able to make sense of what I was saying. Why was I giving her advice about something irrelevant? To her, the purple was purple, and the part that was not working must be elsewhere.

So in some sense, it was true that I didn’t “understand what was going on,” because I didn’t understand her understanding of the problem... And it is relevant that she also said she decided to ignore me and play around with it. What I was saying didn’t make any sense to her, because it came from a totally different interpretation of the situation than the one she had. So she couldn’t pay attention to it! Instead, fortunately, she just kept tinkering until she got her program working.

So, assuming that her understanding about the two purples actually arrived in session two as we watched, it was the watching itself that actually helped her put this all together. And for me, watching us watching is what is helping me understand.

The most important understanding I draw from this experience is about the usefulness of a recording of the learning process as the grounding for a conversation about learning. Learning processes are so slippery, and the details so elusive that they can be difficult to communicate about. Having the audio and video gave Katie and me a shared reference point with concrete details that let us be sure we were talking about the same things. It was fascinating for me to see that even in spite of this seeming concreteness, there were still many points of ambiguity. As I noted in the

excerpt above, I'm still not sure exactly when Katie understood about the two shades of purple.

Another useful function of the recording was to help me understand my own development as a practitioner of critical exploration. It was very useful, for example, to reflect on that moment when I lost my resolve not to tell Katie how to do things, and I told her how to use the set the color on the “touching color” block. Obviously this small move had complex consequences for our interaction. Was it a mistake? Should I have held back from that, the way I held back from telling her other things, so that she could figure it out herself? Looking at the recording of the first session (and also looking at the recording of the second session, which includes a recording of us looking together at the recording of the first session) provided a lot of useful context to help me reflect on those questions.

Finally, I might ask how the use of the recordings in these sessions helped Katie herself. Judging by my own experience, I would guess that it helped her understand her own progress in the previous sessions, and that it helped her communicate about that progress. It may have also helped her understand how our interactions were working—as you can see in the conversation I transcribed in the excerpt, we did a lot of interpreting and re-interpreting of our own communication. Using the recording also helped to reintroduce puzzles from the previous session that Katie had been working on, stimulating her to continue on them without my intervention.

4 Jots System Software Design

The software component of the Jots system has two parts: the Jots pane, integrated with the existing Scratch application, and Jots on the web, integrated with the existing Scratch web site.

4.a Jots Pane

The Jots pane sits in the bottom left corner of the Scratch window (see the figure at the beginning of this chapter). It can be collapsed using a toggle button at its top. Its main feature is a text area with a 250 character limit. A menu above the text area allows people to select one of several prompts, which are sentence stems designed to suggest reflective topics for people to write about. The prompts are:

- I am thinking about
- I am excited because
- This is frustrating because
- I am working on
- I am playing with
- I need help with
- I just figured out
- (blank)

The menu defaults to “I am thinking about.” People can use the “(blank)” option if they do not wish to start their Jot with a prompt.

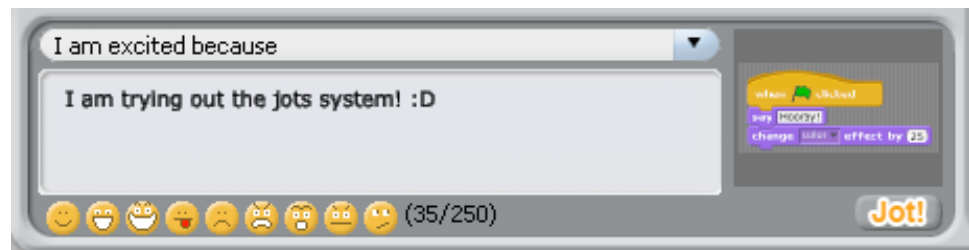


Figure 11: The Jots pane

Below the text area is a row of emoticons, which are small faces, each of which is meant to express an emotion such as happiness, anger, or sadness. Clicking one of these emoticons causes the text field to insert its equivalent in characters (such as :) for a smile). These characters are then converted back into emoticon images on the web site.

To the right of the text area is a small image showing a view of the entire Scratch window, which updates a few times per second. By clicking on this image, people can choose to select a screen region to zoom in on, if for example they wish to highlight a particular script or sprite. The image shown there is uploaded to the web site along with the jot, both in a small thumbnail format, and in full resolution.

The first time in each session that a person clicks on the “Jot!” button, the software asks them for their Scratch username and password. Once they have been authenticated by the website, they can simply click the “Jot!” button to send subsequent jots. Also, their username appears as a link next to the button. Clicking this link will load their My Stuff page on the Scratch web site, where they can see their latest Jot.

4.b Jots on the Web

Once you press the “Jot!” button, the jot appears in a new area I have added at the top of the user’s My Stuff page on the Scratch web site. This area is called “My Latest Jot,” and it is shown in the figure below. This area contains the text of the jot, with emoticons rendered as graphical icons, an indication of how long ago the jot was made, and several links for functions not yet implemented: reply, flag as inappropriate, and delete. The image associated with the jot appears as a small thumbnail, which you can click to see in full size. The “see more” link brings you to a page where you can see a similar display of each jot, in a list running down the page in reverse chronology, with newest jots at the top. If there are more than 20 jots they are divided into multiple pages.



Figure 12: The panel showing my latest jot on the Scratch web site

4.c Infrastructure

Underlying the Jots system is a server that tracks users, stores the jot data for each as it arrives from the Scratch application, and delivers it to the Scratch web site for display. I built this infrastructure using an open-source microblogging platform called Laconica (it can be obtained at the project website, <http://laconi.ca/>).

5 Contexts For Using Jots

The Jots system, as a technological tool, is incomplete by itself. To support reflection, it needs a context for use. Here I discuss the context of “facilitated interaction” in which I used Jots in the empirical study reported in the next chapter, and speculate briefly about other contexts for the use of Jots in private and in public.

5.a Facilitated interaction

In the study described in the next chapter, I worked on an individual basis with each of the study participants. I introduced them to the jot system by modeling its use for them, and asked them carefully posed “reflection questions” (described further in the next chapter) intended to encourage them to use Jots reflectively. I also drew their attention to their past jots in each session, and reviewed their entire set of jots with them at the end. In

this way, I was constantly engaging in the kind of conversation described above in the quotation from Bruner, in which a mentor helps a learner by urging them toward reflection. In particular, these conversations were always grounded by our shared reference point, either in the Scratch project in front of us, or a jot or set of jots the learner had created.

5.b Private and Public use

In the facilitated interaction context used in the study, the jots were private to me and the author of the jot. It was a limitation of the study to keep it simple that I did not attempt to experiment with a larger social context for jots. I could imagine a situation occurring like those in the CSILE classrooms described in the background chapter, where a group of learners look at each other's jots, and engage in a collaborative inquiry process. In the CSILE system (Scardamalia and Bereiter, 1991), students have control over the public or private status of their notes. I could imagine a similar system for Jots, where people could choose at the time of creating a jot, or after creating it, whether it should be viewable only by them, or by everyone. I can imagine numerous benefits for the public use of Jots, which I will discuss more in the final chapter.

6 My Design Process

In the spirit of the Jots system itself, which seeks to help learners reflect by preserving process information about their learning even when it is messy, I have decided to present some of the messy information about my own design process, so that I can learn by reflecting on it, and hopefully others can benefit as well. I present a narrative about my selection of a thesis topic, a fragment from my early notes, an earlier idea for a theoretical framework on reflection, and my own jots from my use of the system as I was developing it.

6.a Choosing a Thesis Topic

I had some difficulty arriving at a thesis topic. During the summer before beginning work on this thesis, I considered several alternate topics which I still think are fascinating, but none were quite right in scope or in conceptual appeal. As I struggled to come up with something that felt right, I had many conversations with fellow graduate students, and with my advisor. These conversations helped me understand my own sense of my strengths and weaknesses, and what I felt I could offer to the world in a thesis project. This was a challenging but very rewarding process. In Professor Duckworth's course "The Having of Wonderful Ideas," she asks students to reflect on their learning in journal entries. In one of these entries, I wrote:

"I had started to think, late at night as I was going to sleep... about reflection. Thinking about thinking. This connected quite well to what I see as one of my personal strengths, which is that I try very hard to understand how people are thinking as they puzzle something out. I also know that this is a topic with a lot of depth, and so I can fruitfully study it... So I began thinking about the importance of reflection in learning processes, and wondered how we could encourage kids who are learning Scratch programming to reflect."

This is my own documentation of my first moments of realization, that reflective learning could be an appropriate and rewarding thesis topic.

6.b An Early Fragment

In my proposal document for this thesis, I included on the cover page a kind of artistic palimpsest of fragments of my notes from the development of the ideas in the proposal. One of these notes reads: "kids can share processes with each other (instructables)— process bundled with

product... way to create a new kind of tutorial?” Early in the process of developing ideas about reflective learning, I became excited about the idea of embedding rich process information in a final product such as a Scratch project. In this way, the final product contains not just a recipe for creating itself, but a whole elaborate messy narrative of how it was created, including interesting failed experiments and mistakes. These negative results are typically omitted from the tutorials that we use to help each other learn, but could prove quite useful. I did not have a chance to explore this idea given the structure of the system I ended up building, and its private context, but I am still interested in this idea and will return to it in the discussion section.

6.c Reference Frames

In a conference paper (Rosenbaum, 2009) written in the midst of my work on the thesis, before I had begun the user study, I articulated a rather different theoretical framework for reflection than the one presented here. I described the idea of “reference frames,” which is a way of mapping out different scopes for thought. In a narrow reference frame, you think only about an immediate task at hand, such as making the brush strokes in a painting. In a broader reference frame, you might plan which part of the painting to work on next. More broadly yet, you might consider the meaning of the painting, wonder what kind of painting you might make next, or why you are painting in the first place.

The reference frames idea was inspired in part by a psychology paper about bulimia (Heatherton and Baumeister, 1991). It describes a phenomenon called “cognitive narrowing,” in which people avoid difficult questions about themselves or their lives by focusing narrowly on the sensory stimulation of an activity like binge eating. I wondered if we might formulate an analogous “cognitive broadening” mechanism, by which people are encouraged to think about those bigger questions. I also

wondered if we could formalize this narrowing and broadening further, by describing specific reference frames through which our thought processes pass.

As I read Schön's work (1995) on reflection-in-action, I thought it could be described in terms of reference frames. In particular, the moves that expert practitioners make as they reflect-in-action seem to be a fluid movement from moment to moment between reference frames, or levels of analysis of a problem. At that point I was seeing the role of Jots as a system to aid in the development of a specific ability, that of making the frame-shifting move under conscious control, the way experts do as described by Schön. I imagined the reflection questions that I would ask the participants in the study to be specifically aimed at encouraging them to make these frame-shifting moves.

As the study got underway and I began to see the patterns in the uses of Jots, I realized that my picture of frame-shifting was not adequate to capture the complexity of what was occurring, and so I have now moved to using the more generalized view in several perspectives of reflection that I presented in the background section.

6.d My Own Jots

As I developed the software for the Jots system, I used it myself. I wrote nearly 300 jots. Many of them are simply testing messages, but a large number are documenting my own learning experiences as I worked. These included many jots about frustration, several about strategizing and setting goals, and a few that show in various ways the value of rich documentation of my development process.

