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Learning for learning economy and social learning

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ABSTRACT

Failure to meet the preferences and needs of users has been consistently stressed as a major cause of unsuccessful R&D for over 30 years. Yet little seems to change. An important element in this “producer–user paradox” is a lack of frameworks able to inform empirical research and the work that people do when they bridge designing, implementing, using and managing new technology. “Learning economy” and “social learning in technological innovation” appear promising as such integrative frameworks not least due to their emphasis on learning between producers and users. The present paper examines the value in the way learning is treated in these frameworks for empirical research and for the practitioners, and to this aim contrasts these frameworks to findings from a line of studies on learning between producers and users of new health technologies.

1. Introduction

Failure to meet the preferences and needs of users has been consistently reported as being a major reason for unsuccessful R&D, particularly in high technology and software. In the 1970s a series of studies, including project SAPPHO, compared successful and unsuccessful innovation projects with regard to a range of different characteristics. Understanding of user needs was found to be one of the very few factors that was statistically significant and consistent (Coombs et al., 1987, 93–119; Rothwell et al., 1974). In the 1980s 70% of UK and US large information systems were classified as functional failures, bringing only harm or marginal utility for their customers (Gibbs, 1994). In the mid-1990s product developers' own estimates about the failure rate of software projects was an astonishing 84%, in which failure to meet user needs featured again as the most common reason at 12% (StandishGroup, 1995). The situation has not changed. More in-depth inquiries about the dynamics of particular R&D processes also portray a similar difficulty in dealing with use and user-related issues in design (e.g. Miettinen et al., 2003; Rohracher, 2005; Williams et al., 2005).

At the same time, there has been a steady increase in management literature stressing users and clients as a key competitive asset (e.g. Leonard, 1995; Prahalad and Ramaswamy, 2004; von Hippel, 2005). This state of affairs has been characterized as the producer–user paradox (Miettinen et al., 2003): while research is consistent about the importance of addressing user needs better in product design, changes in technology production seem small. The explanations for this phenomenon vary from the hard-headedness of engineers and misplaced management practices (Cooper, 2004; Leonard, 1995) to users' poor competence in purchasing and stating their requirements (Cooper, 2004; Lundvall, 1985, 1988).

Attention could also be turned back to research as well as to what it has provided for professional training. Implementation, consumption, post-launch improvements, product development, industrial and systems design, management and policy are predominantly treated by disparate disciplines (Tierney and Williams, 1990). Integrative frameworks such as economic models of innovation or product development models, in turn, tend to give only a stylized treatment of issues such as information exchange, technical and cultural content as well as learning that connect these areas (Pollock and Williams, 2008). Integrative models stressing learning and interaction in producer–user relations have been argued to remedy this shortcoming (Lundvall and Johnson, 1994; Lundvall et al., 2002, 221; Williams et al., 2005).

However, approximating the processes and interactions by which innovation takes place as a learning by doing, using and interacting (DUI) in “learning economy” (LE) (Lundvall and Johnson, 1994) or as “social learning in technological innovation” (SLTI) (Williams et al., 2005) may lead to another problem. The scope, scale and types of phenomena that are analyzed as “learning” differ somewhat from studies of learning in behavioral sciences and in organizational learning (Lehenkari, 2006). This harks back to Jean Lave's apt remark (1993, 8): “That learning occurs is not problematic. What is learned is always complexly problematic”. Indeed a mere emphasis on learning in ‘learning economy’ and ‘social learning’ would remain almost trivial: People acting in changing

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socio-economic formations can be expected to be involved in all sorts of recursive learning processes. The added value from learning in these integrative frameworks for researchers and practitioners may hinge on what more specific orientation about the objects, nature and organization of this learning the framework can provide.

To clarify the issue further, this paper first examines Lundvall's work on producer–user interaction and the 'social learning in technological innovation' framework (Sorensen, 1996; Williams et al., 2005) and then contrasts them to findings from a line of study on interaction and learning between production and use of new health technology. Cast in terms of a research question, this means two interrelated concerns: How does the way DUI and SLTI treat learning affect the way these frameworks are able (a) to integrate a relevant scope of issues in producer–user relations? (b) to deal with learning as an empirical object of study?

2. Organized markets, learning economy and learning

Lundvall's research reveals that many producers and users do not leave themselves at the mercy of markets, but, instead, develop sustained relationships with one or several selected user and supplier organizations, which allow the exchange of qualitative information related to user needs and technological possibilities (Lundvall, 1985, 1988; Lundvall and Vinding, 2005). He asserts that such "organized markets" go against assumptions in standard microeconomics where "agents – firms and consumers – are assumed to behave as maximizers of profits and utility". And where "the only information exchanged relates to products already existing in the market and it contains only quantitative information about price and volume" (Lundvall, 1988, 349–350).

The result is a "focus upon a process of *learning*, permanently changing amount and kind of information at the disposal of actors... [a] focus upon the systemic interdependence between formally independent economic subjects" (Lundvall, 1988, 350 emphasis in original).[1] Lundvall here refers to "learning by doing", which was originally offered as an explanation of why the cost of manufactured goods tends to decline significantly due to the accumulation of skill in producing them (e.g. Arrow, 1962; Wright, 1936), and "learning by using", the users' increasing skill in and/or understanding of using the product, leading to, for instance, less maintenance, new uses and improved products after becoming "embodied" through redesigns (Rosenberg, 1982). Innovation is therefore seen as an interactive process that tends to be continued by both its users and developers over a significant period of time. To capture the overall thrust of these findings, Lundvall introduces the term "learning-by-interacting" and the ensuing learning by doing/using/interacting model (DUI), to stress the active engagement between designers and users as a source of new knowledge, technical improvements and economic growth (Andersen and Lundwall, 1988; Lundvall, 1988; Lundvall and Vinding, 2005).[2]

