Research Design: Necessary Bricolage

Sally Fincher
Computing Laboratory
University of Kent
Canterbury, CT2 7NF, England
+44 1227 824061
S.A.Fincher@kent.ac.uk

Josh Tenenberg
Computer Science & Systems
University of Washington, Tacoma
Tacoma, WA 98402-3100 USA
+1 253 692 5800
jtenenbg@uw.edu

Anthony Robins
Computer Science Department
University of Otago
Dunedin 9015, New Zealand
+64 3 479 8314
anthony@cs.otago.ac.nz

ABSTRACT
In this paper we suggest that in order to advance, the field of computer science education needs to craft its own research methods, to augment the borrowing of "traditional" methods such as semi-structured interviews and surveys from other research traditions. Two example instruments used in our recent research are discussed. We adopt the metaphor of "bricolage" to characterise not only what researchers do, but to argue that this may be a necessary step towards developing theory.

Categories and Subject Descriptors
K.3.2 [**Computer and Information Science Education**]: Computer Science Education

General Terms
Design

Keywords
Research methods, bricolage. research design.

1. INTRODUCTION
The methods that we use to investigate learning within the discipline embed assumptions about learning, human capabilities, social life, and the bio-physical world. For example, Eckerdal et al (2005) explored first-year student understandings of *object* and *class*, employing semi-structured interviews and a phenomenographic analysis. These interview studies take for granted that human speech provides an accurate account of an individual's phenomenological experience of a situation, and that research subjects will disclose their sentiments accurately to an interviewer with whom they have no prior relationship. Or consider the observational studies of Barker et al (2002) to gain insight into "the student experience of the social environment" in the Computer Science classroom. These methods embed the assumption that researchers immersed in (and taking contemporaneous field notes about) the ongoing cultural and material worlds of their research subjects will gain understanding of the social meanings of human interaction within the observed setting.

As educational researchers, methods are our toolbox, our stock in trade, the hammers and shovels that provide purchase for gaining insight into teaching and learning. As we have argued elsewhere (Fincher & Petre 2004, Tenenberg & McCartney 2010), there are a number of extant methods that we can borrow from, developed in other human sciences. In this paper, however, we make a different and contrasting argument: that there are cases when we need to craft our own methods, or reshape tools to better suit the phenomena that we wish to investigate.

ICER '11, August 8-9, 2011, Providence, RI, USA.

When students are engaged in a task, whether learning new syntactic concepts, or practicing programming skills, there is a portion of the endeavour, maybe the largest portion, that is not externally visible. Yet we, as researchers, are interested in this. Exactly when does a student get their program working? What do they feel at that point—triumph? Success? A weary recognition of another step taken? And does what they feel affect their motivation for the next task? Do they work on problems alone, what scaffolding do they perceive in their environment—and what do they use? How does their knowledge build over time, and how does their understanding develop?

None of these tasks and processes (nor their associated research questions) are discrete enough to be studied in a controlled setting, none can be performed to order, and many happen outside of the gaze of others. As researchers, we have to find methods that permit us to examine these without our continuing presence.

The class of problems, then, that we are interested in concern ephemeral events, that may have occurred in the past, and are not amenable to direct observation. We think that these three characteristics, which we call *researcher-distant*, are present for many aspects of CSEd research, aspects that are currently served by less well-suited methods, such as semi-structured interviews or questionnaires. By *researcher-distant*, we mean not distant of influence – we are, after all, researchers actively pursuing questions – but distant of perspective. We want to allow the participants to expose their world as they see it; we don't want to focus on features which seem to us to be prominent, from our standpoint a rather long way away.

2. RESEARCH FOCUS
We were interested – as are many – to study novice programming students. We are in the process of exploring two central research questions, each informed by a research tradition. The first question concerns what cognitive strategies novice students pursue in programming, and how these are related to the material and social support that is available to them. We are pursuing this from a cultural-historical perspective (Vygotsky 1978, Rogoff 2003, Cole 1998) that takes activity as its focus, and examines how internal mental operations are mediated by external resources, including tools and symbolic representations, as well as social interaction.

