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Reflections on the Cognitive and Social Foundations of Information and Communication Technology Fluency

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Abstract

Since the publication of the *Being Fluent with Information Technology* report in 1999, the importance of the topic has only increased in societal importance—even with the dramatic decline and reconstitution of the associated ICT industries. In this paper, I outline two sets of remarks related to a contemporary understanding of information technology fluency.

First, I react to the existing FITness framework from the perspective of the research literature on cognition and learning. Although the cognitive and learning sciences have only moderately focused on specific portions of the ICT domain (e.g., the disciplinary examination of networked information by K-12 students), there are also probable connections to be made in some areas (e.g., problem solving features associated with sustained reasoning and metacognitive processes associated with expert problem framing / finding, testing, and fault identification). On the other hand, there are numerous research opportunities that still need to be pursued. I focus on a couple of areas where the validity and systemic interactions of FITness components could be studied in the context of everyday ICT activities that exemplify fluency (e.g., among high school students).

Second, I spend some time developing what might be considered a new framework dimension consisting of *FIT social practices*. The existing FITness framework is predominantly framed around an individual-mentalistic construal of ICT fluency. I argue that these foundational social practices enable, contribute to, or in some cases fully constitute ICT fluencies. I leverage the 'practice turn' associated with recent research on human learning and development in order to highlight a few central FIT social practices documented in sociocultural research on sophisticated ICT usage. Specifically, I discuss two practices: (a) cultivating and participating in a FIT learning community governed by shared norms associated with distributed expertise, and (b) the practice of ICT 'storytelling' for bridging the abstract to the concrete and vice versa. These examples serve to exemplify this social practice dimension and highlight new possibilities for ICT education. I conclude the paper by detailing some of the associated educational implications of these FIT social practices.

Reflections on the Cognitive and Social Foundations of Information and Communication Technology Fluency

1. Introduction

Since the publication of the *Being Fluent with Information Technology* report in 1999, the importance of the topic has only increased in societal importance—even with the dramatic decline and reconstitution of the associated ICT industries. K-12 schools have continued efforts to expand access to ICT, provide the necessary computer network infrastructure, and engage teachers in relevant professional development and curricular integration activities. Also, research focused on exploring the unique affordances of ICT in formal education settings still seems to be on the rise.[1] And importantly, specific information and communication technologies have become cornerstones of the everyday activities and culture of youth—information and communication technologies have become fully integrated into the texture of their routine, daily activities (e.g., Ito, 2004; Lenhart, Rainie & Lewis, 2001).

In this paper, I outline two sets of remarks related to a contemporary understanding of information technology fluency. First, I react to the existing FITness framework from the perspective of the research literature on cognition and learning. Second, I spend some time developing what might be considered a new framework dimension consisting of *FIT social practices* that enable, contribute to, or in some cases fully constitute ICT fluencies in the twenty-first century.

[1] This is evidenced, in part, by the concentrated focus of ICT within the learning sciences community in terms of research activities and scholarship.

There seems to be a tension in the 1999 NRC report related to how FITness was bounded. This tension can perhaps be summarized by these two guiding questions:

1) What aspects of computer science should citizens understand with regards to information and communication technologies?

2) What understanding of and competencies with information and communication technologies should citizens possess?

Where some may see these as equivalent guiding questions, I take them to be overlapping and somewhat divergent ways of being fluent. I take the latter as being more inclusive of a range of sophisticated everyday activities associated with ICT (e.g., being able to participate in a variety of ICT modes of communication, using ICT to inform personal decisions) that do not part in parcel necessarily connect to an understanding of computer science. In this response, I consider both frames on FITness to be important given the set of rationales enumerated within the report and ICT trends in society.[2]

2. Reflections on the cognitive and learning foundations of FITness

The NRC report *Being Fluent with Information Technology* (1999) presents a tripartite FITness framework consisting of core intellectual capabilities (IC), fundamental concepts (FC), and contemporary skills (CS) associated with information and communication technology fluency. To date, the cognitive and learning sciences have only focused on specific segments of the ICT domain. In order to explore select aspects of the cognitive and learning foundations of the FITness framework, I begin by asserting some connections to general principles or

[2] I do see evidence of both fluency frames in the 1999 report, although there is more of the former than of the latter. Perhaps it was a natural result of working within the constraints of the 30 components of FITness.

characteristics of cognition and learning and then describe some areas of specific research on FITness components. It should be noted that having to rely upon general principles is less than ideal; below I also detail a research agenda that would help resolve this issue.