To thrive in the learning economy, actors are encouraged to complement their specialization with active linkages and in-depth trust-based relations with strategically chosen partners (Lundvall et al., 2002; Lundvall and Vinding, 2005). The specific measures include monitoring the innovations and modifications that users make to existing equipment as well as scrutinizing the bottlenecks and technological interdependencies that represent potential markets for the innovating producer. Along with seeking direct collaboration with some users, producers should estimate their skills and capabilities in adopting new solutions as a basis for their design decisions (Lundvall, 1985, 1988; Lundvall and Vinding, 2005). The scope of useful information to keep track of spans from codified "know-what" to explanatory "know-why", "know-who", "know-when" and "know-where" and, finally, to skills and actionable knowledge as "know-how". The perspective recognizes that power, trust and loyalty among actors are important as well as orients them towards balancing new learning, and forgetting and remembering issues in regard to the current relevance of knowledge (Lundvall and Johnson, 1994; Lundvall et al., 2002; Lundvall and Vinding, 2005). All in all, DUI model integrates a range of non-trivial issues that have practical relevance for policy makers (Lundvall et al., 2002, 221) as well as for practitioners grappling with the producer–user paradox at company floors.

In regards to our second concern—providing empirically grounded insight about learning—LE has more problems. Eric von Hippel and Marcia Tyre note: "Although the economic significance of learning by doing and using has been made clear, the *process* by which these gains are achieved is still quite unclear. That is, we do not know the micro-level mechanisms by which learning by doing is actually done" (von Hippel and Tyre, 1995, 1 emphasis in original). Indeed, the present author is not aware of Lundvall's or his co-researchers' work trying to do this.[3] Likewise, interaction, firm, organization, use, production remain for the most part assumed on the basis of earlier theory (e.g. Lundvall and Vinding, 2005). Taking these for granted may, however, neglect complexity involved as innovations tend to feature highly uncertain, shifting and only emerging relations and actors (Sorensen and Williams, 2002; Van de Ven et al., 1999), as becomes evident from the SLTI framework. This is where we turn next.

3. Social learning in technological innovation: the processes and contexts of developer–user interactions

Social learning in technological innovation (SLTI) "seeks to explore empirically and in detail the operation of learning economy... as a process of negotiation, subject to conflicts of interests amongst players with rather different capabilities, commitments, cultures and contexts" (Williams et al., 2005, 8). It draws from the social shaping of technology approach in placing particular design episodes within multiple, overlapping cycles of development and appropriation and focusing on the coupling between technological and social change (Rip et al., 1995; Sorensen and Williams, 2002; Williams and Edge, 1996). SLTI has further drawn on a range of research fields to understand the difficult and contested processes of learning that are integral to innovation (Rip et al., 1995; Stewart and Williams, 2005). These include cultural studies of artifacts and marketing, engaging with the consumption of goods and services; innovation studies stressing non-linear and heterogeneous innovation processes; and work on organizational learning and the reflexive activities of players in the innovation process (Williams et al., 2005).[4] The framework views the devel-

[1] Organized markets feature frequent innovations targeted at external users (product innovations), also implying that in-depth information sharing does not lead to integrating user or producer into an hierarchical relationship (Lundvall, 1985; Pavitt, 1984). The formidable investment in diversifying competences and unfavorable competitive position contribute to this on the developer side (Freeman, 1994; Lundvall and Johnson, 1994), while transaction costs and further agency costs (von Hippel, 2005, 48–50) do so from the purchaser side.

[2] Any pairing between designers and users is of course affected by the context in which it happens. Evolutionary economics regards that many such contextual issues are path dependent and form deterministic "natural trajectories" within and across industries. Associated "technological regimes" set preconditions and limits for what are sensible actions for both producers and users (Nelson and Winter, 1982).

[3] In some of his recent work Lundvall refers to Kolb's theory of experiential learning, but it has not been used in empirical analysis, its relationship to learning-by-doing, using and interacting has not been elaborated, and nor have its characteristics been compared to other equally potential theories of organizational, group or individual learning.

[4] Work on and referrals to social learning around social shaping of technology approach are by no means restricted to the particular model of SLTI, even as this

opment of new technology as an uncertain process, characterized by complexity, contingency and choice (Williams and Edge, 1996). It orients analysts to examine changes in technological visions, their material shapes, intended uses and identities of its users as well as in the network of actors involved.

Social learning in the SLTI framework is not a narrowly cognitive or social modeling process, and very different to its use psychology (Bandura, 1977). In the socio-technical usage of SLTI social learning denotes the reflexive yet often negotiated, complex and 'political' processes in transforming environment, instrumentation and work. This usage differs also from more generic conceptions of social learning in evolutionary economics (e.g. Gertler and Wolfe, 2002), where learning tends to be taken as an explanatory term, close to its use in learning economy.

SLTI findings stress that actors in innovation are involved in (a) *representation of uses, user*s and systems, beginning from concept design and continuing through product cycles. These include both implicit understandings of use as well as planning, conducting and evaluating explicit investigations on use, users and contexts of use. (b) *Translating and inscribing* understandings of use into technical characteristics during design. And (c) *Adapting* technology and work at implementation and further appropriation. The cyclic relationship between user representation, design and appropriation emphasizes "that design is not a one-off act, but is part of an iterative series of activities, informed by earlier design practice and feedback from the appropriation and use of other systems (earlier technologies in this application domain; similar technologies in related domains) (Williams et al., 2005, 110)."

Against this backdrop SLTI stresses the significant differences between proxy, intermediate and final users, and likewise, between final application or content producers and providers of the components and the substrate on which the developers of a given application build. The interactions and learning that takes place between the parties can take on a radically different shape depending on the nature of technology; whether it is a discreet object, tightly coupled system, its component part or a "configuration" of various basic components, delivery systems, applications and products, and their content programs (Fleck, 1993; Williams et al., 2005, 24–27).