Our other question concerns what narratives students tell about their programming activities, and how these are related to their identity as programmers. We seek not only descriptive accounts of activities, but also stories that relate individual identity to programming. Narratives of the self are an important genre of

research into identity (e.g. Mishler 1991, Labov 1967). These narratives, according to Bruner (1987), have a reciprocal influence on the teller: not only do we tell the lives we live, "we *become* the autobiographical narratives by which we 'tell about' our lives" (Bruner 1987).

The current paper describes our growing realisation that exploring these questions requires new tools, and gives a preliminary description of two of the tools that we have developed, *My Programming Week* and *Emotional Timelines*.

3. MY PROGRAMMING WEEK

"What happened here? Well let's see.
On a central square, in a city of the sun rose a palace.
It was high and handsome gleaming like the crown of a king."
Adam Guettel, *Light in the Piazza*

Were we investigating these questions in the 1970's, when we learned to program, an obvious choice would be ethnographic observation and interviews in the centralized computing laboratories, since this is the only place where computers (and hence programmers) could be found. "Obvious" because of the taken-for-granted social interactions that might not be elicited through interviews off-site; because immersion *in situ* makes resources (both human and material) available to the researcher; because human interaction is ongoing, discursive, gestural, fluid, multi-valenced and meaning-laden, all features which are visible to the ethnographically-trained researcher.

But computing in the early 21st century is not physically constrained to centralized computing laboratories. The social, material, and technological organisation of learning has changed dramatically during the last several decades. Currently, the spaces and times where learning to program occurs, and the physical and social resources available vary by student, by time, by need, by opportunity. If we wanted to see where learning to program happens today, *where would we go*?

Although an ethnographic approach might still be useful, it would be infeasible for us, as researchers, to follow students around all the time, observing when and how they worked. This would not only be burdensome, but would face insurmountable issues of access and privacy. So we had to devise a proxy.

3.1 Recording

Without access to the relevant spaces, another option was to conduct retrospective interviews, where students recall what they do when they learn to program. This was methodologically attractive, but we were concerned that students would not have ready linguistic access to their own practices, particularly since practice knowledge is something that is often tacit and enacted, rather than rule-based and explicitly understood (Collins 2001, Polanyi 1966, Sternberg 1999). We thus augmented a retrospective interview with a student-generated representation of their programming activity designed to serve both as a record, and as a stimulus to recall.

In order to ground the study in concrete activity, we chose to focus on a single week centered around a single programming assignment, which we refer to as *my programming week*. We hoped to elicit students' natural patterns and rhythms of activity, to determine the resources they call on both in workaday activity and when they get stuck, and the stories they tell of their efforts.

Just after students were assigned a programming assessment (due one week later) we provided them with a grid, on a single side of a single sheet of paper, which had a cell for every hour of a seven-day week. The instructions we gave them were to note on the paper any time they did anything related to programming–thinking about it, talking over problems, consulting notes, creating design documents, reading textbooks, looking for material online, coding. We also asked them to note the *space* they were in when they did the noted activity, and, for each new space they encountered, to take a *photograph*.

At the end of the week–as close to the finish of the task as possible–we invited the students to a debriefing session. In this we asked them to talk through their week, from start to end. Unlike unstimulated recollection, the diary grid and photographs allowed them to index their episodic knowledge (Tulving 2002) about the activity represented.

3.2 Photo elicitation

Our use of photographs borrows from the use of visual methods in the social sciences (see (Pink 2007) and (Harper 2002)). In his ethnographic study of a handyman in rural, upstate New York, Douglas Harper (1987) wanted to record the complex interaction between Willie (the handyman) and the tools and materials with which he was so skillfully engaged. But Harper wanted as well to have a shared reference that Willie and he could both look at and from which Harper could probe more deeply into Willy's tacit, embodied knowledge. What then, was Harper to capture on film? "The question of what to photograph became, in fact, the question of how to see things at least roughly as Willie saw them"

Harper used a method that he borrowed from John Collier [1967] that Collier called *photo elicitation*. "In the photo elicitation interview the subject and the interviewer discuss the researcher's photographs, giving the interview a concrete point of reference. This approach is different from other sociological interviews because a photograph, rather than an interviewer's question (which may or may not make sense to the individual being interviewed), is the focus of attention. Roles are reversed as the subject becomes the teacher" (Harper 1987).