Problem solving. As we might expect, there are many connections to be made between accounts of problem solving and many of the components of FITness—from principled and disciplinary identification and specification of a problem (cf. IC #1), to the decomposition of problems and the sequencing of corresponding components of a problem solution (cf. IC #2), and to the broader utility of more abstract domain knowledge (cf. IC #10). It is worth noting that beyond the relevance of these general features of problem solving associated with ICT fluency, many features of ICT expertise involve domain-specific problem solving. For example, the details of quality debugging procedures while programming (cf. IC #4) are best understood through direct empirical studies of programmers than a reliance on general principles.

Metacognition, learning & trouble-shooting. A broad range of research has highlighted the benefits of metacognition when learning—about concepts and inquiry—and when engaging in problem solving (see Bransford, Brown & Cocking, 2000 for a summary of much of this research). Similar benefits of reflection are referenced in the NRC report with regards to the cultivation of more abstract knowledge about technology (cf. IC #10). Beyond this one explicit reference, there is likely an important role to be played by metacognition associated with the intellectual capabilities associated with 'testing a solution' (IC #3) and 'managing problems in faulty solutions' (IC #4) (e.g., during fault identification as part of troubleshooting; Frederiksen & White, 1998) as well as with the cultivation of technological concepts (cf. the conceptual change in science research of White & Frederiksen, 1998).

It is also useful to note the central importance of utilizing a mental model for the system in question during associated reasoning processes. Frederiksen and White (1998) argue for the benefits of functional models in particular, which reveal the device-centered propagation of system effects, to aid in the troubleshooting complex technical systems.

Organizing, navigating and evaluating information (IC #5). There is extensive literature on how people process and manage information, and the 1999 report gives a fair amount of attention to the matter (under IC #5 and in the section on 'information literacy'). Since the publication of the report, learning scientists have continued to document how information and communication technologies can be used in educational settings to support students in disciplinary learning and inquiry. For example, our Web-based Inquiry Science Environment (WISE) project has explored how to support students in important epistemic practices associated with the natural sciences (e.g., forms of scientific argumentation, critique, and design) as they critically engage with scientific information from the Web (Bell & Linn, 2000; see Linn, Davis & Bell, 2004 for a summary of a decade of such research). This is similar in kind to the Kids as Global Scientists effort discussed in the NRC report. More generally, there are a range of similarly motivated research projects that have explored such things as: scaffolding students' explanation of complex scientific data sets (Edelson, Gordin & Pea, 1999; Sandoval & Reiser, 2004) and engaging students in scientific modeling linked to complex data sets over the network (Horowitz, 1996). One aspect of these efforts that sets them apart from 'information literacy' approaches to information evaluation has to do with the discipline-specific focus of how students are supported in working with the information at hand—the epistemological criteria used for information and data, the nature of the 'theory work' at hand, and the underlying conceptual details which are implicated in the analysis. To put it another way, one would not want to have

students interpret a piece of historical information in the same way as information derived from a scientific experiment (cf. Stevens, Wineburg, Herrenkohl & Bell, 2005 for a relevant description of a research agenda associated with developing a comparative understanding of school subjects).