My very first jot was “wooooooooo.” Clearly I was excited to get things working. There are several other early excited jots like this, as I passed small milestones of functionality. The first substantive jot about my development was this one: “alright! I got php parsing JSON, to put micro blog posts onto the Scratch user page, with friendly dates. now I have to figure out some css.” There are a number of technical terms here referring to web technologies, but the important thing is that I was both excited to have gotten several things working, but also overwhelmed by the number of new things, such as css, that I would still have to learn.

6.d.i Frustration

As I began using the jot system myself, I made what seems in retrospect quite a large number of jots about my own frustration. There are 18 jots explicitly about frustration. Partly this is surprising in comparison with the kids in my study, who made only a very small number of jots about their frustration; this might have to do with their knowing I would see their jots, and not wanting to share frustration with me. I on the other hand knew I was jotting only for myself. It is also surprising simply to see how often I become frustrated as I program, because I normally think of it as a challenging but overall pleasing process.

Many of these frustration jots express a feeling of being stuck on a particular programming problem and being annoyed about it, such as: “now on to the next item on the bug list... the layer ordering issue with the posting pane toggle button...bleh”. In addition, some were about feeling overwhelmed: “I am trying to set up the automatic Scratch account verification and Laconica registration system and feeling over my head...” And others were about larger worries than just programming: “I am thinking about what it's going to be like to test this out with kids. feeling a bit nervous about it, but hopeful...” These jots all contribute to my feeling

now of satisfaction at having worked my through a difficult process. It is easy to feel that, just because you have accomplished something, it must have been fairly easy (this is perhaps a version of Bamberger and Schön's wipe-out phenomenon). Looking at these jots, I can remember that it was not easy, but I did it nonetheless. This provides a very positive encouragement for me as I consider taking on new projects that sometimes seem daunting in their difficulty.

6.d.ii Strategizing about goals

I also made several jots about my goals, and strategies for meeting them. Sometimes I got caught up in the details, got stuck, and had to find a strategy to get unstuck, such as simply sleeping on it: "not sure why the first line of the mystuff container is getting indented... time to go to sleep and figure it out tomorrow." Later, I used some other strategies: "feeling stuck. gonna get some coffee and then email some questions to andres." Here my strategies were a break and a change of context (walking up to the café) and asking for help.

Other times I was actively strategizing as I wrote the jot about what to do next, when the right option was not clear: "...It's still not obvious if I should try to write a script that constructs an sb file directly from a template plus images, or invoke Scratch on the server..." In another case, I reflected on a previous strategic decision, and in particular my initial resistance to it: "sweet! the posting pane toggle thing works right now. I had to subclass ToggleButton to make it swap skins in the way I wanted... I was originally resistant to subclassing, since that seemed like overkill, but what the heck, it works."

In one case I was actually reflecting on how jotting itself was helpful: "I am thinking about how its helpful to post about this because I realize I

should try not to get stuck on details, and get things working.” Here I am strategizing about how to adjust my goals so as not to remain stuck on programming details, but also noticing that jotting had helped me do this.

6.d.iii Other uses for rich documentation

Some of my jots preserve process information in a way that is amusingly self-referential. Here’s an example: “I am thinking about whether or not this will be the first successful test of a post longer than 140 characters... whether or not this will b” It is, of course, exactly 140 characters long, because I had a bug in the system. Another amusing example came when I was attempting to create small thumbnail versions of the screenshots that get sent along with jots. I wrote, “I am thinking about trying to make a nice thumbnail for the web...” The associated thumbnail, unfortunately, did not look very nice, or at least not as intended (it came out in black and white, rather than in color, due to an incorrect image encoding). My next jot was simply, “oops...”



Figure 13: A thumbnail created by buggy code

Finally, an unanticipated benefit of reviewing my own jots came when I found this one, about a useful research paper that I had completely forgotten about: “I am excited because I just found a very helpful paper by scardamalia about helping kids reflect as they write. they're looking for evidence that kids can do it on their own, not just with support from a

mentor engaging them in dialog. cool stuff.” I plan now to incorporate this paper into my background section.

6.e My Design Process: Wrap-up

It has been useful in several ways for me to reflect on the processes I went through as I worked on this thesis project. In reflecting on the struggle I went through in choosing a topic, I have been comparing those feelings to how I feel now near the end of the process, which are a degree of satisfaction and pride that would have been hard for me to predict. I have learned that even if the process feels very difficult at the beginning, and even if I feel deeply uncertain and doubtful, by following my sense of what is intuitively meaningful and valuable I can arrive at a very positive outcome.

By looking back in detail at some of my earlier, discarded ideas, and re-evaluating them in the context of my current thinking, I have found new directions for future work. These include my earlier ideas about embedding process in product, and the theoretical concept of reference frames.

Finally, by reviewing my own jots in detail, I found that I was using my own system in richer ways than I had realized. The extensive jots about my own frustration show me what it is really like for me to program, revealing aspects of the process that are otherwise wiped out. The jots about strategizing show that I benefited from stepping outside of my own process to set goals, in much the same way that I hoped the participants in my study would. And the richness of my jots shows that there are many other potentially valuable uses for jots as documentation of learning processes waiting to be discovered.

[4] EMPIRICAL STUDY

This chapter will cover details of the methods used in my empirical study of the Jots system, and my analysis of the resulting data.

1 Research Methods

In this project, my aim was to create, with the Jots system, a new way to support reflective learning as kids design and create. The empirical study was intended to evaluate the design of the Jots system in its ability to support inquiry by kids into their own learning processes as they work with Scratch. This was the first of the three design goals listed at the beginning of the design chapter. The study also addresses the second design goal, which was to make reflection constructive, enabling the creation of artifacts that reify reflection. Additionally, we hoped that the Jots new system would give us a new window in kids' design processes, especially the role of reflection. The study presented in this chapter is meant to help discover what new insights Jots can give us.

1.a Approach

The design of this study draws on two qualitative methods approaches: design-based research and the case study.

Design-based research is iterative, pragmatic, grounded in theory, and integrates multiple methodologies (Wang and Hannafin, 2005). My approach in this work draws on many of the ideas in design-based research methodology. The early design experiments, the single more formal study presented here, and possible future studies make it iterative. It is pragmatic in the sense that I have created an intervention within a software environment that is already in wide use, and would be easily deployed. It

is grounded in the theory of reflective learning, and integrates other qualitative research methods as well.

Case studies are in-depth examinations of an issue within a defined and bounded social context (Creswell, 2006). I am carrying out a multiple or “collective” case study, with three participants, focused on a single concern, which is reflective learning in the context of the Jots system. Having three participants does not enable better “generalization” of the results than one, but it does provide a source of variability for the analysis, so that I will be more likely to encounter a range of interesting phenomena.

1.b Participants

The participants in this study were three students from a middle school in a Boston suburb, all boys in the eighth grade. All had participated in other Scratch activities at the school for several months or more prior to the study and were familiar with the Scratch programming environment and website. My efforts to include a mix of genders among the participants were not successful.

1.c Setting

The study was carried out in a computer classroom in the school attended by the students. Approximately 20 desktop computers were arrayed along the walls of the room. The teacher spent most of the time in an adjacent classroom, and did not intervene except for occasional conversations with the students.

1.d Study Structure

I worked primarily on an individual level with each participant. During each 90-minute session, I spent 20 to 30 minutes with each of the three participants. The sessions are described below. During the time they were not working with me, the other participants were at computers in the same room, working on their own Scratch projects or entertaining themselves with games on the web.

I visited the school on two weekday afternoons per week, over a total of four weeks. This resulted in a total of eight 20-30 minute sessions for each of the three participants (one participant was absent for one of the sessions).

1.e Initial Session

During the first session with each student, I introduced myself and the project very briefly, and we began by looking together at some of the student's existing Scratch projects. I asked a few questions to try to get a sense of the student's attitude toward Scratch, their sense of what they had learned how to do with it so far, and what they might like to work on next. All these questions were grounded by looking together at the students' prior work in Scratch.

Next I launched my experimental version of Scratch, and introduced the Jot system. I introduced it in the style of critical exploration (Duckworth, 1995): rather than explaining or demonstrating the new features of Scratch that I had implemented, I sat with the student in front of the software and allowed them to explore it. I asked open-ended questions such as "what do you notice?" I answered their questions as they came up, as much as possible in such a way as to allow them to find the answers themselves. After this initial introduction, I demonstrated how I use the system,

conveying as much as possible by example the types of uses of it that I was interested in seeing. I then explained that for the purposes of the study the content of the jots is private between me and the participants.

Finally, I handed back control of the computer to the student. As the student worked, I asked questions with the intent of helping students to write jots (see more on these “reflection questions” below).

1.f Subsequent Sessions

We began each subsequent session by reviewing jots from the previous session. Then we transitioned into working on a project. I made clear that we were not working toward a goal of having a completed project by the end of the four weeks. Throughout these sessions, I asked reflection questions.

1.g Reflection Questions

Throughout the sessions I carefully posed questions to the students intended to encourage reflective thinking and jotting. The questions were aimed at encouraging the participants to reflect in both cognitive and emotional ways, and to consider both their past and future work. I describe the reflection question in more detail in the analysis section on them below.

1.h Jot Projects

During the seventh of the eight sessions with each of the participants, I engaged them in a different activity. For each participant, I created a Scratch project with a sequence of backgrounds, where each background contained the text of a jot, and the image of the screen that had gone with

it. These projects were meant to serve as a template for the participants to modify, creating a narrative around their jots that tells the story of their work in our sessions together.

1.i Summative Interviews

An interview session at the end of the four-week study period provided a summative reflective experience for both the researcher and the participants. The conversation was grounded by looking together at the participant's jots collected throughout the study. I aimed to construct, together with each participant, a narrative of the development of their reflective thinking over the course of the study, with details drawn from their jots.

1.j Data Collection

I wrote field notes after each session, and recorded audio and screen capture video during each individual session. I also recorded audio of the summative interviews. All project files created by students, as well as the jots and screenshots they created, were collected for analysis.

1.k Analysis Methods

I used two main approaches to analyze the data collected: meaning categorization and narrative structuring (Kvale, 1996). Meaning categorization involves pooling the data (of all types) across the participants, and gradually identifying common patterns. The narrative structuring was a process of constructing a story about each participant's trajectory toward reflected learning, primarily guided by the summative interview, and enriched by the other data.

2 Analysis

2.a Overview

The most interesting thing that I learned in the study is that kids are able to take a sophisticated view of their own learning process, with some support. In the process of jotting, they documented in rich and varied ways the way in which they worked. Each had a distinct style for their use of Jots. They revealed, through their jots, their debugging and problem-solving processes, their sense of accomplishment, and their efforts to set and meet their own goals. By reviewing their jots at the beginning of each session, and overall in our interviews, they were able to see that they accomplished more than they thought they would, that they used strategies for getting unstuck, and how their emotions changed over time.

2.a.i Jot categories

Looking at the 67 jots created by the study participants, I found that I could divide them into three categories: debugging, accomplishments, and goals (see the table below).

Jots about debugging include descriptions of a problem, hypotheses about the cause of the problem, attempted solutions, and successful solutions. Jots about accomplishments describe something that works or that they have completed. Accomplishments and the “solutions” subcategory of debugging are quite similar. To distinguish them, I’d say that accomplishments are simply reporting or celebrating work completed, while debugging solutions are written in the context of work to solve a problem. Jots about goals include near-term goals, such as what to work on today, long-term goals, and thoughts on how to prioritize goals. Near term goals are similar to debugging problems. To distinguish these, I

would say that near term goals are simply a plan for work, while debugging problems articulate a specific technical issue. Some examples taken from the jots made during the study are provided in the table.