Further differences in social learning processes ensue from differences in "innovation contexts" that are more specific than national, sectoral or regional differences (stressed by e.g. Lundvall et al., 2002, 218–219, 221; Pavitt, 1984). The key variations can be illustrated by constellations of design and use that were distilled out of 23 case studies on just one branch of ICT sector, multimedia products in late 1999s (Williams et al., 2005). Four other "innovation contexts" featured alongside a linear descent of components and supplier–user chains.

The first of these model was user-centered design (UCD), which has been widely advocated as a remedy for the producer–user paradox since the early 1990s. UCD methods enable designers to better tease out user knowledge during the development stage and involve users directly in design (e.g. Beyer and Holtzblatt, 1998; Norman and Draper, 1986). These proxy users allow designers to build a more or less complete and dedicated application that can be rolled out and fine-tuned to the different needs of its final users. However, UCD methods were used relatively seldom and not all UCD projects prospered, nor was UCD the only or most important means to relate design and use even in the projects where it was used (Williams et al., 2005).

More common with multimedia was a "pick-and-mix", "laissez-faire" model that was the closest thing resembling a "market" mediation encountered in these studies. Here designers put forward relatively cheap generic offers, which final users then purchased, mixed and configured for their specific needs. The cheaper price relative to dedicated applications made up for lesser utility and the additional work in compiling and using the system. The coupling between design and use was weak, but rather than market only, it was typically mediated by third parties such as sales organizations, service providers, cybercafés and more knowledgeable peers who gained condensed information on the use and sore-points of technology (Williams et al., 2005).

The third context was "innofusion and domestication", where somewhat asynchronous couplings between users and designers lead to improvement of the technology in use. "Innofusion" denotes continued innovation during the uptake of new technology that alters most of the functions, the meaning and the constitution of a configurational technology (Fleck, 1993). Domestication, in turn, refers to the efforts of users in fitting technology to their desires, social relations, physical arrangements, and in vesting it with sets of meaning they find appropriate for the technology after implementation (Lie and Sorensen, 1996; McLaughlin et al., 1999; Silverstone et al., 1992).

The fourth was technology experiment/evolutionary co-design, where designers, various intermediaries, regulatory agencies, intermediate users, proxy users and gradually also final users are involved in the evolutionary building of system and user-market where design and use are tightly connected in the gradually proliferating technology (Williams et al., 2005).[5]

SLTI is hence significantly more specific about the organization of developer–user relations than DUI and LE models. It does not directly address national or regional environment, but focuses on integrating a scope of findings below this scale of analysis that have direct bearing on how developer–user relations play out in innovation. Articulating further how the 'visible handshakes' (Rip and Groen, 2001; Hyysalo, 2004, 1–29, cf. Lundvall and Vinding, 2005) between development and use play out in innovation addresses important additional *scope in the issues related developer–user paradox* relevant for any actor enmeshed in particular innovation (or line of new product development). Also in regard the second concern of this paper, learning as an empirical object of study, SLTI provides a more fine-grained framework for integrating findings. However, SLTI studies in education (van Lieshout et al., 2001) and ICT design and uptake (Williams et al., 2005) and closely related work in sustainable transport (Hoogma et al., 2002), have focused more on elaborating the patterns of "reflexive governance" and their socio-technical dynamics (cf. Rip et al., 1995), than the details of the *learning* involved. To make this visible let us turn to Finnish studies that focused on learning between designers and users of health technology innovations.

4. Studies on health technology innovation: details of learning between developers and users

Parallel to SLTI studies in their timing and starting points in science and technology studies, these studies drew on socio-cultural psychology and activity theory to focus on learning that takes place "in the wild" at work both on individual and collective planes (Cole, 1996; Engeström et al., 1999; Vygotsky, 1978). Initiated by Prof. Reijo Miettinen and Dr. Mervi Hasu in 1995, these

may be the best articulated model of it. While much of the discussion in this paper applies beyond the particular treatment of social learning in SLTI, not all does. It is further difficult to pinpoint the exact 'boundary' where SLTI ends and 'neighboring social learning conceptions' begin. The situation is the same with Lundvall's work on producer–user learning and likeminded conceptions of learning in evolutionary economics.

[5] A particular innovation may have features of two or more of these generic models or it may shift from one mode to another in its different phases.

studies have examined the development and usages of particular innovations from their earliest visions to early stabilization of their use. The innovations studied include MagnetoElectroencephaloGraphy (MEG)-brain imaging technology (Hasu, 2000a,b, 2001; Miettinen and Hasu, 2002), PostitronEmissionTogmography (PET)-tracer development (Hyysalo, 2000), diabetes management database (Hyysalo and Lehenkari, 2002, 2003, 2005), safety alarm technology for the elderly and disabled (e.g. Hyysalo, 2003, 2004, 2006a), WWW-shopping service for the elderly (Hyppönen, 2004, 2007), a miniaturized clinical chemistry analyzer (Höyssä and Hyysalo, in press). The original research in this 12-year line of study has already been reported as thus far 19 review articles and four PhD dissertations (as well as two books and articles in Finnish), and the aim here is merely to review some of the key findings and illustrate five themes about learning in developer–user relations that have particular bearing on how learning is deployed in LE and SLTI frameworks.

4.1. Learning in complex settings cannot be assumed

Let us begin by recounting one of the videotaped interactions between engineers and medical staff in the clinical test use of MEG brain imaging (reported, in detail, in Hasu and Engeström, 2000). The clinical test in question prepared a shift from research use to a new wider market with real clinical patients, and hence was potentially important for both the pioneering users making the test as well as for the producer. It was hence a key moment in relationship that formed an organized market in Lundvall's (1988) terms and innofusion in terms of SLTI.