If the point is to see what the subject sees, and if access to the research site is off-limits or difficult to obtain, then the obvious solution is to place the camera into the hands of the research subject. *They* decide how little or how much to expose, they choose what to reveal and what to obscure. We were influenced in this choice, of putting the camera into the hands of research participant, by a set of data collection methods called *Cultural Probes* (Gaver et al 1998). Designers Gaver, Dunne, and Pacenti, asked participants to take photographs within their communities so as to better understand the local culture and tacit needs related to an exploratory design project "looking at novel interaction techniques to increase the presence of the elderly in their local communities."

3.3 Interview

At the end of the week, we interviewed participants, with their grids and photos to hand. Our interview protocol involved the following sequence of prompts and activities.

First, we asked them to annotate their photos with the resources available to them at that place. We considered a resource to be anything external to them that they made use of in their programming activities. These might include images and text (in textbooks, handouts, etc), media for writing these (pencils, paper), communication tools (cell phones, email), hardware/software systems (computers, IDE's, compilers, debuggers, web browsers). We expected that they would take many of the resources that they use for granted, so we used the photographs to gently probe, pointing to specific objects and asking about them. We then asked

them which photos were associated with which times on their weekly grid.

We then asked them to note the people with whom they interacted in each of the locations. This interaction might be face-to-face or technologically-mediated: we asked them to indicate this as well.

We then elicited the specific programming-related activities they performed at different locations. This was achieved by means of questions such as "what were you doing in these four hours [pointing to a marked area of the calendar grid]?" and "what happened here [pointing to a photograph]?" In addition to asking descriptive questions about resources, people, and activities, we asked "why" questions to elicit the rationale that links these together. "Why did you choose to work here at this time?" "Do you recall why you emailed your tutor just then?"

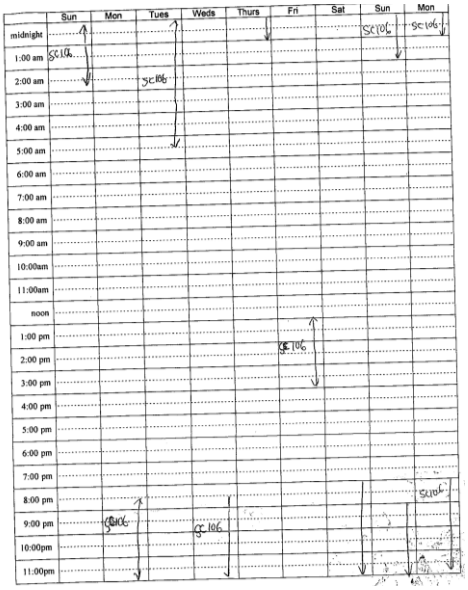
At this point, we asked them to try to provide a *narrative* account of their programming week. Rather than a set of loosely-related locations, resources, and human interactions, we asked them to provide a coherent "story", told in chronological order.

Finally, if these had not already come out in the previous discussion, we asked two *critical incident* (Klein 1999) questions. The first highlighted the point of greatest tension or challenge, and if (and how) they overcame this challenge. The second critical incident question was concerned with any learning breakthroughs they might have had during their week of programming activity.

Our purpose here is not to provide a full analysis of this data, but rather to highlight the qualities of the material these instruments permit us to garner.

3.4 Stimulated recall

Unlike unstimulated recollection, the diary grid allowed participants to easily index back to the activity represented, they were able to recall not only where they were, but who they were with and what they were doing.

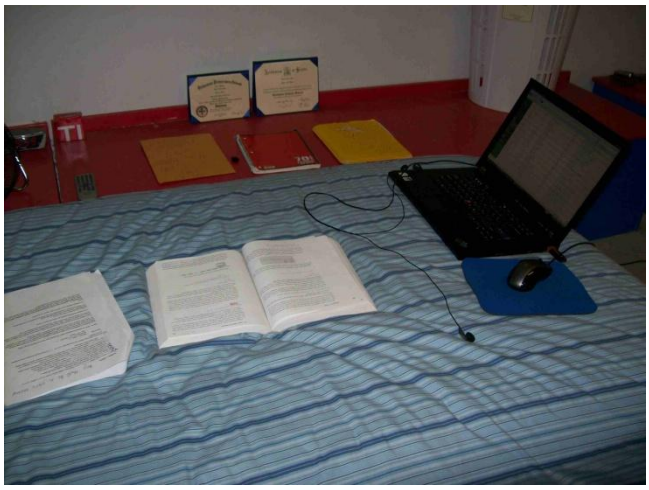


The *patterns* on the grid also allowed us easy access to less helpful practices. A grid with solid blocks of hours of students working alone often indicated that they were stuck on a problem (although not always).