Table 1: Jot Category Examples

Debugging

Problem	<i>I am working on getting a better sprite. Currently Its not so great. Really Really Pixilated.</i>
Hypothesis	<i>it used chan[g]e x and i used move and that might be the problem</i>
Attempt	<i>i tried chan[g]ing touching color and touching line.</i>
Solution	<i>i used 2 different colors to fix the problem</i>

Accomplishments *conditions are DONE!*

Goals

Near	<i>Today I will be doing player animations and backgrounds</i>
Far	<i>if i learn all the basic steps of Scratch i will try to make 3d version games.</i>
Prioritization	<i>first I should work out he bugs and if i have time start synchronizing the tiimes to the songs</i>

2.a.ii Jot categories for each participant

There were differences between the participants in the numbers of jots they made in each category, as shown in the figure above. Eddie made the most jots overall, and the largest portion of his jots were accomplishments. Andy's jots were mainly about debugging. Dave made the fewest jots, and his were mixed. The "other" category on this graph represents jots that did not clearly fit into any of the three categories. They include things like jots about frustration (such as "This is frustrating because magic mana is being a little weird!") and other thoughts and ideas (such as "reducing the duplication makes it less likely for there to be a bug").

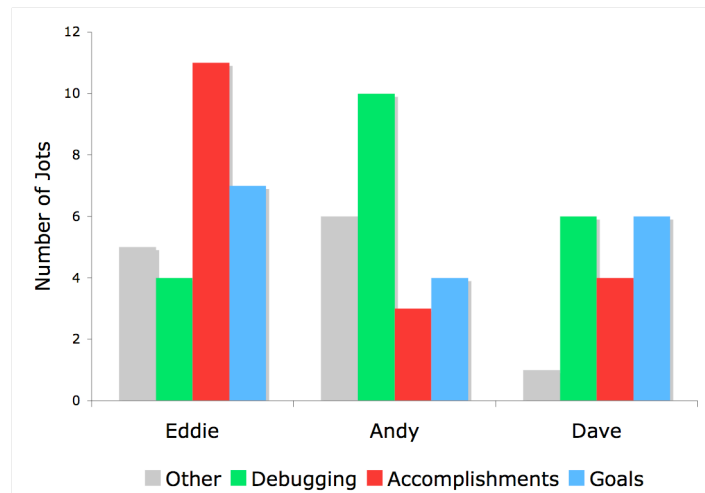


Figure 14: Number of jots per participant in each category

2.a.iii Use of prompts

The prompts, which were intended to scaffold the reflective use of Jots, were used infrequently. Out of 67 total jots, only 8 made use of a prompt. There were several more jots where it is clear that a prompt was included unintentionally (the participant forgot to select "blank") because the resulting sentence doesn't make sense. The prompt "I am working on" was used three times. There was one use each of the prompts "I am

thinking about,” “I am excited because,” “this is frustrating because,” “I need help with,” and “I just figured out.” The prompt “I am playing with” was not used.

In general it appears that the participants wanted to structure the sentences in their own way, and felt constrained by the prompts, so they generally chose the “blank” option. Having the seen the way the participants’ jots fell into categories (debugging, accomplishments and goal setting), I could imagine using prompts that are designed to support those more specifically. For example, two of the jots started with “today I will be doing” and “next time I’m going to,” and either of those would make a good prompt for goal setting.

One of the participants, Dave, had this to say about the prompts in our interview:

“I liked the blank. It’s not always ‘I am thinking about’ or ‘I am wondering about’ thing, it’s like I’m trying to fix the bugs, it’s not ‘I’m thinking about fixing the bugs.’ It’s not the way I’d write it. Another thing you could do is have like an ‘other.’ Like you’d type in starters there, so you could pick them back later, so wouldn’t always have to write them again. Because sometimes people write a certain way the same sentence over and over... So like instead of ‘I was wondering,’ ‘I am trying to’ or like ‘I want to’ or ‘I did this’ or ‘I wonder what’s happening now.’”

Dave is explaining here that he has his own way of expressing his thoughts, and the prompts often did not match it. It could be that Dave is more comfortable writing about his actions than about his thoughts.

2.a.iv Use of emoticons

The emoticons, small emotionally expressive faces that can be added to jots by clicking on them (see figure), were used only a very small amount. I was surprised by how little they were used, thinking they would be popular among the kids. The Scratch web site seems to have a large number of them, though I have not done a formal study of it (I did do a google search for the popular emoticon XD, which indicates excitement by depicting a sideways face with squinting eyes and a grinning mouth. This emoticon appears over 30,000 times on the Scratch web site). Emoticons might become more popular in jots if the jots were public. While kids might not want to use them in writing jots only to themselves, they might use them much more in writing for each other.



Figure 15: The set of emoticons I designed for the Jots interface, representing (from left to right): happy, excited, super excited, tongue out, sad, annoyed, angry, surprised, and confused

Only two emoticons were used in the 67 jots. Both were used in the same session, by Eddie. Here is an excerpt from my field notes:

... he also used the first instance I think among the kids of using an emoticon, a smiley. I had started to wonder about that... I was using them, and the LLK [Lifelong Kindergarten research group] testers had used them, but not the kids! [Eddie] also used another one during the session, a frustrated one (great!).

My guess is that the primary reason the three study participants did not generally use emoticons was a cultural one. All three were to some extent immersed in gaming culture, where emoticons are not popular, and they may have seen them as uncool.

2.a.v Reflection questions

In order to support the participants' use of jots as they worked, I asked "reflection questions" at carefully chosen moments. Initially, these questions were aimed at simply encouraging them to document what they were working on at that moment. Gradually I introduced suggestions to jot about more reflective thinking, such as debugging strategies and goal setting. I hoped as well to encourage the participants to jot on their own, without my suggestion.

For example, in my first session with Andy, after he made an initial jot to test out the system, I made this suggestion a few minutes later:

Me: You know what we should do? We should write a jot about what we're doing right now.

Andy: What should I say?

Me: Well, what are we doing?

Andy: We're looking how to make the person walk [comparing another person's Scratch project to Andy's].

Me: That's good.

Andy: [types jot: we are looking how the other person made it walk smoother]

Later that same day, Andy made another higher level jot, with less prompting from me:

Me: To wrap up, lets do one more jot, so—

Andy: So... I have learned a lot

Me: Like what?

Andy: from the walking [in another person's project] and I want to learn about jumping [then he jots: i lerned a lot from the walking and i want to learn about jumping]

During our second session, Andy made a jot without my prompting as we investigated another person's Scratch project, comparing it to Andy's project:

Me: so, what did you notice about how the walking works in this one that's different from yours?

Andy: It had this part... I never used "if" or none of this stuff... but I don't think you actually need this... but it's still a lot [he jots: "it used chan[g]e x and i used move and that might be the problem"]

Later on, the jots were more often at a higher level (more about the bigger picture, such as goal setting), but still often required some prompting from me to initiate them. Here's an example from Dave, in our fifth session:

Me: Lets jot about these future plans... but let me first quickly check in with [Andy].

Dave: [He jots: I could make many separate games so I can uplaod, because I have too many songs on thins one makeing the file too big.]

In this case, I used the strategy of leaving Dave alone for a moment, hoping to give him some space apart from me to reflect. In this way, I hoped to let him do a bit more abstract thinking about his future goals, without the pressure of my looking over his shoulder. His jot was not very abstract, but it does reflect a new idea for how to structure his project as several smaller projects.

Overall, I found that the reflection questions were generally needed for encouraging the participants to make their jots. I had hoped initially to fade out my use of reflection questions, as the practice of jotting naturally entered their activities. This did not seem to happen, and instead I continued prompting them to jot throughout.

2.a.vi Unsupervised jots

Overall, almost all of the jots were made in the context of participants working directly with me. There were very few instances of jots that were made unsupervised. In session four, Eddie made one such jot, which I describe in my field notes:

[Eddie] definitely jotted while I was working with [Dave], which was great. He made a small modification to marble racer, and jotted describing that. He just added arrows showing which way you are supposed to go— we had talked about marble racer at an earlier session, informally, I think before we got started. I had seen it on somebody's screen, and mentioned that I created it, and that led to a discussion about the fact that you can "cheat" by

*going backward over the finish line and get a very good lap time.
So [Eddie] seems to have followed up on this with a fix.*

Here is Eddie's jot: "I made the example project be a little easier to understand instead of you going across the goal immediately 😊."

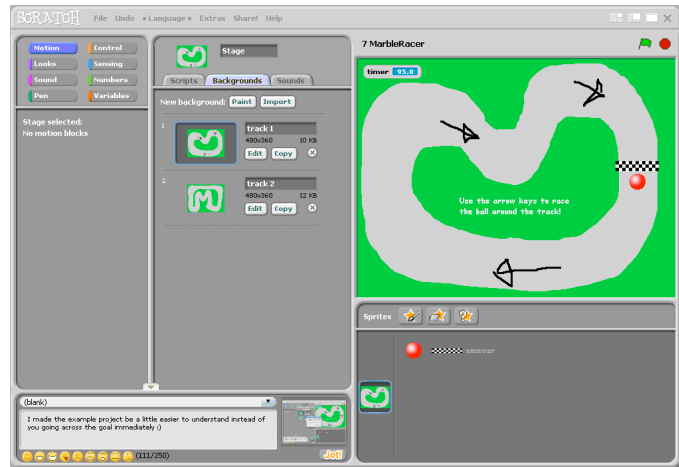


Figure 16: The screenshot associated with Eddie's jot about the marble racer project, showing the arrows he has added to the race course

In session five, Andy also made some unsupervised jots. Here are my field notes:

This time [Andy] jotted a couple times while I was working with [Dave] (who went first). This was pretty cool. The jots were describing a programming problem he was stuck on, which we then solved when we worked together.

While Eddie's unsupervised jot was off of the main topic of our work together, Andy's jots were a continuation of the flow of the work we had been doing the previous time, expressing his confusion about a programming problem. One of Andy's jots was "i don't know why one of

the orange walks on it and the [not the] other.” This is a jot I categorized as a debugging jot, describing a problem. He is trying to figure out why his Mario character lands on one orange platform, but falls through the other. The fact that he made a useful jot outside of our session, which led to productive work in the session, provides a glimpse of how jots could be useful if they are done unsupervised, but this did not happen often enough in the study to draw conclusions.

2.a.vii Jot projects

The use of the jot projects, described above in the methods section, varied somewhat across the three participants. Briefly, the jot projects were Scratch projects containing a sequence of backgrounds showing the participants’ jots along with their screenshots. I provided these in the seventh session for the participants to edit however they wished, hoping they would use the jot projects to construct narratives about their design and learning processes.

Eddie’s jot project emphasized his insider status as a beta tester in the study (see more on this in the case study below). He added introduction and conclusion frames to the sequence, and deleted some irrelevant jots, including the one about the marble racer project discussed above. He also included a “contextualizing” frame, showing a screenshot of Scratch with hand drawn arrows pointing to the Jots pane.

Andy’s jot project was an automated slide show. The opening frame says “thank you for watching my life with Eric teaching Scratch to me,” emphasizing the importance to him of my role in his learning process.