However, this 55-min measurement event worked out poorly. It was first delayed by the need to tune the measurement channels, the organization of the work between nurse and doctor caused further hindrances and it finally had to be terminated without results due to problems with software and the hospital's computer network (Hasu and Engeström, 69–77). Later, when engineers from the producer company were drawn in to solve the problem, a 60-min encounter followed during which they (a) focused on the then present observable state of the system which was satisfactory (b) turned the conversation to how error reports ought to be filed, and (c) had the nurse acting as a patient instead of a real-life set-up when pushed to arrange a further 60-min testing session as well as (d) shifted the evaluation of the test to instructing the medical staff about how to comply with good measurement practice (Hasu and Engeström, 2000, 79–84).

This episode is particularly interesting in two respects. First, as Hasu and Engeström remark, the engineers substituted the object of users work—fluent and reliable patient measurement—with the object they were most familiar with, the technicalities of the measurement system. In their highly proficient management of this object the engineers caused the users to also shift to the technical object and therefore silenced the range of issues, goals and contingencies that went into the users' definition of the problems at stake. The net result was that the engineers failed to gain potentially strategic information for the producer. They also inadvertently taught the users not to raise problems spontaneously or in other terms than those set by the developers. The episode hence underscores how learning hinges on *negotiation between* parties when they perform episodes that comprise learning-by-using (cf. Sorensen, 1996).

While the engineers' handling of this episode left much to be desired in terms of learning from users, they had a tangible rationale: to get back to new development projects, crucial for the survival of the start-up (Hasu, 2001). Here is the second issue. Information in developer–user relations tends to be encountered and handled within multiple, overlapping contexts that set conflicting priorities. These tensions take on particular force because much of the relevant information in developer–user interactions is "sticky", embedded in site- and profession-specific practices and ways of using artifacts (Wenger, 1998; von Hippel, 2005). In other words, information, and reciprocally the need for information, is often not readily visible to people who are not participants in the practice in question, be that in R&D or in users' practice. Making such information actionable requires further steps: for instance translating users' problems to a form solvable by a developer means re-embedding them in the practice of developers be that produced on site as in Orr's studies (1996) and the above example (Hasu and Engeström, 2000), in R&D laboratory (Tyre and von Hippel, 1995) or 'in portal' (Pollock and Williams, 2008). This includes finding time and resources amongst a range of other concerns that are by default pressing both in R&D organization as well as in medical settings. Efforts at learning about the problem of the other party, instead of only one's own problem, can become disfavored, even hazardous organizational behavior. For instance, in the safety alarm project we shall review below, the person charged with mediating between R&D and the customers was sacked or resigned five times in 5 years, while only three other employees of that company left during that time (Hyysalo, 2004, 189). Negotiations and professional politics within producer and user organizations tend to be complex and tied to whatever learning between the parties occurs as SLTI emphasizes. Indeed, organization, let alone firm, is not the only relevant unit here nor are individuals who interact (Fiol and Lyles, 1985), as the learning moves between individuals, groups and organizations (Engeström, 2000; Lehenkari, 2006).

The first lesson on learning: Assuming that learning in design-use relations consists of transmission (let alone transactions) of information is likely to be a recipe for unhelpfully shallow advice for practitioners. In order "to understand the dynamics of interactive learning or knowledge creation, we need to study interaction between people: what was learned, how, by whom and at what level of work and organization" (Miettinen, 2002, 45).

The first implication for integrative frameworks: An integrative framework must not gloss over or filter away relevant empirical insight related to these various micro-level mechanisms and hindrances.

4.2. Learning for interaction has constitutive importance

The second theme is the constitutive role of learning *for* interaction that is needed to make effective information exchange possible. Some of this is presumed but not discussed in detail in DUI model (cf. Lundvall, 1985; Lundvall and Vinding, 2005), while the organization of learning, trials and experiments has been a key theme in SLTI (van Lieshout et al., 2001; Williams et al., 2005). Yet the processes of learning for have received less attention. Findings from the safety alarm and diabetes software cases offer an instructive addition to the MEG vignette above.

The safety alarm system was initially developed within a linear innovation context. Whilst both its developers and users had experience from earlier safety phone systems, they had little direct contact between them prior to the market launch in 1997 (Hyysalo, 2003, 2004). Developers handled problems in reliability and usability as a matter of instructing users better and fixing technical bugs. In 2000 the company changed nearly all aspects of its user relation: marketing, training, field-visits, ways of interacting, processing information in the company, et cetera (Hyysalo, 2004). Many user organizations responded positively and active collaboration ensued providing the company with an influx of information for developing their next generation device.

Interesting here is what made this shift possible. Firstly, as indicated by DUI model at general level (Lundvall et al., 2002) *questioning and unlearning* was vital. This included gradual questioning who the users were (not the still healthy elderly living at home, but more frail people in care-facilities) and what was the make-up of their technology. Developers had treated it as a discreet and fool-proof stand-alone device, and came to understand that in users' settings it was in fact part of a varyingly deployed configuration that included other systems and procedures (cf. Fleck, 1993). This led to reconsidering what aspects of the system had to be changed (e.g. alarm categories, responding to alarms, software interfaces), and further affected the roles set for designers and users in gathering information about problems, for instance, developers' beginning to trust problem identification and site specific configuration for rest-home nurses who were initially seen as too incompetent for such tasks (Hyysalo, 2004, 2006b). Secondly, the shift in orientation was fuelled by a series of mundane encounters with other stakeholders: fixing technical bugs, assembling, training, trying to sell, enrolling partners, et cetera. This could be characterized as 'informal learning', 'orientation' to the environment, or as is preferred here, opening socio-material 'cognitive trails' in the multi-organizational terrain that comprised elderly care and living (Cussins, 1992; Engeström et al., 2003). These trails—meandering around error logs, conversations, users' work-arounds, instructions, and assigning main-users as links to each site—were the ones that were in 2000 broadened for collaboration (Hyysalo, 2006b).