> INTERVIEWER: So the one thing I'm curious about is if this general shape of work, so it looks like fairly large blocks. Some amount at home, some amount at the labs. Is this what most weeks look like?
>
> PARTICIPANT: Usually. I'm a night owl, so I prefer to do most of my work in the evenings, which kind of goes along with, you know, most of the computer industry, computing industry. Gaming industry. You know, that sort of thing.

3.5 The photographic window

In one interview, the student provided a photograph of their bedroom, where they do much of their programming work.



In the following sample of the interaction between interviewer and participant, the photo serves two purposes: it provides a point of mutual reference to which both attend at the same time, and it serves to stimulate recall from the research subject.

> INTERVIEWER: What's up here [points to desk at top of photograph]?
>
> PARTICIPANT: My notebook for when I take notes in class and just my folder with the various printouts and stuff for..
>
> INTERVIEWER: Are there any other resources that you use here?
>
> PARTICIPANT: I don't know if this really helps, but I guess I got a couple of my degrees there… like my high school… I don't know; right now it's a time where I'm stressed out about school and having those kind'a reminds me of the good ol' days when I was just a kid and having fun; just reminds me, when I'm doing any kind of homework, to just have fun and try to enjoy it. It's kind of just…it's symbolic to me; I don't know if it really…

The photograph provides a window into this student's activity that would have been impossible to achieve otherwise. Peering through this window at a distance allows access to the interviewer, and safety to the participant. As researchers we see things of unexpected importance, things we would not have thought to look for from a remote standpoint.

For this student, as for us when we were students, space had special meaning with regard to programming activity. The interview continues:

INTERVIEWER: Are there any other places where you do programming related work?

PARTICIPANT: Besides these two, not really.

INTERVIEWER: Okay. Let's go over to your calendar. ... Do you happen to recall, in these places [pointing to different marked places in the calendar grid], do you happen to recall which ones you did in which locations?

PARTICIPANT: That's kind of a funny story: I tried to work at my desk there, but for some reason it reminds you like a classroom. And it bothers me, so I always just go to my bed; just work on it…just that reminds you of like sitting at a desk, but most of the time…

INTERVIEWER: Okay. So when would you move over to here [pointing to the desk]?

PARTICIPANT: When I know that I really need to concentrate and that I know here I can get distracted by various things. If I'm at my desk I'll know that I mean business; I need to sit down and do this; I can't mess around.

Here we see how their space is imbued with meaning, how space becomes *place* for this student: how the evocation of place connects to individual identity: *here* I am a playful child, yet *there* I am a serious adult.

For other students, place is a more fluid concept. They started their assignment by reading an appropriate chapter from the textbook on the bus.

PARTICIPANT: And then, I continued to work on the assignment at home, late at night; from 1 to 3. And then, I finished the assignment also in the lab. So it went from the bus, to the lab, to home, back to the lab. Right here, where I finished it, and then went to class.

The photographs here illustrate a complex narrative of task and situation, of companionship and isolation:

PARTICIPANT: Well, in the lab, my friend…I specifically wanted to get help. I wanted meet up with my friend. And also I knew that a mentor was going to be there. So, all the time that I had people interaction, I sought them, or they sought me. 'Cause the second time I was here [in the lab], I knew what I was going to do. And that was finish it, and try the extra credit, but my friend called me. So it can go both ways. And for the beginning is where I sought it, and the end is where I actually gave help.

Looking back on these vignettes from the interviews, we can inquire: by what other means would we have achieved these insights? Would we have thought to put tick-boxes into a survey for all of the places that students revealed in photo and narrative ("Please select all locations where you do programming related work: in bed, on the bus, at your desk, at your dining room table, sitting on your computer tower, …")? Would students reveal the times, locations, and resources in an interview *without* the diary grid and photographs to stimulate their recall?

They also reveal three key characteristics that our elicitation method afforded. First, they provided us access to places impossible to enter otherwise: the bus, the bedroom, the computing lab in the middle of the night. Second, they served as shared reference for student and researcher: "What happened here? What resources did you use? And third, they provided stimulus to recall, allowing mental access to things past that might otherwise be forgotten.