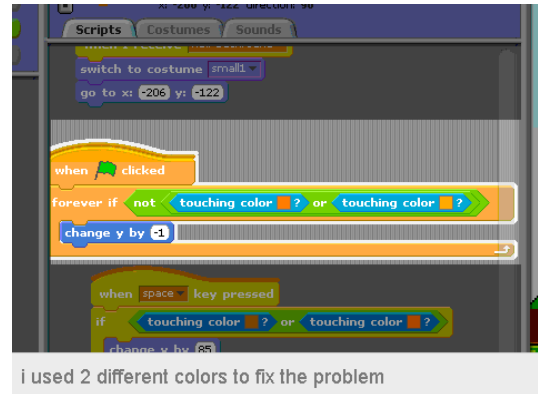


Figure 17: A screenshot from Andy’s jot project, showing one of his jots along with the Scratch blocks he has highlighted

Dave’s jot project includes some introductory frames which he uses in part to advertise the game he has been working on: “These screen shots were taken from my guitar hero game that I will be uploading soon. It is currently too big because of multiple songs. You will be amazed (I hope) by my game.”

2.b Case Studies

The next section will consist of descriptions of each of the three study participants, and an informal narrative account of their progression through our sessions together. The case studies draw on my field notes taken after each session, the jots written by the participants, and audio recordings of each session and of the interviews.

2.b.i Case study: Eddie

Eddie is a tall eighth grader, energetic and quick witted. He seems to have both a nervous energy and an intense focus, anxious to get things working

or get things done. He speaks quickly, sometimes narrating what he is doing out loud. I wrote in my field notes after one of our sessions that he “seems impatient, thinks aloud, kind of narrating his actions in a monotone. I wonder if does that in other situations.” After another session I wrote that he “tends to work fast, thinking out loud, tossing around his code, but not thinking at a very high level that I can tell.”

I got the impression right from the start of our interaction that Eddie is particularly interested in computer games, and immersed in gaming culture. I heard him talking with another kid about a game, and joined in the conversation, comparing it to my experience with the games from when I was their age. I think this helped me gain their trust and comfort a bit right at the beginning of our work together.

Eddie worked throughout our sessions on an “RPG” (role-playing game) style battle game. In his game, the player controls a hero character who is fighting an enemy monster. The player presses a button to attack, and then the enemy takes its turn attacking. The player and the enemy both have “health points,” and whoever runs out first dies. This game format mimics the style of combat systems in popular RPG games. Eddie hoped to create a game that was both playable on its own, and useable by others as a template for creating their own remixed versions.



Figure 18: A screenshot from Eddie's RPG game

Initial meeting: interruptions

My initial meeting with Eddie was a bit tricky for me for a couple reasons. First, as he tried to use Jots for the first time, we encountered a bug in the system that caused his jots not to show up correctly on the web site (I fixed this bug before the next session— it turned out that I wasn't correctly handling usernames with capital letters in them). We recovered pretty quickly from this, and Eddie still got the idea of jotting.

Another thing that made our first meeting challenging was that we were interrupted several times by Andy, one of the other participants in the study, who wanted help with various Scratch questions. After this first session we set better boundaries about our interactions, so that I could work more privately with each of them. We were all in the same room, but I made sure that the two kids who I was not working with at any given time were working at the other side of the room from us, rather than right next to us.

These two troubles set the tone for our time together, in a way, since we often had to make an effort to stay focused in spite of technical problems and interruptions.

Eddie's interest in being an important insider

Eddie was particularly interested in this first session in the new features that were being added to Scratch. I had explained that I was adding the Jots as an experimental addition to a beta version of the software, which would eventually be released as version 1.4. I wrote in my field notes after that first session:

He was particularly into finding out about new Scratch features—when we launched my [version of] Scratch he was clicking around looking for new stuff—this gave me a nervous moment because I thought he didn't think the jot function was interesting. Of course we hadn't talked much about it yet, so I realized I just had to help him focus his attention on it. This worked pretty well.

Later, while completing the Scratch project containing his jots, he wrote this in the project notes: "My beta test of Scratch 1.4's possible feature: Jots!" He is emphasizing the fact that he is using version 1.4 and that he sees himself as a beta tester. He was excited to see himself in this role, perhaps enjoying the feeling of its importance.

Eddie also expressed this interest in being an important insider in our interview after the sessions, by talking about a hypothetical role for jots, where they could serve as a public "game developer's blog," like ones he has seen in the gaming communities he participates in online. These game developer's blogs are accounts by professional software developers and game designers, showing details of games in progress before they are released. These blogs are particularly interesting to Eddie, who plays the games but is also working on making his own games.

He made the leap, in our interview, to imagine that jots, if they were viewable by the public, could serve as a kind of game developer's blog for

him. In this way he could use Jots to show people the progress on his Scratch game as he works, before sharing the game on the web site. Here's what he said in the interview:

"You could tell people about what you've been doing... and they could see like progress... so they could see how games are going... so they have like a whole developers blog plus pictures... you could make a developer blog."

This was an interesting moment, but does it count as reflective learning? Eddie is imagining himself in the role of a professional game developer, which presumably affects the way he sees his own progress as he develops games. Using the jots in this way as a different lens onto his own processes as he learns to program may have changed the way he was thinking about his own learning. Perhaps, by comparing his process to an expert's process in this way, he could see that not just accomplishments but also moments of frustration and being stuck are all valuable.

Eddie's jot timeline

The timeline below shows the sequence of Eddie's jots in each session, divided up by the categories described above.

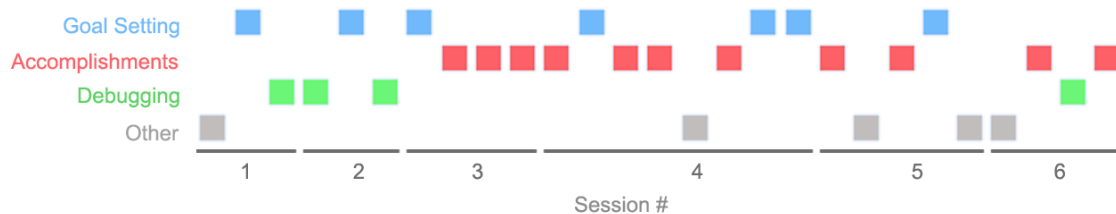


Figure 19: Eddie's jots over time

This timeline reveals mainly that he made lots of jots about his accomplishments (as you can also see in the graph above of number of jots per participant). We can also see on Eddie's timeline that in the early sessions there was more focus on debugging. He wrote during our second session for example "I am working on getting a better sprite. Currently Its not so great. Really Really Pixilated." You can see the pixelated sprite he is referring to in the figure below, which is taken from the image that he selected to send along with the jot. This is not debugging of a program in the ordinary sense, but it does identify a technical problem that he would like to solve.

From the third session on, there are numerous jots about his accomplishments. For example, "...Moving system now works! Sprite for Bone has been fixed. Next to work on player healing attack." In the figure below you can see his improved version of the formerly pixelated sprite for "Bone" (a skeleton character). He had fixed the pixelation by re-importing the image, taken from a free game sprites web site, cropped so that Scratch did not need to scale it down.

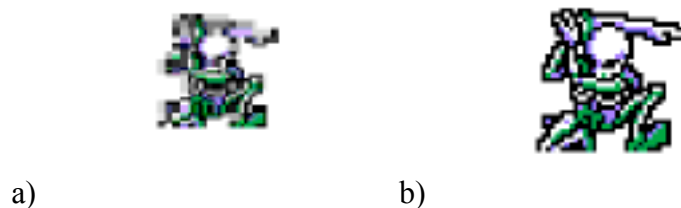


Figure 20: Eddie's skeleton sprite a) before and b) after fixing the pixelation

The shift over time in Eddie's jots toward accomplishments seems to reflect a change in his use of jots more than a change in his behavior

during our sessions. He was doing plenty of debugging throughout, but after the first couple of sessions he jotted mainly about the things he had gotten done or gotten working. I think this is because he started to see the usefulness of Jots mainly in terms of helping him record his accomplishments.

Eddie's focus on accomplishments

It seems that for Eddie one of the most important aspects of jotting was the way they could be used to see how much he had accomplished over time. Many of these are excited or celebratory, like this one: “conditions are DONE!” and this one: “I am excited because Attack Sprite now done!” In another jot, we can also see his sense of an imagined audience for his jots: “Sprite for main character done! Take a look!” Here he seems not just excited that he has gotten the sprite done, but also excited to share it with other people. Of course, he knows that only he and I will be seeing his jots for now, but the idea of an audience is still powerful for him. Perhaps he is imagining a role for himself like that of the writer of a game developer blog mentioned above. I will return to the idea of an audience for jots later in this chapter.

In our interview at the end of our sessions together, I asked Eddie what he noticed about his jots, looking over them as a whole (I had printed out the sequence of jots on paper for us to look at together). He said he noticed, “that I got a lot of progress done over the past four weeks... I got a lot of things done, it was a lot more than I would imagine. I was thinking I would only get maybe up to maybe two weeks ago about ... here [he points to a particular jot].” I also asked Eddie if the way he was feeling as he worked changed over time. He said: “I felt like I was getting lots done over time. Much more than I thought I would. And I felt good about myself for getting so much work done.” By looking back at his jots about his accomplishments, Eddie saw how much he was able to do in our short

time together. He points out that he did more than he thought he would be able to. Perhaps from the experience of reviewing his jots at the end of our sessions together, he learned something positive about how much he is able to accomplish.

Eddie and frustration

Two of Eddie's jots expressed frustration. One, from our fourth session, came when he was stuck on a tricky bug getting the game to end correctly when the player's character dies (he has used a "stop all" block, which stops all running scripts, but the "when sprite clicked" blocks still work after this has happened, so you can continue playing the game). Here's the jot: "Ugh death sequence isnt killing the game 😞" He used both the exclamation "ugh" and an emoticon (one of only two emoticons used in total) to express what must have been very intense frustration.

In our interview at the end of the sessions, we talked about this jot as we were looking over the whole sequence of his jots. I noticed that Eddie read almost all of them out loud, but he skipped over this "ugh" jot. I asked him about it:

Me: What was happening here [pointing to the jot]?

Eddie: When you died it wouldn't do anything you would just be dead and then you could attack again and then you'd just attack again and then you could just attack again and then you could just attack again and the enemy would go under and he would just keep attacking relentlessly.

Me: So what was that like? You wrote ugh and you used an emoticon. Why did you do that?

Eddie: It was really annoying because I had to do like a stop script and that really annoyed me. And since the stop script never worked in the first place I was like what? And it just really just annoyed me because I stopped everything, it means it shoulda just killed everything but it still didn't kill everything. And that's why I wrote that.

In our interview, weeks after Eddie had found and fixed this bug, he couldn't help but re-experience his frustration over it, as can be heard in the way he uses repeated phrases and expresses his annoyance. I imagine, though this is just speculation, that it would have been hard to find a way to recapture this experience of frustration without the jot there to cue it for him. The creation process is often smoothed out in our memories, and these messy or painful parts are lost, as in the wipe-out phenomenon described in the background chapter. This jot helped to bring Eddie's experience of frustration back into his awareness, enriching our conversation about his learning process.

The other jot about frustration came in our sixth session, when he was stuck on another tricky programming bug, to do with the way a variable is being set using a sequence of "if" statements. He wrote, "this is frustrating because magic mana is being a little weird!" Here he actually used the prompt "this is frustrating," the only time it was used.