In the diabetes software project learning for interaction took a very different form due to an 'evolutionary co-design' innovation context and a history of building earlier systems for the same purpose. This innovation process was initiated in 1996 by a group of (lead) users, medical researchers and practitioners specialized in diabetes. A software company joined their development effort, and the parties spent intensive months in learning about each others' skills, environments and goals. New user-partners were enrolled from other occupational groups treating diabetes to tailor the system for the requirements of the whole scope of diabetes care and key local variations in Finland. By 2001 the database had spread to most of the hospital districts in Finland, while in total 21 prior programs had failed in this (Hyysalo and Lehenkari, 2003, 2005). Much of the learning on how to build this kind of software (what data should be entered, in which order, how, and under what priorities and constraints) as well as learning for organizing the developer–user collaboration was known by the *users* due to *their* previous development projects—yet resided only in the previously unconnected memories of various user-developers entering the project (Hyysalo and Lehenkari, 2002, 2005).

The second lesson on learning: Learning *in* network collaboration among developers and users is preceded and accompanied by learning *for* this collaboration, and propelled by prior actions and events that have highly varying shape.

Second implication for integrative framework: Adequate comparisons between different projects and further elaboration of their dynamics is something that integrative frameworks such as DUI and SLTI could clearly be useful in. The variations in the 'learning for and in' owe much to the innovation context and the histories on which developers and users build—this favors more detailed treatment of the issue given by SLTI in comparison to DUI.

4.3. Conflicts and power are mixed with collaboration: multilevel games

The third theme is the power relations between and among users, developers and regulators that was an important facet in the learning between the parties, even though none of the health technology projects were very controversial as such.[6] LE and DUI model stresses that interactive learning may not be just a positive sum game but lead to creative destruction, and stresses also the effects of opportunistic behavior on learning and the potential conflicts due to power and income (Lundvall et al., 2002, 226; Lundvall and Vinding, 2005). SLTI connects conflicts and power to social learning between the parties.

The harmonious co-design of the diabetes software lasted only until the second version of the product in 2001. At this point two conflicts of interest became prominent. Firstly, the company had accumulated functionality and created customized versions to a point where it wished to close the design despite further requests. Secondly, no regular primary care unit wished to use the program because it would have practically meant filing in much of the data of each diabetic patient, basically after hours, while the net beneficiaries of the information were the specialists and researchers, who could now also scrutiny all treatment given in primary care through the program. In effect, the database would have subjugated the non-specialists (who treated the majority of diabetics) into comprehensive recording of the disease and place them more firmly under the control of the specialists, who had been involved in designing the program (Hyysalo and Lehenkari, 2002). A less burdensome version for primary care was developed, but slowly: the producer preferred to minimize its effort, as well as to work separately with users who, in turn, were now divided over the appropriate content (Hyysalo and Lehenkari, 2005; Miettinen et al., 2008).

Such *multi-level games* reach beyond technical content (Hoogma et al., 2002; Sorensen, 1996; Williams et al., 2005). In the safety alarm case key features of the business case—such as introducing continuous monitoring of relatively healthy residents and seeking cost-savings through technically supported extra-mural care—were resisted as potentially harmful for elderly care by many caregivers and health care officials. The developers learned to differentiate their message for different audiences, to tone down these most unnerving ideas and introduce a set of changes to make staff in elderly care more positively disposed (see Section 4.2). When the reputation and reliability of the technology increased, the developers returned to more stringent instructions on how to deploy the system (entailing more changes in work procedures) and some of the new care facilities hired one less staff member because of the added technical security (Gävert, 2008).

An aspect of multi-level games concerns filtering what is to be learned from evaluations and feedback (see also Hoogma et al., 2002; Williams et al., 2005). This can be as blunt as in the e-grocery shopping service project: When the new technology in the project collapsed in use so did the quality of shopping for the recipients. Even though they were medically diagnosed as requiring help, many quit the service. The total costs for the city went down, and it announced its satisfaction with the new more cost-effective delivery model (Hyppönen, 2004).

The fourth lesson on learning: Learning in developer–user relations includes reflexive domination and strategies of passive and active resistance. Yet, these can be mixed with mutually benefiting engagements made possible for a time or through efforts to differentiate the game played with different stakeholders (more on this see Lehenkari, 2006; Pollock and Williams, 2008).

The implication for integrative framework: Domination and power-relations should not be divorced from the register for addressing collaboration and learning.

4.4. Distribution of cognition and learning: user representation

The fourth cross-cutting theme arising from the Finnish studies is the importance of how learning is distributed socially and materially. Learning was not reducible to intra-mental cognitive processes of human individuals or to a "behavioral process" cut off from "cultural content" (Cole, 1996). Hence, "linkages between developers and users", "channels of information" and "monitoring" may not be

[6] In contrast to, for instance, new contraceptive pills, genetic screening or decision support software.

neatly analytically separable as DUI model assumes, here resting on information theory (Lundvall and Vinding, 2005). “User requirements capture” presents an illustrious point. There are literally hundreds of process descriptions and methods for how to do this (Hansen et al., 2007), yet, both SLTI and Finnish findings underscore how the referents of ‘the user’ and ‘uses’ tend to be far from obvious during an innovation project, even as competing representations may be closed for the duration of a particular design episode.

The Finnish projects feature a range of explicit requirements-gathering techniques, such as market research (in the diabetes database, safety alarm and MEG projects), business strategy studies, user interviews (all projects) literature reviews (safety alarm and internet grocery shopping projects). As in the safety alarm project, user-centered methods are sometimes used to complement these representations. As in many other studies on user-representation in none of the projects were these investigations the sole or sufficient source for representing use (Akrich, 1995; Oudshoorn et al., 2004; Williams et al., 2005).