4. EMOTIONAL TIMELINES

My Programming Week examines cognitive strategies and narratives on a small time scale. We were also interested to examine these within the ecology of an entire academic course. In pursuit of this, we conducted an interview study of 20 students from an introductory programming course (approximately 10% of the number enrolled). We were interested in a phenomenological account of the course as a whole, a retrospective of a whole learning experience and in how students felt about it (not necessarily how successful they were in accomplishing it, although these are, of course, often closely linked).

4.1 Representing time

We again developed an instrument that both served as a stimulus for recall and as a shared reference to structure the interview. The inspiration for our instrument construction this time was not in methods from other disciplines, but methods from industry, specifically *project retrospectives* (Kerth, 2001). Project retrospectives are used where teams want to reflect on recently-past experience and learn from it to inform future work of the same kind. We appropriated three features of project retrospectives: timeline stimulus, recollection (and labeling) of significant events, and the creation of an "emotional seismograph".

In software project retrospectives, the (re)construction of the project timeline is a chance for everyone to recall what happened when, in what order: to create a shared representation. We approximated this by providing students with a single sheet of paper, with a vertical line down the middle representing time (see accompanying figure). On the left-hand side of the sheet, rows were labeled by week, lab, and lecture number, with the first week of the academic term at the top of the sheet and the last week at the bottom.

As researchers living in an industrialized social order (for those of us who do so), we take for granted "clock" time. Yet this public, socially shared demarcation of time is a relatively recent socio-cultural accomplishment. "In the United States alone, there were about 70 different time zones as late as the 1860's. … In 1883 … the railroads established the four time zones used in the United States today" (Levine 1997).

4.2 Remembrance of things past

" For a long time, I went to bed early."
Proust, *Remembrance of Things Past*

By contrast, experienced time has a different character: non-uniform, personal, subjective. We asked these students to annotate those weeks of the semester represented on the left-hand-side in which significant events occurred. Typical annotations were "This one was fun :-)" or "Hard. Intimidating code". We then turned the paper 90° (to a "landscape" orientation) and asked students to overlay a curve against the central timeline that represented their "emotional seismograph" for the course, where the x axis indicates their overall emotional reaction to the course at different times. As Levine et al (2006) note: "a person's memory of past emotional reactions plays a vital role in the construction of personal identity."

The *retrospective recall* of time is subject to a set of biasing influences. First, because of mental resource limitations, past events are not encoded completely, but partially in terms of prototypical or salient features. On recall, these memories are reconstructed, with the detail "filled in", often from information acquired after the remembered event so as to create a seamless whole (Gilbert 2006). Second, the affect associated with a remembered event is strongly influenced by both the peak intensity of the event, and the quality of the end of the event, the so-called *peak-end rule* (Do et al 2008) We thus deliberately constructed the timeline, labeling, and seismograph to contrast the "objective", socially shared scale of the calendar against the biased, affective, phenomenological experience of an individual as they recall their movement through the past.

4.3 The retrospective interview

Finally, we asked students to talk through the timeline, narrating it from start to finish, annotating the extreme peaks and troughs on the seismograph as they did so. Again, the shared representation allowed the interviewer to probe with particular questions:"What happened here?" The shape of their seismograph and the events they singled out for annotation afforded the opportunity for many *why* questions.