FIT research priorities. My personal sense is that there are significant gaps in the FITness literature, especially when one takes a more 'whole cloth' approach to understanding the associated learning phenomena—across cognitive, affective, social, and cultural dimensions. This is particularly the case within the context of rapidly evolving technologies. Let me briefly detail one example to highlight this kind of gap. Consider the proliferation of chat and instant messaging technologies within youth cultures over the past five years—involving synchronous, multi-stranded textual exchanges among groups.[3] Such exchanges involve arguably new forms of social interaction mediated by specific technological implementations (e.g., intermixed strands of discourse from a variety of participants who may or may not know each other) as well as significant linguistic stylization (cf. Crystal, 2001). An understanding of the cognitive and learning phenomena at play within such technological environments might consider dimensions of text comprehension, working memory, specialized linguistic registers, novel interactional processes, and related micro-cultural processes (e.g., establishing participation norms). And, frequently, youth are engaged in chat or IM activities while 'time cycling' with one or more other activities or parallel communication sessions. It should also be noted that workers are also frequently IMing with collaborators these days as constituent parts of larger, collective work efforts. Some of the foundational research of the kind I'm describing exists for chat and IM (e.g.,

[3] The NRC report makes reference to chat communication technologies, but it is not a central feature of the existing FITness framework relative to its prevalence within youth and workforce segments of society.

Schönfeldt & Golato, 2003), but much remains to be done—especially with appropriate attention given to FITness.

With this kind of 'whole cloth' orientation, let me discuss a couple of research directions that need to be pursued more systematically. First, many youth communities are vigorously adopting and customizing information and communication technologies for their own purposes (e.g., social networking, multimedia journaling, entertainment). In that these uses in many cases represent sophisticated and authentic ICT fluency, we need to directly observe and systematically understand how such activities are accomplished in the naturalistic settings where they occur among individuals and groups who represent FIT experts. This *'everyday cognition' ICT agenda* would allow us to do the following: (a) confirm the ecological validity of specific FITness components, (b) investigate how FITness components are coordinated in action and more generally interrelated, (c) potentially identify important, "missing" components of ICT fluency associated with contemporary fluency with a range of quickly evolving technologies (e.g., blogs, wiki, IM, gaming engines, podcasting) and project domains (e.g., civic engagement, open source development, family communication), and (d) document the 'learning ecologies' associated with sophisticated ICT fluency (cf. Barron, 2004).

A second research priority naturally follows from the products of the first. After documenting the range of ICT fluencies associated with a specific population (e.g., high school students) for a particular kind of project, educational research could then be mounted to learn how to bring such fluencies to broader populations. This sequencing of research should serve to enhance the ecological grounding of educational ICT efforts. A related kind of ecological

grounding might also be accomplished by systematically observing students learning about FITness in their projects that take place outside of the bounds of the original course.[4]

A third research agenda—already enumerated above—might focus on developing a comparative understanding of how ICT can support disciplinary-specific learning and accomplishment (e.g., how it can support a student in thinking more like a mathematician versus thinking more like a scientist).

2. FIT Social Practices

The existing FITness framework is predominantly framed around an individual-mentalistic construal of ICT fluency—as evidenced by this quote from the NRC report:

> FITness is a body of knowledge and understanding that enables individuals to use information technology effectively in a variety of different contexts. (p. 40)

I believe it is fruitful to leverage the 'practice turn' associated with recent research on human learning and development (cf. Jessor, 1996; Schatzki, Knorr Cetina & von Savigny, 2001) in order to consider social practices that seem to be important components of FITness. In the following sections I highlight two candidate social practices documented in sociocultural research on sophisticated ICT usage. Taken together, these components can be used to argue for a new framework dimension consisting of *FIT social practices* that enable, contribute to, or in some cases fully constitute ICT fluencies.

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[4] Versions of the first two of these research priorities are currently being pursued in the NSF-funded Learning in Informal and Formal Environments (LIFE) 'science of learning' center (for more details on this effort see http://life-slc.org/ as well as Bransford, Vye, Stevens, Kuhl, Schwartz, Bell, Meltzoff, Barron, Pea, Reeves, Roschelle, J. & Sabelli, in press).