Users are sometimes keen enough to act as testers of early beta and later pilot versions of the technology, participants in consumer panels, user-groups and even as partners in designing or visioning new products (Bødker et al., 2004; von Hippel, 2005). Whilst the diabetes software and PET-tracer development stand out as the most prominent of the Finnish projects with regard to direct user involvement in development activities, also in the MEG project brain researchers were prominent in its development during early R&D and in the safety alarm project users initiated several design ideas for its second generation.

Designers also use their own experiences as representational of the behavior of users. Using oneself as a reference for the user—I-design (Akrich, 1995; Oudshoorn et al., 2004; Williams and Russell, 2002)—was a common practice in the Finnish cases. For instance, in the safety alarm project a designer used his children’s and his own wrist to model how much length for adjustment must be built into the wristband for the elderly. Designers’ in-depth personal experience from doing users’ activities, such as climbing or sailing, whilst designing for these activities can be a highly successful resource (Kotro, 2005).

In design discourse common sense and folklore about specific groups of users such as the elderly accompany—and fill in gaps between—explicit requirements (Agre, 1995; Johnson, 2007). Generic visions about the future can also function as focusing points and proxies for what the users’ context will look like by the time the product is launched (Lente, 2000; Lente et al., 1998). All the health technology projects studied built on projections concerning the cost of health-care, such as the rising costs and amount of the elderly and diabetics. On the other hand, they built on generic imagery of greater efficiency of digital information handling, even though the diabetes, safety alarm and internet grocery applications in fact also generated significant amounts of new work.

Product developers’ professional backgrounds provide another set of representations of use. Design is conducted with limited resources and heuristics as well as pressing schedules and is affected by organizational divisions of labor, rules, career paths and hierarchies of decision-making (Bijker, 1995; Bucciarelli, 1994; Van de Ven et al., 1999). R&D professionals rely on experience in handling use-related issues in previous development projects and implementations. In the safety alarm case many design decisions affecting future usage resulted from other R&D priorities and trade-offs, such as those related to technical simplicity, reliability or cost of manufacturing. Such ‘de facto representations of use’ can pass into, for instance user interfaces, without ever being considered from the ventage point of how they would affect usage (Hyysalo, 2006a).

Finally, many representations of use build on ‘cultural maturation’: widespread media and technology genres that are assumed familiar to users. Generic genres of prevailing technological culture such as “movie”, “telephone call”, or interface using Windows – Icons – Menus – Pointing device (WIMP) are powerful conventions in bridging design and use. As generalized appropriation experience, such conventions, images, grammars and narrative structures can be trusted by designers to be decoded in fairly nuanced ways by all those people who have basic competency in a given technological culture (Haddon, 2004; Williams et al., 2005, 122–127). All Finnish projects built on this source of user-representation in some respect. It is however noteworthy that the (often dramatic) professional, age and gender differences between developers and users rendered developers’ initial assumptions of shared experience rather misplaced (as it did with I-design too), particularly in both technologies for the elderly. These sources of user representation are schematically portrayed in Fig. 1.

Moreover, there were important shifts in which user representations were relied on and who was considered reliable representative of future users and usages (cf. Akrich, 1995; Oudshoorn et al., 2004). In the safety alarm case the majority of early representations had to be abandoned or clarified after experiences from actual appropriation; in MEG the ones that were followed proved over-optimistic, and in the diabetes software the strong and articulated representations from expert users turned out unrepresentative of primary care practices. An ensuing point is this: even when developers have already formed sustained relationships with a number of key clients, the *ongoing innovation*, even in the same line of products, results in the need for further coordination, negotiation and articulation of competing user representations between developers and users. For a *routine* information *exchange* (Lundvall and Vinding, 2005), let alone market-signals, to become the links between developers and users, the innovation may need to become routine and incremental.

The third lesson on learning: Objects, instruments and contents are pivotally important mediators of learning in developer user relations. For instance user representations tend to be dispersed in the innovation network due to members’ varying access, competence, background and engagement with different aspects of the technology.

Implication for integrative framework: A substantial array of key issues for the producer–user paradox will fall by the wayside if objects and cultural contents receive only glossy treatment or discussed as separate from interaction and information.

4.5. Bridging situated learning episodes to slow changes in technologies and practices

The final theme is to deepen what the above means for studying empirically the learning between developers and users. Clearly, the learning that occurs in design-use relations is not limited to the small scale problem-solving tasks typical to behaviorist and cognitive learning research. To paraphrase Lave (1993, 9), this learning is a part of substantial forms of action, spread over time and place, taking its meaning from its connections with and within other activity systems; it concerns multiple aspects of participation at once, and tends to surpass any given problem or event. Neither is the learning reducible to firm-level or organizational learning both in that the learning of individuals and groups (see Section 4.1) and learning between organizations play an important part (Lehenkari, 2006). The resulting need to orient to, conduct and integrate findings from qualitatively different analyses of learning poses a further challenge for integrative frameworks such as DUI or SLTI. Let us exemplify with the Finnish studies:

(1) Studying co-located interaction between developers and users such as MEG troubleshooting episode are perhaps best captured by video-taped ethnographic material on actions and interac-

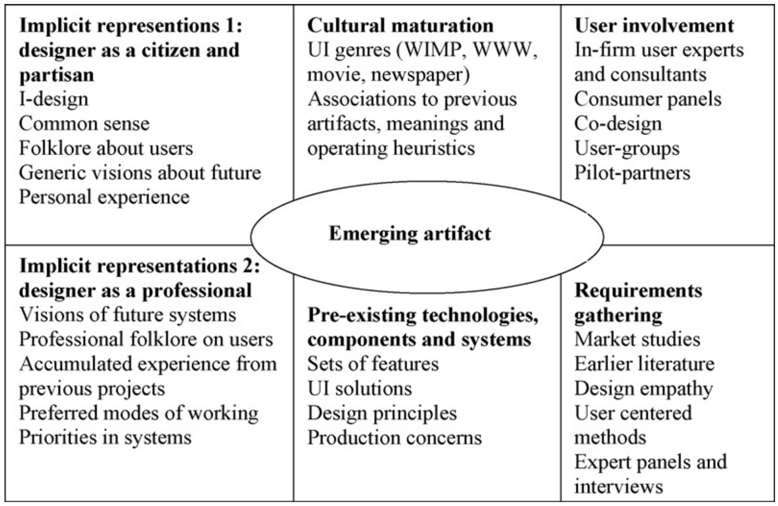

Fig. 1. A schematic portrayal of sources of user-representation.