4.4 Emotional seismograph as narrative

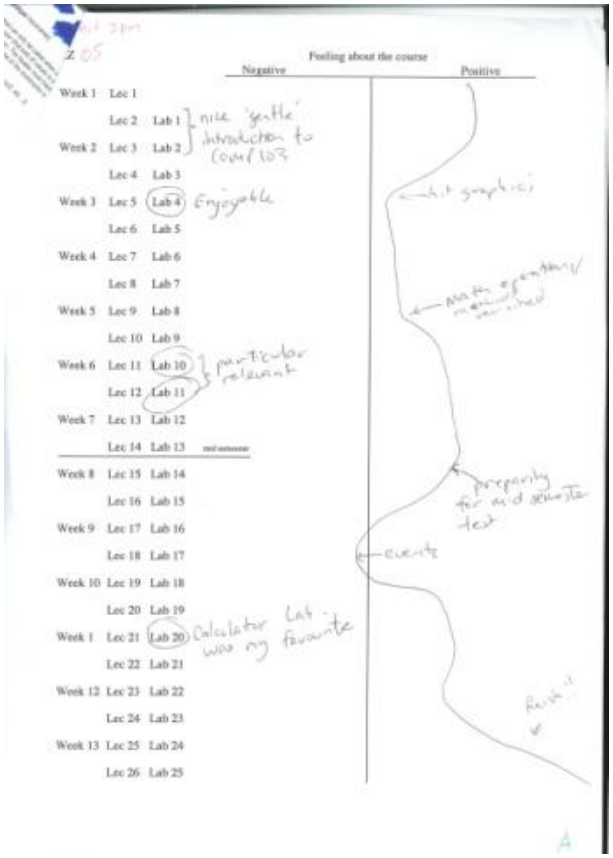
For us, one of the surprising features of this technique was the narrative richness of the representation itself. The stories that students have to tell emerge not from transcribed dialogue, but powerfully from the page itself. Not only do these representations provide students access to memories of particular past events, but also these events—and their affect—can be viewed in relation to one another, as a coherent whole. It is not simply "the terrible time that I had with lab 6" but the fact that this was preceded and followed by a particular historical trajectory, all of which is evident to the researcher and the student, all available for perception, reflection, and explanation.

Two examples show the very different nature of experience of two students from the same course. The first student hardly recollects a negative moment: the only point the seismograph dips into negative is prior to the mid-semester test, and the student finishes the course more positive than they started.

> INTERVIEWER: There was a big dip right around the mid-semester, what was going on there?
>
> PARTICIPANT: Ah we did the test then - I missed a couple of lectures there … I guess I wasn't a huge fan of having a lecture - was it the day before? I wouldn't recommend that. I didn't go,
>
> INTERVIEWER: That lecture the day before wasn't part of the expected test.
>
> PARTICIPANT: I know but, but you know.
>
> INTERVIEWER: So it's a big dip but a rebound?
>
> PARTICIPANT: We have the events I think about then, … it was quite a useful thing and being able to respond to button clicks, that sort of thing, so you sort of get more happy with it then.

A second student, although they start off in a similarly positive position, rapidly sink into a negative decline and although there is a small mid-semester rally, it is short-lived. The seismograph finishes at Week 9 with the annotation "gave up". These representations thus "tell" and in so doing are subject to scrutiny and interpretation by both student and researcher.

As with the diary grid and photographs of *My Programming Week*, we do not believe we could have discovered this mix of learning and emotion in any other way, this coherent narrative of the phenomenology of an introductory programming course by individual students.



5. On *bricolage*

Denzin and Lincoln (2008) recognize our impulse to create appropriate instruments "The qualitative researcher as bricoleur, or maker of quilts, uses the aesthetic and material tools of his or her craft, deploying whatever strategies, methods and empirical material are at hand (Becker, 1998, p.2). If the researcher needs to

invent, or piece together, new tools or techniques, he or she will do so."

As programming and computation are increasingly embedded in the contextual, situated, everyday world, in a complex ecology of inputs and activities, and if we as researchers are to inquire into how students learn within these contexts, it will require us to engage in methodological bricolage. Computing Education Research utilizes a relatively limited set of methods. Yet many research questions cannot be answered by the questionnaire, the experimental study, the semi-structured interview; rather, researcher distance—ephemerality, occurrences from the past, and outside the researcher's gaze—are important characterisitcs, and hence bespoke methods will be required. For us, these methods are also *researcher-distant*, that is to say that we are not putting ourselves in the frame, not biasing response with our questions ("When you program, at what point do you consult the textbook?") or expectations ("The work in week six was really very easy"). Instead, we craft instruments that let participants "speak for themselves" and allow us the insight to see the world as they do.

Peter Fensham (2004), in talking about the maturation of his own specialty (science education) into a field with a separate identity notes that one marker by which a field may claim identity is theory, and its development. He makes the argument (amongst others) that it may be too early in the disciplinary lifecycle for our sort of enquiry to develop theory and that we have "to live through a much longer adolescence of careful observation (as natural sciences like chemistry and biology have done)" (p.80). He puts the position that the kind of research needed is "extended systematic observation of the complexities of actual social situations" which may "yield valid descriptions of the multiple perspectives and consequent actions of those involved, and just possibly some tentative generalizing assertions" (p.103).