Here's what I wrote in my field notes about this sixth session:

[Eddie's] session was short, only about 15min, because I had gotten behind schedule, but high energy. He still seems impatient, thinks aloud, kind of narrating his actions in a monotone. I wonder if [he] does that in other situations. He had a bit of a weird interaction with [Andy] where I was worried that he had insulted

or intimidated [Andy] (who is smaller and less assertive). I don't remember exactly what he said- I think [Eddie] kind of ordered [Andy] around a little bit, as they were transferring files. [Eddie] was also on the edge of frustration this time, getting upset about problems where his file wouldn't transfer properly (there were no crises with lost files, though).

This scene makes it clear that Eddie was particularly frustrated that day. I do not have field notes on it, but I know that there was at least one incident later, on the day of our interviews, where Eddie had been bullied by another kid at the school. The teacher I was working with helped him report the incident to the school administrators, but he was so upset that I decided not to make him do the interview that day, and instead came back to interview him on another day. It seems likely that the bullying was ongoing before then. So perhaps on certain days Eddie came into our sessions a bit upset by it, and expressed this upset through frustration with Scratch.

So did Eddie learn something about himself, in seeing his own frustration in retrospect? I tried to get at this in our interview:

Me: I noticed that you used the word annoying a few times, and in your jots you have the word frustrating.

Eddie: Because that would tell me, I did that when it was really hard to do, when I had a problem. With the scripting.

It seems that Eddie was able to see that he could overcome even very difficult challenges, in spite of his frustration. Here is a frame from his jot project, summarizing all of his jots:

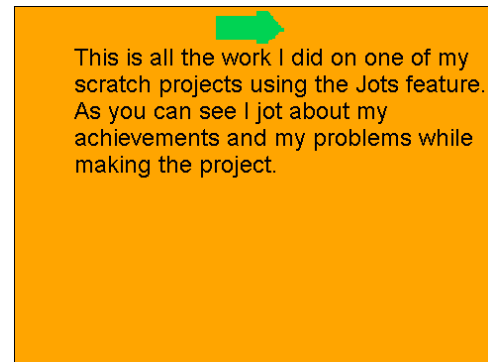


Figure 21: A scene from Eddie's jot project

As you can see, Eddie's summary of all of his jots puts equal weight on the achievements and the problems he had as he worked, showing that he was aware of the importance of those moments of frustration. Perhaps his focus on accomplishments also heightened his attention to obstacles to achieving those accomplishments.

Case study of Eddie: wrap-up

Eddie's style in making jots was mainly to focus on his own accomplishments. It seems likely that this emphasis comes from his desire to feel important, and an insider, like his role models in the gaming community. This focus on accomplishments also helped him see, in our summative interview, that he had gotten quite a bit done in our time together, and that it was more than he might have expected. He also jotted about his frustration as he worked, and was able to see the importance of this in his learning process in retrospect.

2.b.ii Case study: Andy

Andy is a small, intense eighth grader. He speaks somewhat quietly, and English is not his first language, but his complex and thoughtful ideas come out when I give him space and ask him the right questions. He is a

bit clingy, often coming to me with questions during my sessions with the other kids, or after we are done, so that I have to carefully redirect him. He has an intense focus on making things work in a particular way that he has imagined, which helps him keep his attention on a task.

Andy worked during our sessions on his own version of the classic game Super Mario Brothers. He used graphics and sounds found on the internet to make it look and sound exactly like the original. Most of the work we did was in trying to use programming techniques to make the game dynamics work like the original: making Mario walk and jump while the player controls him, land on top of platforms, and change size and movement speed when he gets a special mushroom.



Figure 22: A screenshot of Andy's Mario game

Andy's jot timeline

This timeline shows Andy's jots over the course of our sessions together.

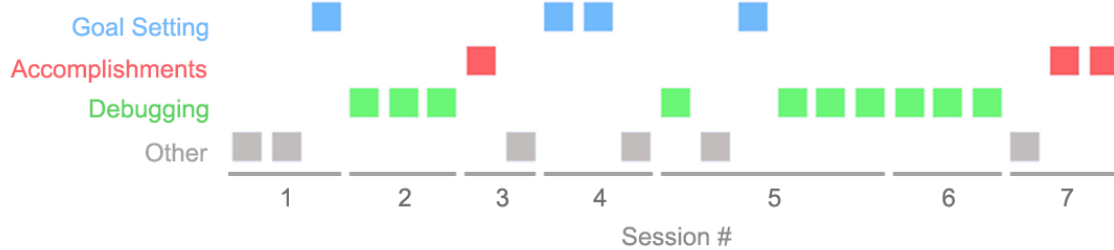


Figure 23: Andy's jots over time

Andy's jotting emphasized debugging processes, especially toward the end. The two initial jots, in the "other" category, were a question and an observation about another person's Scratch project: "how do i jump on the mario game" and then "we are looking how the other person made it walk smoother." These two questions point to an area that dominated much of our time together: figuring out how to program Mario's movement. The many debugging jots were all various hypotheses and attempted solutions to movement problems. The final debugging jot on day six was a successful solution: "i figured out that if touching mushrum you have to set big or small." Here he has learned how to use variables, a new concept for him, to represent Mario's change of state when he touches the mushroom, so that Mario can become larger and move faster. In the final session, we see two accomplishment jots: "i fixed my problem by trying things out" and "i fixed everything and i am happy about it." These arose from a very rich interaction we had around being stuck and getting unstuck, which I describe below, with the jots showing only the final outcome.

Andy and critical exploration

In an earlier chapter of this thesis, I describe critical exploration, Duckworth's (1995) method for teaching. Briefly, it involves allowing a learner to make their own choices, ask their own questions, and arrive at their own answers. As I worked with Andy, at first it was a struggle to use

the method with him, because he wanted to be told the answers. But by the end of our sessions together, he understood what I was doing with him, and described it in his own words in our interview.

In our early sessions together, I noticed that it felt particularly challenging to try to do critical exploration with Andy, and I wrote about it in my field notes. Here are my notes from our second session:

Again this time he stayed next to me, and wanted to keep asking questions as I worked with the other kids. I tried to hold him back from interrupting without shutting him down- another tricky balance.

Andy was anxious for my help, but I couldn't work with him while I was working with another one of the kids. This was a sign that, at first, Andy wanted to depend on me as a source of knowledge, rather than depending on himself. Here are some notes from our third session:

The challenge with [Andy] will be to encourage him not to rely on me to give him the answer. He seems to have learned that way of interacting with teachers. He is a bit impatient, and really wants to learn how to make his mario jump... If I had had an hour with him we might have gotten closer to it [figuring out how to make Mario jump using simulated gravity], but as it was, he kept making small changes and then looking to me to ask why it didn't work. I hope next time to help him experiment more independently. The trick will be not telling him the answer, but asking the right questions that get him asking his own questions in a fruitful direction. Looking forward to that.

As you can see, I was having some difficulty in using critical exploration with Andy in our first few sessions, because he had an expectation of me that was different: that I would help him by telling him the answers, which was exactly what I was trying not to do. Nonetheless I felt optimistic. Gradually, we fell into a pattern of working together where I was able to ask questions of Andy that helped him understand his own questions, and arrive at the answers himself. After our fifth session together, I wrote this in my field notes:

I felt like I was asking him good questions, not leading into the answers, but encouraging him to investigate himself. I did sometimes encourage specific strategies (like reading a stack with some Boolean logic aloud in order to think through what its meaning is), so I was guiding a bit, but without even modeling in that case or giving any answers. [Andy] seemed very engaged, and very satisfied when he got solutions to this and a couple other puzzles we came upon.

And after our sixth session:

I felt a strong tension between explaining and trying not to explain. I think the outcome was good though, because the tension was brought to the surface by [Andy]— he made a comment about how he knew I would not tell him the answer (even though he wanted me to), but instead I would ask him a question. So he was recognizing my strategy, even though he also felt a tension with it. This moment also allowed me to say something about how my goal for the strategy was that, since he is the one finding the answer, he would be able to do it even without me there. I think he understood this. Now that we have worked together in this way over several sessions, I think we have got beyond his early

frustration with my approach, and he is now closer to having an explicit idea of the usefulness of the critical exploration style I'm using. I think!

By the end, Andy had his own understanding of the critical exploration approach I had taken with him. Here's what he said about it in our interview:

Me: What was it like working with me?

Andy: It was fun, you helped me, and when I got stuck you didn't say. You tried to make me learn how to do it, and that was good, and I learn now, I never forget. If you said it, I would have forgot it.

Here he is explaining in his own way that when he got stuck I “didn’t say,” meaning I didn’t tell him the answer. It was wonderful to hear him say “I never forget.” Not only did our critical exploration together result in what felt to him like powerful and enduring learning, but he also understood what was happening at a more abstract level. He learned something about his own learning: that he could arrive at the answers himself. He jotted in our final session, “i fixed my problem by trying things out,” and “i fixed everything and i am happy about it.”

Andy and variables

As we worked on getting Mario to jump, we encountered the question of how jumping works. We investigated some other projects to see how they had done it, and this led eventually to an exploration of variables. Initially, I got excited about showing Andy the way to simulate gravity, and how to use that to simulate jumping, but later I realized we would have to start

much more simply because the concept of variables was new and challenging for him.

As we began this exploration, I wrote in my field notes for our second session:

I feel like I want to work with him for a longer period, so we can get deeper into things like how to use variables to represent velocity (which is useful for a physics-based jumping system, but which he doesn't seem to know about yet).

In the following session, I came up with the strategy to help him learn about gravity by showing him a simplified example, in one of the sample projects that come with Scratch:

He is a bit impatient, and really wants to learn how to make his mario jump. I thought carefully about a good pathway into figuring this out- while it's not a lot of code, there are lot of concepts. One key idea is using a velocity variable and constant acceleration to model gravity. I tried to simplify things down by switching over to have him look at "gravity blocks," the sample project, which actually does not use gravity— I thought we might incrementally add it in.

It was not until a few sessions later, in our fifth meeting, that I realized that the very idea of variables was part of the challenge:

We ended on a kind of cliff-hanger to do with using a variable to set mario's speed— it made me realize he does not have much concept yet of how to use a variable. I think earlier when I was trying to explain physics of jumping to him I was trying to go too

fast, and he wouldn't have been ready anyway— he needs to get fundamentals about variables first I think.

From this point on, we made much better progress, focusing on simpler uses of variables that made sense to Andy. His three jots in session six were all about the use of variables. First he wrote, “i used the varivle speed to put set speed on to the left and right.” Here we are using a variable to represent the speed at which Mario walks. Originally it was represented as a number, but we wanted to make the speed change when Mario gets big because of the mushroom. The “left and right” in the jot are two sections of code handling Mario’s movement in each direction when you press the arrow keys, both of which needed to refer to the speed variable. Next he wrote, “we used set speed to 10 and the direction for only speed.” We can see from the screenshot that was uploaded along with the jot (which you can see in the figure below) that he is using “set speed” to change the speed when Mario touches the mushroom. Finally, he wrote, “i figured out that if touching mushrum you have to set big or small.” This is a distinct use of a variable, to represent one of two possibilities, rather than an amount (like a speed). The variable “big or small” contains a zero if Mario is small, and a one if he is big. This allows the program to react in different ways depending on Mario’s size. It’s clear from Andy’s jots in this session that he has made a leap, from very limited understanding of variables to using them in two different ways correctly in his program.