tions and careful interaction analysis, including scrutiny of the material means and interpretations of participants (augmented by interviews before and after, Hasu, 2001). Studies of such 'in the wild' interactions has been typical to ethnomethodology, but few studies have addressed learning in this tradition (but see Melander and Sahlström, in press).

(2) Such analyses are vital to gain a grasp of the situational specifics of interaction, but leave much unattended: apart from technology experiments, developers and users are relatively seldom co-located. Interlinked episodes in developers' and users' activities need to be bridged in a principled way, even if the analyses then use similar data and analysis of directly observable behavior (Hasu, 2001; Hyysalo and Lehenkari, 2005).

(3) The above discussions on learning, however, predominantly describe strings of events distributed to both producer and user sites within which learning happens or fails to happen. These can only partially be ever directly observed, but require inferences from multiple, more or less indirect, sources of evidence. Some of their aspects became visible during field-observations of design meetings and product usage, and were further confirmed through interviews. Some only became visible because of the longitudinal scope of the study. Each of the Finnish studies focused on one innovation and lasted between 4 and 6 years. Historical and ethnographic inquiry was combined in order to zoom in and out between the over a decade-long development processes and the minutiae of interaction and learning in the design, implementation and daily use of these technologies.[7] This was seen as a prerequisite to studying how individual and collective learning processes emerged and evolved over time.[8] For instance in the analysis of post-launch learning in the health monitoring case changes internal to organizations of developers and users were first examined historically and then more thoroughly throughout a 5-year period. Changes in the relations between them were then mapped along six dimensions: the constitution of the product; designers and users orientation to the product; the physical terrain of interaction; the temporal extent of interactions; the nature of contacts and their means, and the contractual and normative assumptions of relationship. Data was then revisited for behaviors that had directly led to or acted as catalysts for these changes, and these were further analyzed as 'learning dynamics'. In doing this it was vital to compare interview statements with my field-notes on actual behaviors and to support inferences with the remaining documents, pictures, artifacts, and so on (Hyysalo, 2006b).

Conceptually the Finnish cases addressed the range of issues and scope study by using activity theory (Cole, 1996; Engeström et al., 1999). It emphasizes changing participation in relatively durable collective formations, activity systems, and underscores the mediation of human cognition and action by signs, instruments and other people. While this makes activity theory a kin to communities of practice (Wenger, 1998), it differs from it in important respects. It stresses the role of objects both as mediational means and as materializations of collective motives that animate an activity (Cole, 1996; Engeström et al., 1999). It further emphasizes precision in locating the action and learning in question in terms of slowly transformed activities, goal driven actions, and short term operations, and insist on working out the connections "from individual actions to collective activities and back" (Engeström, 2000). At the broadest level it would define learning between developers and users along the lines of an expanding capacity to transform objects and related contradictions in and between the participating activity systems (Engeström, 2000). This includes mechanisms often discussed in terms of single loop, double loop and deutero learning (Bateson, 2000; Argyris and Schon, 1978) with recognition that tentative searches, terminated efforts and shifts in orientation by individuals and groups are as much part of the learning as its possible later consolidation as more apt responses in the new situations that arise (Engeström et al., 1999). Introducing the approach further is beyond the scope of this paper—it has an 80-year history and several thousand publications—save the argument, *the fifth lesson on learning*: the conceptual register for addressing learning in developer–user relations needs to cover situated learning episodes as well as slow changes in objects, practices and participations. It further needs to link these in a principled manner.

The implication for an integrative framework is that it even if does not aim to offer such nuanced conceptual repertoire for studying

[7] Covering both the design and uses of the same technology and doing so on multiple time-scales has been surprisingly rare (Pollock and Williams, 2008). There are some more studies that do so in regard to changes over decades and years (e.g. Fisher, 1992; Kline, 2000) rather than the unfolding of actions in weekly let alone minute-by-minute basis.

[8] The safety alarm case is roughly illustrative of the amounts of data: 105 ethnographic field visits each of several hours, including over 80 hours of video recording; 77 semi-structured interviews on both developers and users, of average length one hour; six full folders of documents (detailed account is available in Hyysalo, 2004, 51–63).

these learning processes, its treatment of learning should make it compatible with framework(s) that can do this. At minimum the integrative framework needs to adequately discern and link different kinds of learning, settings and scales wherein they happen.

5. Discussion

Juxtaposing three approaches to learning between developers and users as constitutive of innovation makes evident the differences in what is represented through learning in them. In LE and DUI, learning stands foremost in opposition to neo-classical economics and assumptions of circular flow. It is used to emphasize the importance of a continuously changing amount and kind of information as well as the interdependencies and organization of economic actors in an innovation system (Lundvall, 1988; Lundvall and Johnson, 1994). In SLTI, learning is deployed to underscore the importance of trials, experiments, interactions between actors, and carry-over between projects in socio-economic change (Sorensen, 1996; Williams et al., 2005). In the Finnish studies, learning is used to grasp the dynamics of how developers and users interact and how this affects innovation processes (Hasu, 2001; Lehenkari, 2006; Miettinen, 2002). These differences in the referent, interests and disciplinary audiences are significant. The sceptically minded might be tempted to conclude that these approaches could not be usefully compared or learn from each other.