Cultivating and participating in a FIT learning community governed by shared norms associated with distributed expertise. Solutions to ICT problems sometimes reside within distributed communities—not in the mind of an individual who encounters a given problem. It is an important form of ICT fluency to be able to locate or broker a solution from individuals in such a community. Generally, individuals routinely leverage their social networks to identify useful knowledge and relevant learning resources as part of their day-to-day dealings. For those immersed within what could be characterized as an *ICT learning community*,[5] they may learn about new technological systems and approaches from others in their social network. They consult individuals with different kinds of expertise to aid in solving problems being encountered. Networked forums and other forms of electronic communication allow for these ICT learning communities to be geographically distributed and inclusive of diverse forms of expertise. Similarly, Barron's research on the development of technological fluencies has identified how individuals navigate their 'learning ecologies' to best effect during their technology design and development work—which includes tapping others with differential knowledge (Barron, 2004).

In our ethnographic research on the technological fluencies of undergraduate engineers (cf. Bell & Zimmerman, in preparation), we have documented an interesting social norm associated with an ICT learning communities. These undergraduates have established sets of blogs used to share various kinds of information associated to their technological activities. Through our observations and interviews it has become apparent that this distributed, informal learning community maintains its vibrancy—its growing information database and hence its utility—through a shared social expectation of individuals systematically contributing newly

[5] An ICT learning community can be considered a specialized form of what Engelbart has referred to as a 'networked improvement community.'

acquired information to the community through their personal blogs as a routine course of daily affairs (i.e., before anyone expresses a need for that particular information). By routinely documenting their problems and associated solutions to these online information spaces, the community is facilitating future ICT problem solving of others and making the distributed expertise of the group more readily available.

I am arguing that being able to participate in these kinds of informal learning communities—where distributed expertise is the norm and collective practices are in place to share expertise and "hard won" practical knowledge—is an important, and perhaps even a foundational, form of ICT fluency. I fully expect to find similarly constituted ICT learning communities in the workplace as well as in education.

Storytelling as a means of bridging the abstract to the concrete and vice versa. Occupational communities make central use of storytelling in order to function. In his ethnographic research studying the social and technical activities of photocopier technicians, Orr (1996) documented how the routine production and exchange of technology-related narratives serve to: (a) describe the 'ill structured' problems encountered in the field, (b) convey relevant information and past solutions among technicians, customers, and management, (c) situate information for use in a given context (i.e., to bridge from the abstract to the concrete), and (d) diagnose issues in order to make problems soluble.[6]

The nature of human development prepares us to engage in sophisticated forms of narrative cognition and communication (Bruner, 1987). Being able to engage in ICT

[6] Other social functions of narratives, further afield from FITness, include demonstrating competence to colleagues and customers, maintaining social bonds among clients and technicians, demonstrating organizational hierarchy, and define group memberships and boundaries (see Orr, 1996 for details).

storytelling—to construct and interpret narratives that map onto problems and projects—can then be thought of as a foundational practice associated with information technology fluency. Interpreted from the perspective of this social practice, sustained reasoning (cf. IC #1) is often a social process.

Educational Implications of FIT Social Practices. I believe the two aforementioned social practices serve to exemplify a possible way to elaborate the FITness framework. They also provide insight into ICT education. As is more generally the case, social practices provide relatively concrete images of how students can be engaged in activity as part of educational experiences. In this case, students learning about information technology could be systematically brought into the two sets of practices outlined above. First, they could form (or join) an ICT learning community and learn the social norms associated with operating as a distributed expertise community. Second, through appropriate modeling and scaffolding, students could learn how to engage in productive ICT storytelling related to the projects and problems they are working on. In the process students would likely be learning relevant intellectual capabilities, fundamental concepts, and contemporary skills in the process. It is possible that through 'team-based' courses, many students likely are being brought into such practices—but I believe it would be helpful to more explicitly focus on these social practices as fluency outcomes to be cultivated through educational efforts.

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