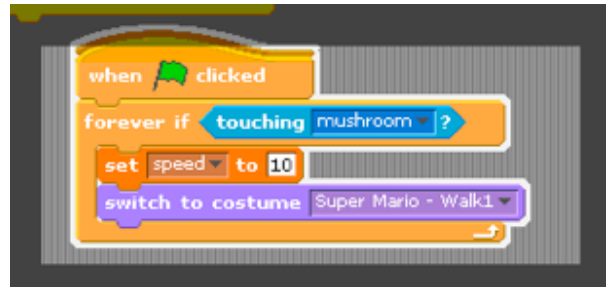


Figure 24: A crop of the screen shot associated with the jot about using “set speed,” showing the region Andy has highlighted

Andy and getting unstuck

In our interview, Andy and I had a conversation about what it’s like to be stuck and then get unstuck. By looking together at his jots, we reconstruct what Andy was thinking and feeling in our final session, when he encountered a very frustrating moment when nothing worked, but then overcame it.

Andy: [Reading a jot] “Everything is messed up.”

Me: What was happening there? That was on our last session I think, right?

Andy: Yeah. I don’t know what happened that time. Everything got stuck.

Me: Yeah.

Andy: But when I went to my home computer, it went all worked fine.

Me: Well, I remember there were more things that happened on that day.

Andy: [Pauses for several seconds] It was... the mario wasn't jumping. The things were staying and stuff.

Me: Yeah. So but then what did you write?

Andy: [Reading a jot] "I fixed my problem by trying things out." That was the part when we had the broadcast. Instead of new background we did start and everything worked fine.

Me: Ah. So by trying out a few different changes...

Andy: And [Reading a jot] 'I fixed everything and I'm happy about it'

Me: So, how were you feeling during that session? Do you remember?

Andy: [quietly] I was sad.

Me: You were sad?

Andy: Yeah,

Me: Do you remember why?

Andy: Because all that work was for nothing.

Me: But was it, in the end, for nothing?

Andy: No. And it was fun.

Me: Oh good. So you kinda felt bad, and then you felt better. That's good. Does that happen other times?

Andy: Sometimes. When I make Scratch, or when I type like three pages of work and then I press something key and it deletes everything.

Me: Oh, I hate when that happens!

Andy: And I don't save. But now, every single sentence I save.

Me: That's a good idea. But it's also important to remember that, even when you feel like this, everything is messed up, you're still eventually gonna get here, you'll be happy about it.

Interestingly, at the beginning of this dialog, Andy seems to think that the resolution to his frustration had not happened during our session. Everything worked fine when he got home afterwards, to his surprise. But as we look at the jots, it becomes clear to him that he resolved the problem himself, by trying things out and eventually fixing the bug.

Case study of Andy: wrap-up

Most of Andy's jots were about debugging, because much of our work together was grappling with ideas that were just at the edge of Andy's comprehension, mainly to do with variables and getting Mario to move and jump. These debugging sessions were fruitful, as the jots and our interview at the end show. Andy came to understand the critical exploration style that I was using, and felt that he was learning in a powerful way because of it. He also managed to learn how to use

variables in a sophisticated way, and overcame a time of frustration in order to get his game working the way he wanted.

2.b.iii Case study: Dave

Dave is a clever and sometimes sarcastic eighth grader. He would often make strange jokes, perhaps trying to impress me with his sophistication. For example, in our interview, I opened with a question about what it was like to work with jots. He replied by singing a line from a song by the band “The Who,” called “Behind Blue Eyes,” that goes “no one knows what it’s like.” Was he really implying that his experience of jots was lonely and completely individual, not available for understanding by others? Maybe, maybe not. At least, I can recognize this theme from my own experience of middle school, and see how he might relate to the song.

Dave worked during our sessions together on his own version of the game Guitar Hero. Guitar Hero is a video game in which the player holds a game controller in the shape of a guitar, with several colored buttons on the neck. As a rock song plays, they watch the screen, where colored discs slide from top to bottom. When a disc reaches the bottom, they must press the matching button on the guitar. If they do, they hear the corresponding note in the song plays. By perfectly playing all the notes, you can recreate the original song. Dave’s version mimicked some of this functionality, but it is controlled by keys on the keyboard, and the discs arrive at random times rather than being synchronized to notes in the song.



Figure 25: A screenshot from Dave’s Guitar Hero game

Dave’s jot timeline

Dave made the smallest number of jots of the three participants, and his were the most balanced in the mix of categories of jots used. One distinctive feature of his jot timeline is that in every single session but the last, he made a jot about goal setting. This seems to have been because he both struggled with and benefited from our conversations about setting goals in his work.

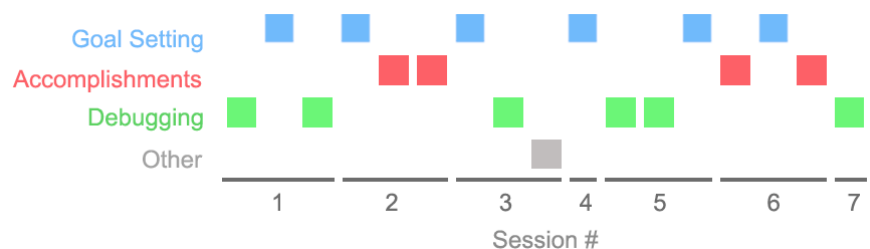


Figure 26: Dave’s jots over time

Dave and setting goals

Dave used a jot in almost every session to write about his goals, and he also spoke in our interview about the ways in which setting goals for his

work was useful for him. He was able to set near term goals, but thinking about larger goals was difficult for him.

In our interview, Dave spoke about how setting goals made his work easier and more fun:

At first it was hard, for the programming and everything, it started out kinda hard, cause I thought I was done, like not really done but I mean I definitely knew I had more to do I just didn't exactly know what I was going to do or I didn't have any ideas planned and then definitely near the end it got a lot easier and a lot more fun as well cause I knew what I was doing, I was creating something new and I had a plan of what I was going to do.

He also compared what it had been like to work without explicitly setting goals, in other situations, to what it was like to work with jots:

I set the goals of what I was going to do, and in what order. Because when I don't have anything, I'm like, hm, maybe I should do this, oh well, it's not working that well, maybe I should go with this, and I flipped around and I never really got anything done. Sometimes I did but not as efficiently as when I set a plan.

Here he compares “flipping around” without a plan to working with jots and setting goals, which makes him more work efficiently.

As we reviewed his sequence of jots in our interview, Dave described the development of his plan for his work as a “the start of a flowering agenda.” This seems to be one of his ironic comments, at once sarcastically diminishing the importance of his planning, and pointing to its actual importance to him. He also spoke about his uncertainty in the

planning process in choosing between alternative plans, showing the sophisticated level at which he was making decisions.

Other than that we didn't do much, just the start of a flowering agenda... cause that was the first time I started laying out a plan for myself, whereas I did it more later. See then right here, I did it again [reading a jot] "synchronizing the times to the songs should be before synchronizing the notes to the songs."... Because it was easier. Not only that, but I wasn't sure at that point if I still wanted to do the notes to the songs, cause I had made my own version of it where it's random and it's always different and I remember we were debating about that.

At the halfway point of our work together, in the fifth of eight sessions, Dave and I reviewed all of his jots up to that point. One comment that Dave made was that looking at the jots showed that he had made progress. Interestingly, to him progress meant both work accomplished so far and the start of ideas for the future.

Me: I'm interested in your observations about your jots from before. What did you notice as you read through it, and what does this tell you?

Dave: That we've made some progress.

Me: In what way exactly?

Dave: Cause we've gotten rid of some of the bugs that were happening, and we've started to think about some of the ideas that are going to happen in the future, after we finish the bugs that are happening now.

In that same fifth session, I wanted to try to help Dave articulate his long-term goals more:

Me: Before we dive into it lets just talk about the big picture a little bit more.

Dave: I think the big picture would be to upload this and make it a very good and popular game that many people view and use.

Me: What would your strategy be for trying to make it popular?

Dave: Kindof the reason I made this is that a lot of people like guitar hero, and therefore people might like it in Scratch. I know there's a lot of other ones, but most of them either don't work very well, have many bugs, or don't have very good variety.

Me: So by creating your own unique twist on guitar hero, you might grab people's attention.

Dave: Yeah.

Me: Is there an even bigger picture?

Dave: What do you mean?

Me: ...What are some other reasons you might be interested in working with Scratch or in doing this kind of thing, making games, learning to program, over time?

Dave: Ah, I don't know

Here, Dave is able to articulate his larger reason for wanting to make the project, which is get recognition and popularity in the Scratch community, and his strategy for accomplishing that. But at the same time, he is not able to think in a broader way than that about what even larger goals might be. In a way, with my questions about the “even bigger picture” I was fishing for him to say something about his goals for his own learning, but he did not. Either he had these goals on some level, but was not able to identify and articulate them, or they simply did not exist for him. It’s hard to know. It may be that kids have an easier time reflecting on their design processes than on their learning processes, which are even more abstract.

Dave and switching gears

In our interview, Dave described his experience of switching gears, changing from one task where he felt stuck to another where he knew he would make progress:

We never pinpointed it [a particular complex bug]... since we couldn't do that we moved on, cause we don't want to get stuck on that forever, not getting things done, so we moved on to personalizing the times to the songs, which was actually pretty easy.

Looking at one of his jots about goal setting was what cued this conversation. Dave was also able to generalize, comparing this experience to a strategy he has been taught to use on standardized tests:

That's what they tell us to do on the MCAS or other tests, like if you don't know this, then go on and do the stuff you do know and then come back to it.

It may be that having the jots about goal setting in front of us enabled us to have this meta-level conversation about Dave's strategies for getting unstuck, and that our conversation helped him generalize and reinforce his understanding of them.

Dave and me

Dave's relationship with me as we worked together seems to have been somewhat different from my relationship with the others. This quote from our interview casts doubt both on my success in doing critical exploration with him and on his feeling of agency in setting goals for himself:

Dave: I mean you definitely helped me out... you gave me ideas of what I could do and how I could do it, and that definitely helped. Cause I thought I was at a dead end but actually there was a stairs right in front of me.

Me: How did you find the stairs?

Dave: You showed me the way [laughter].

The metaphor of the stairs, and my showing him the way, seem to be another of Dave's ironic moments. He is perhaps suggesting that I was guiding him in a powerful and almost magical way, and at the same time mocking this idea. I certainly felt that I was trying as hard with him as with the others not to guide him or give the answers, but to let him lead. So perhaps I did not succeed as well with him. Another possibility is that Dave was trying to tell me what he thought I wanted to hear: that I was important in the process, and in guiding him.

Case study of Dave: wrap-up

From Dave's sometimes ambiguously ironic comments, it can be hard to interpret plainly what happened between us. Nonetheless, it is clear that setting goals was for Dave an important part of the experience of using jots and of working with me. He set near-term goals using the jots, and carried them out. The jots helped him strategize, choosing between alternate possibilities and "switching gears" in order to get unstuck. The idea of longer-term goals was still somewhat elusive in the context of our work together.

2.b.iv Case studies: wrap-up

Here I will explicitly relate the case study results to the theoretical framework for reflective learning presented earlier in this thesis. Each of the participants clearly benefited from cognitive aspects of reflection, mainly manifested as debugging and goal-setting activities. The jots helped to reinforce these activities, making the participants both more aware of them in the moment and in retrospect. There was also some emotional reflection, as shown in the jots with affective content such as excitement and frustration. Both the explicit description of these emotions, and their discussion in retrospect, constituted emotional reflection. The social aspect of reflection was borne out in the mentor relationship I had with each of the participants. The use of jots also addressed both temporal scales of reflection: the act of jotting can be seen as contributing to reflection-in-action, and reviewing them (at the beginning of each session, in jot projects, and in the interview) can be seen as reflection-on-action. All three participants experienced a mitigation of the "wipe-out" phenomenon, as we reviewed their jots at the end and recovered messy but useful details of their learning processes.