On the other hand, learning and interaction between producers and users—however these are treated—are key elements used to clarify socio-techno-economic change in all of the three approaches. DUI, SLTI and the Finnish case studies also share referents and some of the audience in innovation research, policy making and among practitioners. This more positive view was adopted in the present paper, and in this view the findings from detailed case studies should give some indications of the effects of how learning is treated in DUI and SLTI. More specifically, the interest has been in how this treatment allows these frameworks to integrate the scope of relevant issues in the producer–user paradox as well as to treat learning as an empirical object of study.

In terms of the *scope of relevant issues*, the emphasis on learning in both DUI and SLTI draws attention to the long-term organization and interconnections between various episodes in development and use. Themes one to four from the Finnish studies underscore this. It is vital to expand the typical project-focus that confines researchers, practitioners and handbooks in R&D and implementation (e.g. Bouwman et al., 2005; e.g. Ulrich and Eppinger, 1995) and clouds over the interactions and continuities in how given events in development and usage relate. Indeed, in the Finnish studies none of the developers' early ideas about uses and users carried through as such. The only clear-cut failure without any follow-on development, the e-grocery shopping project, was also the only instance where suppliers' solutions were not modified by user feedback (Hyppönen, 2004). Developers and users seem to systematically underestimate the challenge involved, leading the needed work to fall through the cracks of work roles and responsibilities. However, particularly themes one, two and three above indicate that models of learning economy would become stronger if it took on board the insights SLTI studies have produced on the variation in the shape of technologies, innovation contexts and the mechanisms by which different development projects and deployments of technologies feed on each other even within singular sectors.

DUI, SLTI and the Finnish studies are in agreement that learning *for* interaction is among the key issues in developer–user relations in innovation. This said, issues pertaining to everyday practices of developers and users remain under the radar of LE and DUI. This applies also to its treatment of themes one, three and four, which underscore how learning in developer–user relations is tied to the objects and relations it is about (and wherein it takes place). Users' gradual learning of their actual requirements, managing conflicting priorities in mundane encounters, difficulties in judging between competing representations of use, and multi-level games each characterize phenomena that practitioners struggle with, but do not expect.

Hence, while LE has offered means for analysing innovation systems and developer–user linkages within and across industries and regions (Lundvall, 1985, 1992), R&D practitioners rather need to master learning challenges—and to compare experiences—resulting from particular projects, technologies, contexts and representations. This is the kind of integrative capacity the more specific SLTI framework has. At best it could bridge findings from particular innovation processes to more aggregate level descriptions of learning economy and vice versa (cf. Pollock and Williams, 2008; cf. Williams and Russell, 2002).

With regard to *learning as an empirical object of study* learning-by-doing, using and interacting denotes phenomena with economic significance, yet the learning processes involved may be less clear. For instance, decades long improvements in new airplanes have been characterized as learning-by-doing and learning-by-using (Gardiner and Rothwell, 1985; cf. Rosenberg, 1979). Even if learning is regarded as an unintentional outcome of processes that have a different aim than learning or increasing competence (Lehenkari, 2006; Lundvall and Vinding, 2005), glossing as learning—or taking learning as the side-effect of—all the adjustments, calculations, competition, planning, tinkering, requests, complaints and so on that went on all this time in a number of large companies runs into serious over- and under- determination problems.[9] Even such problems aside, in learning-by conceptions "the learning process remains a black box whose input consists of producers, users and their interactions and whose output for innovation is recognized, while what occurs between the input and output is obscure" (Lehenkari, 2006, 45). These problems concern both DUI and SLTI insofar as they resort to the "learning-by" register without treating learning in more nuanced ways; the same problems affect both the way they are able to orient practitioners and further research as well as their capacity to integrate findings from more detailed studies on learning.

Indeed, LE and DUI still seem to treat learning in a sanitized social, behavioral and objectual sense in comparison to SLTI and the detailed case studies. Objects, domination, miscarried efforts, sacrifices, and unwillingness and failure to learn—all crucial parts of learning between developers and users—are not elaborated as parts of the treatment of learning in this framework. With regard to studying learning (lessons two and five) both frameworks rather provide an integrative background-frame for learning processes rather than engage directly with them. Even the exemplary analysis of troubleshooting in the digital environment of a global software company by Pollock and Williams (2008) only documents the *types* of engagements and interactions, but does not explicitly follow the development of the individual, group, organizational and inter-organizational learning processes leading to them. In both frameworks there is also a lack of concepts for discussing micro-level learning processes and there has been little reporting on research designs concerning ways to study them. Specific studies on learning in the wild could provide useful cues for how to strengthen this side of the frameworks.

[9] Many events that in hindsight may appear to have produced convergent or stabilizing outcomes visible in products and procedures could have had little to do with learning. At the same time, much of the learning in developer–user relations leads to divergent outcomes and trials that will not be visible as aggregate outcomes visible in the traditional data-sets or methods used by economists and economic historians (Miettinen, 2002, 45).

To sum up the line of argument, the juxtaposition of the three approaches suggests taking learning between developers and users seriously—including its micro-level mechanisms—as a key issue in socio-techno-economic change, and particularly with regards to the producer–user paradox. Indeed, the micro-level case studies (both within SLTI and the Finnish ones) lend support for emphasis on the many visible hands and handshakes and organized markets instead of arms-length market signals when it comes to innovation. Yet almost ironically, the way learning is treated in the DUI model—as in many other treatments of learning in innovation studies—leaves a clear gap to findings about it at the level of actual innovation projects: Capitalizing on learning as a socio-economic explanation has come at the expense of economizing on it as an empirical object of study. Mid-range frameworks such as SLTI hence appear useful with regards to bridging this gap and particularly with respect to the accumulation and comparisons of research results, vital for providing orientation for researchers and practitioners enmeshed in innovation processes.

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