It is our hope that in seriously and thoughtfully engaging with questions specific to our field and our work, inventing and "piecing together" our own tools, rather than only adopting well-used methods from other disciplines, Computer Science education too may move tentatively towards our own theory.

6. Acknowledgments

We are grateful for financial support from the University of Washington, Tacoma's Chancellor's Fund, to the University of Otago's Research Committee, to the student research subjects who agreed to participate, and to the Helen Riaboff Whiteley Center of the Friday Harbor Laboratories of the University of Washington for providing the environment that enabled us to develop this paper.

7. References

Barker, L., Garvin-Doxas, K. and Jackson, M. (2002). Defensive climate in the computer science classroom. In *Proceedings of the 33rd SIGCSE technical symposium on Computer science education* (SIGCSE '02).

Bruner, J. (1987). Life as narrative. *Social Research* 54(1).

Cole, M. (1998). *Cultural Psychology: A Once and Future Discipline*, Harvard University Press.

Collins, H. (2001). What is tacit knowledge? In Schatzky, T., Knorr Cetina, K., and von Savigny, E. (Eds.) *The practice turn in contemporary theory.* Routledge.

Denzin, N. and Lincoln, Y. (2008). *Collecting and interpreting qualitative materials, 3e.* Sage.

Do, A., Rupert, A., and Wolford, G. (2008). Evaluations of pleasurable experiences: The peak-end rule. *Psychonomic Bulletin and Review* 15(1):96-98.

Eckerdal, A., Thuné, M., and Berglund, A. (2005). What does it take to learn 'programming thinking'?. In *Proceedings of the first international workshop on Computing education research* (ICER '05).

Fensham, P. J. (2004). *Defining an Identity: The Evolution of Science Education as a Field of Research*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Fincher, S. and Petre, M. (2004). *Computer science education research*. Routledge-Falmer.

Gaver, B., Dunne, T., and Pacenti, E. (1999). Design: Cultural probes. *interactions* 6(1): 21-29.Goody, J. (1977). *The domestication of the savage mind.* Cambridge University Press.

Harper, D. (1987). *Working knowledge: Skill and community in a small shop*.

Harper, D. (2002). Talking about pictures: A case for photo elicitation. *Visual studies* 17(1):13-26.

Kerth, N. L. (2001). *Project retrospectives : a handbook for team reviews*. New York: Dorset House.

Klein, G. (1999). *Sources of power.* MIT Press.

Labov, W. & Waletzky, J. (1967). Narrative analysis: Oral versions of personal experience. In J. Helm (Ed.), *Essays on the verbal and visual arts: Proceedings of the 1996 Annual spring Meeting of the American Ethnological Society (pp12-44). Univeristy of Washington Press.*

Levine, R. (1997). *A geography of time.* Basic Books.

Levine, L., Safer, M., and Lench, H. (2006). Remembering and misremembering emotions. In Sanna, L. and Chang, E. (Eds.) *Judgments over time: The interplay of thoughts, feelings, and behaviors.* Oxford University Press

Mishler, E. (1991). *Research Interviewing: Context and Narrative*. Harvard University Press.

Pink, S. (2007). *Doing visual ethnography: Images, media, and representation in research.* Sage.

Polanyi, M. (1966). *The tacit dimension*. Doubleday.

Rogoff, B. (2003). *The Cultural Nature of Human Development*, Oxford University Press.

Rogoff, B. and Lave, J. (1984). *Everyday cognition: its development in social context.* Harvard University Press.

Rose, Mike. (2004). *The Mind at Work.* Viking Adult.

Scott, J. (1999). *Seeing like a state.* Yale University Press.

Sternberg, R. and Horvath, J. (1999). *Tacit knowledge in professional practice: Researcher and practitioner perspectives.* Lawrence Erlbaum.

Tenenberg, J. and McCartney, R. (2010). Why discipline matters in computing education scholarship. *ACM Transactions on Compututing Educaction* 9(4): 18:1–18:7.

Tulving, E. (2003). Episodic Memory: From Mind to Brain. *Annual Review of Psychology.* 53:1–25.

Vygotsky, L. (1978). *Mind in Society*, Harvard University Press.