Editorial:
Entry Points for Computing Education Research

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The goal of this editorial is to to provide entry points into the literature on making and warranting claims in the social and behavioral sciences that might be of use to computing educators. In addition, we provide some heuristic advice on getting started and continuing along this direction based on our experience as computing education researchers.

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In a previous editorial [Tenenberg and McCartney 2010], we argued that making claims about effective teaching in the computing disciplines (e.g., about compiler optimization, programming, or discrete mathematics) is different than making claims about the discipline itself, and the former requires borrowing theory and method from outside the discipline.

> This is because making and verifying claims about human learning differ fundamentally from designing, building, and using computational artifacts. To study human learning in computing, we need not only disciplinary knowledge (to understand what the important questions and to interpret student behavior and artifacts), but we need knowledge about the teaching and learning processes: how students learn, how learning and teaching interact, and how the effectiveness of these might be evaluated. Researchers in the social and behavioral sciences in particular have already developed epistemic cultures of considerable subtlety and depth that can provide insight into many of the questions about teaching and learning that computing educators might ask [Tenenberg and McCartney 2010].

The goal of this editorial is to provide entry points into the literature on making and warranting claims in the social and behavioral sciences that might be of use to computing educators. In addition, we provide some heuristic advice on getting started

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and continuing along this direction based on our experience as computing education researchers.

1. NOT ONE ENTRY POINT, BUT TWO

An entry point is a place to start: short, accessible, understandable, and immediately applicable. The goal of entry points is not to impart expertise, but to provide a basis for beginning a research study. In addition, it should provide the rudiments of language used by other research communities so that one can discuss research design and data analysis with researchers from the communities from which theory and method are borrowed. This is what Collins and Evans [2007] call *interactional expertise*: talking the talk without necessarily being able to walk the walk.

Our metaphor for thinking about entering computing education research is the Swiss army knife: a small, functional set of tools applicable to a broad range of problems. One does not learn everything at once. Our discussion of entry points thus does not include textbooks or primary literature that one might encounter in “methods” courses in schools of education or social science. It is the opposite of a survey. We instead focus on readings that present a small number of new concepts and skills that nonetheless provide purchase on a wide range of problems that the everyday academic faces.

There is no single source that we have found that provides the short, functional, immediate entry into computing education research. But we have found two which taken together provide this entry: one is centered on theory and the other is centered on method and pragmatics. We discuss each in turn.

1.1 Theory: What Is Known About How People Learn

To have a common point of reference, we take theory to be a “system of ideas or statements held as an explanation or account of a group of facts or phenomena” [Oxford English Dictionary 2010]. Theory lifts above the specifics of particular settings, of “time and place” [Hayek 1945]. The very fact of making theoretical statements embeds the ontological assumption that there are similarities between settings, such as my classroom and yours. In the physical sciences, we are accustomed to theoretical statements applicable at all times and in all places, such as the relationship $f = ma$. In the social and behavioral sciences, it is increasingly recognized that such universal statements are rare. Causal relationships true in my classroom (such as that students using IDE X learn more of the subject matter than students using IDE Y), even if established under the strongest research designs, may not be true in yours. This is because of such things as the prior experience common to all students tested, the other courses that students might be taking simultaneously, the peer mentoring program that is in my university and not yours, and many other such contextual variables. Rather, many social and educational researchers seek *conditional* generalizations, statements that are true outside of a single time and place but that are not universal [Stern et al. 2002]. They thus seek to understand those conditions in which the generalization holds and those in which it does not.

Theories are useful for prediction: they alert us to those aspects (or variables) of setting to attend to, and possible causal relationships that may hold between different variables. In other words, we can use theory developed in other settings to inquire whether it is true in our own. We can as well use theory to explain data collected in one setting; it can provide an account for why certain things occurred.

But theories also provide framing, the interpretive perspective that informs all of the choices within a research study. If the theory is not explicit, then there is an implicit theory that is still operating, embedded in all of the choices that are made by the researcher: how data is collected, how it is interpreted, the inferences that derive from it, and the sense that is made. Making this theoretical base explicit in a research study makes it amenable to scrutiny, critique, and improvement.