All three of the ways discussed of making learning reflective were also observed. Though it was not a focus of the analysis in this thesis, the externalization of thought processes as Scratch programs was likely beneficial to each participant in understanding their own thinking. The fact that we were directly engaged throughout in a process of design and creation gave us rich context for a reflective conversation with the materials. And the mentor relationship I provided was crucial to the reflective use of jots.

2.c The Many Uses for Jots

I found over the course of this study that there were numerous distinct uses of the jots. I will describe them here in these categories: uses of jots in the study, other uses imagined by kids, and other meta-level uses.

2.c.i Uses of jots in the study

As discussed above, most jots fell into three categories: debugging, accomplishments, and goal setting. There were several other uses of the jots in the study. Here I will describe the uses of jots as a memory aid, as a conversation with yourself, and as emotional expression.

Memory aid

A useful function of Jots that was frequently mentioned by the kids in our sessions and interviews was as a memory aid. At the beginning of each session, we would review jots from the previous time, which often helped them quickly focus on what they had last been working on a few days before.

In our interviews, I asked each of the participants to say how they would describe Jots to someone else who had not used it. All three primarily talked about its usefulness as a memory aid:

Andy: “A jot is something that you put on your site that you could remember what you did... and next time when you open your Scratch you would remember what you did and where you left off, and not worry about which sprite I was in, what was I gonna do next.”

Eddie: “You would just go to the site and get a recap of what you did, the last time you did something.”

Dave: “It definitely helps you remember what you were doing last, what you have to do, and actually puts it down, because a lot of people don’t want to take the time and write down on a piece of paper and put it in your pocket and have to remember to bring it with you next time, whereas with Scratch with jots, you can go ‘oh that’s what I was working on, oh yeah, I remember that.’”

For each of them, there’s a clear usefulness to simply getting back to where they left off. I definitely suggested this use explicitly to them, by structuring our sessions with a review of previous jots at the beginning each time.

Conversation with yourself

One of the participants articulated the idea in our interview that the jots can create a unique kind of conversation with one’s self:

Andy: It was helping you when you get stuck on something. Kind of like ask the person by typing.

Me: So how did it help you when you were stuck?

Andy: It felt like a real person talking to you.

Me: Huh. How so?

Andy: Because when you write, then you open it and see what I wrote, but kind of see what [Andy] wrote. And I would like, try to tell myself, you do like this and stuff.

Andy is saying here that he felt that his jots were a way of talking with himself. This seems to point to a profound idea: Andy is saying that the externalization of his own thoughts in jots allows him to see and interact with his thought processes in a new way. This externalization, making your thoughts concrete so that people can interact with them, is at the heart of the way in which jots can support cognitive reflection.

Emotional expression

The kids also used jots to express emotions in a few cases. There were two uses of emoticons, described above. There were also some jots that used the prompt “I am excited because” or used exclamation points to express excitement. For example, Eddie wrote “LET IT BURN!!!!!!” in a jot showing off his new sprite showing a fire effect.

Dave wrote this jot which seems particularly expressive: “I made the cheat menu block. *applause* *cheering* *parades in the street*” I asked him about it in our interview, and he said “that was just random. I was bored and I wanted to do something. Just cause I could pretty much... I was just like, cool I made the cheat menu block. Then I was just like, huh, I want to be ironic.” So this jot apparently is a complex expression of emotions: he

is simultaneously expressing his excitement that he has gotten the cheat menu working, and also mocking his own excitement using irony.

2.c.ii Other uses for jots

Beyond the uses of jots in the study, there were some additional ideas for uses that were imagined by me and by the kids. These included jots in public view, jots for giving and getting help, and jots for reflection-in-action.

Jots in public view

The jots created in the study were private, viewable on a development version of the Scratch web site only, and even there viewable only to the individual participant who created them, and to me. Nonetheless, the participants imagined from the beginning what it would be like to have jots that were viewable by the rest of the Scratch community.

As early as our second session together, Dave was imagining publicly viewable jots, in context of getting acknowledgement for his accomplishments. I wrote in my field notes: “one nice moment today was that Dave looked at me and said something about how jots could be a way to show people all the hard work that had gone into a project.”

Eddie also imagined what it would be like to let people see his accomplishments using public jots. In our interview, he described a version of jots he imagines where you choose to make a jot private or public:

Me: How would you imagine using jots in the future? Should it be more public? More private?

Eddie: It should be public and private [he describes having an option to make each jot public or private].

Me: Why would you want to have that option?

Eddie: Say if you just want to have notes to tell yourself, you shouldn't just be like, what if your project was like private, and you didn't want to tell people about it and you're really unorganized, you could have a private function to view those jots and tell what to do with them, and if you made them public, you could tell people about what you've been doing and maybe also going over those jots on what you were doing over time and they could see like progress.

As I described in the case study on Eddie, he also imagined this use of jots functioning in a way similar to the game developer's blogs he has seen in the video gaming community.

Jots to help others

With jots viewable by the entire community, one could imagine seeking out jots where people seem to need help, and helping them. In our interview, Andy described just that:

Me: what did you like the most about the jots?

Andy: How you see on the internet your own writings. And I hope you could open it and not being private and so everybody could see what you did and where you did. And try to help other people too.

Jots to get help

Andy also described a function of the public jots that would let you send a message to another Scratch community member in order to ask them specific questions about their projects:

Me: what improvements would you make to jots?

Andy: First of all, to publish, so that everyone could see, and talk... You talk to real people with your own voice, or you could make video... so if you're bad at typing like me, if you type slow, you could just say 'how do I do this.' ... or send like a message...

Me: Who would you want to talk to?

Andy: I think people that, like the star wars person [whose project we had investigated together, trying to learn from it], like how he got it working, like how did you do it, I can't understand what you did.

For Andy, communicating directly with people to get their help is especially important. Because of his difficulty with typing, he imagines doing this with audio or video messages.

Jots for reflection-in-action

Many of the uses of jots so far have been in the vein of what Schön calls reflection-on-action (Schön, 1995), which is reflecting on an experience after the fact. The jots were used either in one of our reviews of previous jots at the beginning of a session, or in the summative interview, to reflect on what has happened in the past. Jots may also be useful for reflection-in-action (Schön, 1995), which is a kind of reflection that happens in the moment. It can be described as a kind of fluid movement from moment to

moment between levels of analysis of the problem at hand, from a narrow view to a broad one and back.

One of the adults with whom I made a brief pilot test of the jots system remarked that he thought it helped him solve problems in a way that sounded to me like this reflection-in-action mode. He explained that the act of jotting caused him to step outside the narrow context he was in, of solving a programming problem in Scratch, in order to describe it. This act of describing by itself forced him to think in a broader way about the problem, opening up new ways of thinking about it, and suggesting new possible solutions, to which he could then return after jotting.

As I developed the jots software, I used it myself, as I described in the design chapter. There was at least one case where I made a jot that was about the act of jotting, and which also seems to represent the jots helping me to do reflection-in-action: “I am thinking about how its helpful to post about this because I realize I should try not to get stuck on details, and get things working.” It appears that the act of writing this jot, and perhaps the ones before it about my frustration with the details, helped me to step outside of the process, and adjust my goals so that I did not have to remain stuck.

It would be difficult to document this reflection-in-action phenomenon with certainty in one of the study participants, because it takes a significant degree of self-awareness and metacognitive ability in order to recognize that it is happening and talk about it. Nonetheless there was at least one moment with Eddie where his comment just after jotting suggested that this was happening to him:

Me: If you were to make another jot right now, what would it be?

Eddie: [writes a jot “I need help with Getting a good poison attack system down.”] Do you know how to do a constant poison system, like, once you’re hit by it it will last for... oh that means I’d have to make a turn system.

It seems that what is happening here is that Eddie jots about needing help with figuring out a problem, then asks the question out loud, partly to me and partly to himself, and then after a few seconds comes to a realization on his own about how he might solve the problem. It seems likely that simply having to write the jot helped him realize that he needed to solve this problem, which in turn helped him step outside of what he was doing in order to consider possible solutions.

2.c.iii Reflecting on reflection

This final category is for the uses of jots at a meta level, for reflecting on reflection in research and in pedagogy. Here I describe jots for grounding conversations about learning, in which jots serve as a shared referent, and jots as a tool for research on learning.

Jots for grounding conversations

One of the most important aspects of jots that I have come to understand through using the system with kids is that they can be used as a way to ground conversations about learning. Learning processes are so complex, passing through so many different phases at times scales of seconds, minutes, hours, days and weeks, that it is impossible to understand everything that is happening with a learner, not to mention recall it in order to review it later. The jots record brief moments in the learning process that are very likely to be important or representative, because they are chosen by the learner. They provide a concrete artifact representing an

otherwise very evanescent moment, that can be pointed to later as a way to cue the experience back into awareness of both the teacher and the learner.

One example of this cueing can be seen in the scenario described above in my interview with Eddie, where we discuss his jot about frustration, which leads him to some extent to relive his frustration, leading to a fruitful conversation about frustration in learning.

Jots as a new window into thinking

Jots may provide a new kind of window into the thinking of people as they learn, which may be useful for researchers studying learning. The typical tools for investigating kids' thought processes all have somewhat different affordances from jots. Pre- and post-tests, and surveys are more indirect, being removed in time from the learning process itself. Interviews typically can also only be done outside of learning processes rather than during them. Direct observation of the learning process can be very rich, but does not generally give the learner's own perspective on what is important at that moment. So a unique affordance of jots is the ability to see into a learner's thinking while they are in the middle of a learning process, using their own words and their own sense of what is relevant.

[5] REFLECTIONS

In this final chapter, I reflect on the results of my design process and on the empirical study, looking again at the results in terms of the theoretical framework for reflection presented in the background chapter. I conclude with a discussion of possible future work on jots and on technologies for reflective learning.

1 Discussion of the Jots System

1.a My Design Process

The Jots system passed through several phases, which are discussed in the design chapter. First, in my thesis proposal, I was focused mainly on recording process information, though I made mock-ups of some alternative approaches including the microblogging idea that became Jots. Next, I carried out a preliminary study of recording process information with a learner working with Scratch. Finally, as I developed the Jots system, I jotted about my experiences, revealing details about my own process.

What can I conclude from all of this information about my own design process? First of all, I am glad to have detailed documentation of the ideas that I did not pursue in this project, because they provide lots of material to discuss as future work. I see those initial ideas in a new way, having much more direct contact with the area now. In presenting and reflecting on detailed information about the process I went through, I myself benefited by gaining new insights about my own learning processes. I also believe that presenting this information in all its messiness will be helpful to future students in their thesis process. In the

end, the usefulness of the rich documentation I was able to create about my own process of designing, creating and reflecting on the Jots system is validating to me. It shows the inherent value of the approach I have taken in the design of the Jots system, which is ultimately about creating documentation of learning processes.

1.b The Case Studies

Several themes emerged across the case studies. These included the roles of debugging, frustration, accomplishments, and goal-setting.

All of the participants engaged in debugging, and documented their debugging in their jots. Debugging was a particular focus for Andy, whose jotting proved fruitful for helping to push him through struggles where he was just at the edge of comprehension of new ideas, for example about variables.