A useful entry point for theory in the social and behavioral sciences that can be applied to education is provided by Svinicki in *A Guidebook on Conceptual Frameworks for Research in Engineering Education* [Svinicki 2010]. This report was developed and funded as part of the project *Rigorous Research in Engineering Education* funded by the U.S. National Science Foundation (DUE-0341127 and DUE-0817461) [Cleerhub 2010]. In a mere 53 pages, it discusses theories about learning, motivation, cognitive development, disciplinary ways of thinking, and assessment. A bit heavy on psychology, and light on theory from many of the traditional social sciences that might bear on educational research (e.g., sociology, economics, political science, anthropology), this guidebook nonetheless satisfies our Swiss-army-knife criteria: sufficient for entering and for summarizing a large body of research in a small space in ways that are useful right now.

1.2 Method: Investigating How People Learn

Method refers to the way in which empirical work is carried out, the "how" of social and behavioral research. Methods are the intellectual tools that disciplinary communities have developed in order to pursue their problems of interest. Methods determine and structure the collection of data from probing the ontic world so as to determine what people do in what contexts for what reasons: surveys, interviews, instrumented software, card sorting, observation, to name a few.

Method also refers to the manner in which this collected data is analyzed. It is fundamentally about making sense, developing an understanding of the phenomenon under study. This includes such things as statistical calculations (e.g., analysis of variance) from survey data, and grounded theory for coding, classifying, and building theory inductively from interview data. Data collection and data analysis are not independent; one collects data with the methods of analysis already in mind.

Method is also not divorced from theory, for it comes with theoretical assumptions "built in." So for instance, if one is investigating changes in student motivation based on a particular intervention using pre- and post-intervention surveys, the survey questions (e.g., "Did you enjoy the activity?") embed assumptions about the nature and characteristics of human motivation. Theory and method are thus tightly coupled.

A useful entry point for method in the social and behavioral sciences that can be applied to education is provided by Sally Fincher and Marian Petre in the chapter "Use methods that permit direct investigation of the question" from their book *Computer Science Education Research* [2004]. While the entire book may be useful to the novice researcher, this chapter in particular targets empirical research methods. At 17 pages, this chapter is not a primer on any particular method, but rather a broad overview that maps the territory. It defines and distinguishes a number of major types of data collection and analysis methods, indicating when and where they are most usefully employed. From this overview, a novice researcher is well prepared to delve more deeply into the specifics of particular methods using additional resources.

2. HEURISTICS FOR UNDERTAKING COMPUTING EDUCATION RESEARCH

We end this editorial with a small set of heuristics for the researcher getting started with computing education research. Our belief is that empirical research is best learned in its doing.

— Swiss army knife: Pursuing the Swiss army knife philosophy, learn one or two methods, such as surveys and semi-structured interviews, that will serve over a broad range of studies.
— Start small: Start with a simple, small study that answers a straightforward question. Use a single data collection and analysis method that can be carried out in a relatively short period of time.
— Collaborate with colleagues from "source" disciplines: Find a colleague in education or one of the social sciences. Even if they do not join as an equal partner, they may be happy to serve as a consultant before, during, and after the data collection.
— Be willing to ask questions other than "is X better than Y": Expanding the range of questions that you ask (e.g., "how do students interpret a UML class diagram") may lead to surprising insights. We pursued this topic further in a previous editorial [Tenenberg and McCartney 2008].
— Be agile: At many points during a research study, the researcher is faced with choices about what to do: how many subjects, how many questions to ask, how many methods to use. We recommend at each choice point asking "what's the simplest thing," and choosing this unless there is a compelling reason otherwise.
— Look before leaping: Data collection and analysis take time and resources. Before going to the trouble, ask "suppose I have this data. What will it tell me?" Will it provide useful insight into the questions that you care about?
— Pilot your data collection protocols and instruments: Prior to undertaking full-scale data collection, it is important to make sure that the data collection instruments (and procedures for their use) have been tested on a few research participants. It does not matter if the data you expect would be useful if the instruments deliver something else.
— Keep an audit trail: Just as the lab scientist keeps a careful log of the procedures followed, the empirical researcher in the social and behavioral sciences should be similarly careful. Not only is it important to document what is done at each step, it is also important to document why. Using this audit trail in reporting results will provide warrant to other researchers who might question the truth claims.

Undertaking research in computing education requires a complex blend of disciplinary knowledge, as well as sufficient skill in making empirical probes and making sense of the collected data. Borrowing method and theory from the social and behavioral sciences leverages the intellectual depth of these disciplines to improve the teaching and learning within computing. We look forward to publishing the results that stem from these efforts.

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