Each of the participants expressed frustration about their work, either in the jots or in other ways, and found ways to work through it. Our conversations about frustration, grounded by shared reference points in jots and in Scratch projects, helped the learners understand their own frustration. Frustration was a particular focus of my case study of Eddie, who jotted most about it, and with whom I had the most explicit conversation about the role of frustration in learning.

Each of them jotted about their accomplishments, but it was a particular focus for Eddie, who seemed especially concerned about documenting his hard work so that others might see it. This may have been related to his desire to seem like an important insider in the Scratch community and in the gaming communities of which he is a part. Jotting about his accomplishments, and discussing the jots, helped bring his frustrations

into focus as well. Reviewing these jots also helped him get a better sense of his own ability to learn and get work done over time.

The participants each also jotted about setting goals. This was a particular focus in the case study of Dave, who used them the most to strategize about what to work on next. This involved especially using strategies to get unstuck, and having the jots about that in front of us led to a rich conversation about these strategies. Most of the jots about goal setting across all the participants were about near term goals, such as what to work on next; there was much less explicit jotting or discussion of long term goals either for work in Scratch, or for learning over time. This lack is not surprising given our intuitions and also research results such as those presented by Scardamalia (1984) about reflection in writing.

1.c The Uses of Jots

I discovered numerous actual and potential uses of jots in the course of the study. In addition to those already discussed, there were several other things that the participants actually used them for in the study: as a memory aid, for having a conversation with one's self, and as an outlet for emotional expression. The participants also talked about other uses they could imagine, such as jots that could be viewed by a larger community, and used for helping others and getting help. Finally, I also saw that there were meta-level uses for the Jots system, including supporting and documenting reflection-in-action, grounding conversations about learning, and providing a new window into learning for researchers.

1.d The Facets of Reflection

In this section I will evaluate the Jots system with respect to the four facets of reflective learning described in the background chapter.

The Jots system supports the **cognitive facet** of reflection by scaffolding metacognitive problem solving skills. With the prompts, and the mentor, aiding the learner, they are able to elaborate on their debugging processes, set goals, and strategize about their goals. By reviewing their jots in retrospect along with a mentor, learners are also able to evaluate their own thinking skills.

The Jots system addresses the **emotional facet** of reflection by enabling learners to document their emotional processes such as frustration and excitement, using prompts, exclamations, punctuation, and emoticons. This documentation can lead to the understanding later of emotional trajectories that otherwise would have been lost, wiped out by the “revised” understanding described by Bamberger and Schön (1983). Instead, it enables a rich conversation about emotional processes after the fact between the learner and a mentor.

The Jots system addressed the **social facet** of reflection in this study only in its use in a context facilitated by a mentor, rather than in a larger learning community. The crucial role of me as a mentor in the use of the Jots as a system was made clear by the lack of spontaneous, unsupervised use of the Jots system and by the importance of the reflection questions in encouraging reflective use of jots. The success of my role as mentor was shown by the richness of the jots and interviews.

The **temporal facet** of reflection played out primarily in the use of jots for reflection-on-action. I looked at the jots with the participants at the beginning of each session, and in our interview at the end. The conversations that we had around the jots helped the learners think about their design processes and their learning processes. There was some evidence that jots could be a way to support reflection-in-action as well,

helping learners step outside of their current context and think more broadly.

1.e The Design Goals

Did the Jots system satisfy the design goals articulated at the beginning of the design chapter? The first goal was cultivating reflection. This is covered by the discussion of the four facets of reflection above.

The second design goal was making reflection constructive. The act of jotting is one sense of constructiveness, where the learners are creating individual jots that persist over time, as well as a whole sequence and history of jots. In this way the jots system was successfully constructive.

Another way in which I experimented with constructiveness of reflection was with the jot projects, Scratch projects gathering together all of each participant's jots. I had hoped that the participants would craft these into narratives about their own process of designing and of learning. While their details were interesting and revealing, the projects did not turn into this type of coherent narrative. This may have been because we did not have adequate time to work on them, or because the participants did not understand well enough this intention. It may also have been simply because such a narrative would have been too difficult for them to construct, and at a higher level of reflectiveness than they were ready for.

Third, making reflection social. As I've discussed, the study investigated the relationship between mentor and learner, but not the context of a larger social community. This design goal lies largely in the future and is one of the topics in the following section on future work.

2 Future Work

In this section I describe some of the many ideas for extensions to the jots system that have come up in the course of this research. I begin with more straightforward modifications to the current system, and continue toward more radical modifications. Finally, I conclude with a discussion of the relationship between the jots system and its associated pedagogical techniques.

2.a Improved Prompts

Prompts were one of the underused features of the Jots system that could benefit from a re-thinking. In describing the development of the CSILE system for collaborative learning, Scardamalia and Bereiter (1991) point out that such prompts should not be invented in advance, but in response to needs of learners:

“... procedural facilitations [like sentence-opening prompts]... must grow out of diagnosis... the idea is not to decide in advance how a process should be carried out and then contrive to get children to do it that way. Rather, the idea is to watch for situations in which learners appear to be blocked from achieving their goals—possibly because their goals are too vague or because their procedural repertoires are too limited or because the task is too complex—and then design relevant aids to help them over the impasse.”

Having seen the ways in which three eighth grade boys use jots, I can now see that most of the prompts were not useful to them. One way they might be changed would be to explicitly support the actual uses that arose, in debugging, accomplishments, and goal-setting. Perhaps we could help learners expand their repertoire for explaining their debugging procedures

or articulating their goals, using carefully chosen prompts. Another way the prompts in the Jots system might be changed would be to support uses of jots that we did not see but would like to, such as high level goal setting, and explicit reflection on previous learning experiences.

2.b Multimedia Jots

There's no particular reason that jots should be limited to text and screenshots. As Andy mentioned in our interview, transcribed in the empirical study chapter, it might be useful for some people to be able to make jots in other media such as audio and video. For example, you could simply record yourself talking about what you have done, instead of having to type it, which is easier for many kids. For full expressiveness, you might want to use a video of yourself. You might also want to make a "screencast" type video, showing what is happening on the screen as you narrate. This would be a way to document a bug that is particularly difficult to describe, or an exciting accomplishment. It would also be a way to create video tutorials to show other people how to do what you have done.

2.c Jot Projects

The jot projects used in this study, Scratch projects containing the participant's sequence of jots and screenshots, were generated by hand. During the development I hoped to create an automated system for generating these projects from a user's jots, but I did not have time. I could imagine a server based system that generate jot projects on request, which people could use for various purposes such as narrating the story of how they made a project or learned a particular concept, or for creating tutorials about using Scratch.

2.d Process Trace

It seems worth returning to an early idea presented in the design chapter of this thesis, of recording process information using snapshots of the screen. This would generate a kind of process trace, representing a user's work in Scratch over time, which could be visualized in various ways. This process trace could serve as a supplemental source of information for reflecting on past activity, and for grounding conversations about it. For example, a learner might omit to jot about their extensive work in painting a new sprite; a mentor working with them would not know about this part of the process unless they saw it on the process trace, which would let them initiate a conversation about what the learner had been doing.

2.e Process in Product

Another idea from early in the design process, of embedding process in product, also seems worth returning to. How could the process information from jots be embedded in a Scratch project itself? One way would be to create a feature on the Scratch web site that associates together a Scratch project and any jots about it. This would allow others coming to the project to see the jots about it and learn about the process its creator went through making it. Another possibility would be to embed the jots (and perhaps other information, such as a process trace) directly into the Scratch project file, so they could be accessed while viewing and editing it.

2.f Public Jots

Each of the participants in the study expressed in various ways their desire for public jots. Eddie wanted to seem important by having his jots make up a game developer's blog. Andy wanted to give and get help from others with his jots. Dave wanted to be able to show people how much

work he had put into a project. If jots were viewable by others in the Scratch community, these things would be possible. The Jots system would have to be deployed with a main release of Scratch, rather than an experimental version, and the web site feature would have to go live on the main site. The system would need functionality for commenting on jots, for flagging them as inappropriate, and for their creator to delete them.

It would also be interesting to try adding functionality for searching jots, including categorizing them by prompt or with a tagging system. This would enable people to seek out, for example, Scratch users who have been asking for help within the past day, and help them by commenting on their jots. It would also enable people to seek out jots about a particular problem they are having, to see if others have worked through the same problem.

Another potential use of public jots would be to allow novices to compare their processes of learning and design to those of their peers, and of experts. One could imagine learning several types of valuable things from this comparison, such as the fact that one's peers go through the same frustrations, or that experts use strategies to prioritize their goals as they work.

Another potential enhancement to the system would be to create a "jot-feed," showing the jots from the entire community, or just from your friends, live as they stream in. This would allow you to see from moment to moment what people are working on.

I can also imagine some of the above functionality, such as the jot-feed and search capabilities, being incorporated directly into the programming environment, rather than separated from it on the web, so that for example

it is easier to communicate with others as you are seeking help on a programming problem.

2.g Jots and Automated Recommendation

Schön (1983) writes, “when a practitioner makes sense of a situation he perceives to be unique, he *sees* it *as* something already present in his repertoire.” Experts in this way draw on their existing experience, forming a metaphor between a past situation and the current one in order make sense of it. Because children learning Scratch are not experts, they do not have access to this kind of rich store of past experiences to draw on. Perhaps instead they could benefit instead from the experiences of others, stored in jots. Children might be able to use the search functionality described above to seek out an analogous situation to their own, but identifying a situation in a sufficiently abstract way to compose a search is difficult.

For this reason it might be useful to have an automated recommendation system that can form these analogies automatically and generate suggestions. It would probably need more information than is included in the jots themselves, such as a representation of the Scratch scripts the learner has recently written. With this information, the system might detect for example that a learner is struggling with the use of variables, and automatically pull up relevant jots by others with useful information about how they figured out how to use variables. While this type of system seems in principle possible to construct, it is hard to imagine it working well across all situations, because of the wide variety of problems and confusions that learners have in learning to program. An incorrect or irrelevant recommendation might also be confusing or frustrating.

2.h Jots and Research

As I've discussed, jots may have a role as a new window for researchers into the thinking of children as they learn to program. With some extensions, such as the addition of an embedded representation of the code in the Scratch project, jots could become an even more valuable resource for studying this topic.

2.i Jots for Other Platforms

One could also imagine systems like jots being integrated with other platforms. For example, the Computer Clubhouse network's Clubhouse Village web site might be a good candidate. On that site, kids who are members of a Computer Clubhouse can share their work in a variety of media. In this case, rather than integrating the Jots system with a particular authoring application, it would be its own stand-alone application. It would allow you to enter a textual jot, and take a screenshot of anything on your screen to send to the web site. It would also allow you to drop a file of any type onto a widget, to serve as an update about what you are working on. For example, you could post incremental versions of a music file you are creating, jotting about the changes you make as you go. Others could then view these jots on the site, and listen to the piece of music as it evolves.

2.j Jots and Pedagogy

One of the most important aspects of the Jots system in this study was the interpersonal aspect: the relationship between me as a mentor and the participants. My strategies for encouraging them to reflect, including the reflection questions and interviews, were probably more important than the technological tool itself to their reflectiveness. This raises the question of how to develop these pedagogical strategies further. Given its success

in the study, I would argue that Duckworth's critical exploration method (1995) would be a good choice for a future pedagogy with jots. Of course, I could imagine that many other pedagogical approaches might also work well. How to construct a pedagogical strategy for reflective learning in other situations, such as a classroom or web community, is an open question worthy of additional research.

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