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TRACING INNOVATION: AN ACTIVITY THEORETICAL APPROACH

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Abstract

This paper argues that tracing the diffusion of innovation is a challenging endeavour. The difficulty is that an innovation comes into existence as a cognitive and inter-personal idea and transforms over time into tangible and material manifestation. Grasping the evolutionary transformation from one form to the other requires a holistic methodology which crosses the boundary between both levels. Cultural-Historic Activity Theory is proposed as one means by which we may fulfil these requirements and bridge both worlds. An industrial research project set in the German automotive industry is analysed from an action research perspective. The framework of Cultural-Historic Activity Theory is utilised to explore the applicability of this as an intellectual approach that can assist our understanding of practice. The case study demonstrates how the framework aids the unravelling of an activity system, providing a narrative of the innofusion of a specific technology – a supply network decision support system (SNDSS). Finally, the paper concludes that the framework has merits for both practitioners and scholars.

Keywords: Innovation Studies, Diffusion of Innovation, Tracing Innovation, Activity Theory.

1 Introduction

In order to trace technological innovation a methodology is required which bridges the boundaries of the external, material world of the reality and the internal, cognitive world of the human mind. This paper argues that there is no appropriate methodology which crosses these boundaries and traces an innovation from its cognitive emergence through to its material manifestation in a technological artefact. Then, the paper proposes that Cultural-Historical Activity Theory, also referred to as activity theory, can be utilised as a suitable lens to frame the creation and progress of innovation and to track its traces retrospectivelyacross dimensional boundaries.It is demonstrated how the framework was applied to study the emergence and diffusion of a decision support system in the German automotive industry. The outcome of applying the framework is an analytical narrative which reflects the evolution of the innovation concerned.The paper begins with a review of relevant theories regarding innovation, the diffusion of technology and related methodologies. Then, Cultural-Historical Activity Theory is introduced as the framework utilised in this study. In the third chapter, the context and the research design are described. The activity theoretical analysis of the case study is presented in the forth chapter. The fifth chapter discusses the findings and describes the future direction of this work.

An innovation is defined as a subjective perception of the newness of an idea or a technology (Rogers, 2003). The diffusion of innovation within an organisational setting relies, among other factors, on the successful communication of the advantage and the adoption of the innovation throughout the organisation. McLoughlin (1999) emphasises that organisational learning is a major skill for the adoption of innovation. Many stakeholders see the diffusion of innovation as a linear activity. However, the adoption and implementation of a technological and, therefore, innovative change can be contradictory over time and does not follow any expected trajectories. For this reason, the term ‘innofusion’ is coined by Fleck (1988) to emphasise the multiple influences an innovation is exposed to and transformed by in the course of its implementation and use. Hence, Williams & Edge (1996) constitute innovation as a 'garden of forking paths' depicting its contingent evolution. From an activity theoretical perspective these forks are described by contradictions. Contradictions exemplify interruptions or conflicts in the process of learning. Engeström (1987) distinguishes four levels of contradictions ranging from internal contradictions within an activity system to contradictions affecting neighbouring activity systems. Resolving these conflicts changes the underlying activity and transforms it into a new activity. The diffusion of innovation is a trajectory of such evolving activities. Tracing these activities of innovation is a difficult undertaking. An innovative idea in one’s head is not easily cognizable. Its interpersonal diffusion occurs at the mental level. Only the externalisation into an explicit form such as spoken words or a technical artefact makes it visible and tangible. Popper (1972) introduced an ontological distinction of three worlds. World 1 contains physical objects, world 2 is the world of mental states and world 3 is the abstract world of thoughts and theories. World 2 mediates between the other two worlds. Rogers (2003) points out that cognitive innovations, for example ideas, are hardly observable, and concludes that studies of cognitive innovation lack an appropriate methodological approach. Using the words of Popper, a methodology is sought which crosses the boundaries of world 2 to the neighbouring worlds equally. Thus, the main quality of a methodology for studying innovation and its diffusion is the flexibility to cross dimensional boundaries. In scope of this research work, three theories were scrutinised regarding their applicability: Social Shaping of Technology (SST), Actor Network Theory (ANT) and Cultural-Historic Activity Theory (CHAT).

SST is a theory that draws strongly from Pinch and Bijker's (1984) theory of ‘Social Construction of Technology’ (SCOT). SCOT describes a social process where a technology is socially constructed through decisions of adoption or refusal by people involved in the development process. The contribution of SST is its relativisation of the ‘closure’, the finalisation, of a technology by means of a never ending process of shaping of a technology (Williams & Edge, 1996). Williams and Edge indicate, however, that SST is a ’broad church’ describing the various influences but not providing

further methodologies to utilise. ANT is another social theory describing the technology creation process from a group, here actors, point of view. A technology results as a consensus among members of a fluctuating network (Sætnan, 1991). Although ANT offers a viable methodological concept to study a heterogeneous network of actors it embodies some limiting assumptions. For example, Miettinen (1999) criticises ANT's symmetric perception of human and non-human agents and, thus, the neglect of Machiavellian actors. Instead, Miettinen regards CHAT as potential theory to fill these gaps. CHAT is a philosophical and cross-disciplinary framework offering instruments to examine social dynamics in developmental activities (Kuutti, 1996). This study follows Miettinen's (1999) recommendation and argues that the framework of CHAT enables the production an analytical narrative to examine the innofusion of a technological innovation. The following section introduces the framework and its applicability for the study of innofusion.

2 Cultural-Historic Activity Theory for tracing innovation

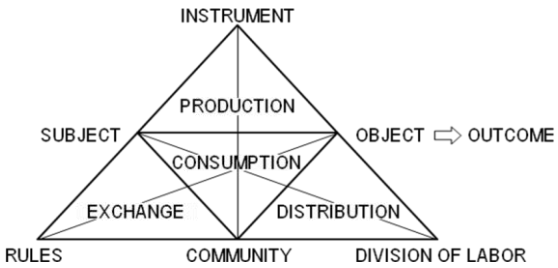

Figure 1 General model of an activity system (Engeström, 1987)

Activity theory emerged from the cultural-historical school of Russian psychology which was led by Vygotsky and his students in the early 19th century (Engeström &Miettinen, 1999). Today activity theory is a widely applied framework which has undergone further theoretical elaboration. For example, the theory of expansive learning, which studies learning processes, draws strongly from activity theory as the underlying theory (Engeström &Sannino, 2010).

As an intellectual framework, activity theory is based on the belief that human activity is object-oriented and tool-mediated (Engeström, 1987). A subject, whether an individual or a group of social actors, engages with an object following an intrinsic motivation to transform or manipulate it, into what eventually results in an outcome. The interaction between subject and object is mediated either by psychological or technical tools. This triangular model describes the main elements of an activity from a single subjective perspective and describes the aspect of production in an activity. However, activity theory succeeds in connecting the worlds of an individual and a society by incorporating further contextual factors. Within an organisational context, an activity always satisfies needs of a collective. Therefore, collaboration is an important characteristic and described with three collective elements. Firstly, division of labour represents what and how tasks and interactions are distributed within the activity. Secondly, the community element shows what social actors are involved. And finally, the element of rules depicts explicit and implicit norms of behaviour (see Figure 1 for a general model of activity theory).

Rogers (2003) outlines four factors which constitute the diffusion of innovation: the actual innovation, the communication channel where the innovation is spread, the time and the social system where the innovation diffuses. Activity theory, it can be argued, addresses all four 'factors', however, the richness possible through tracing a trajectory over time can also provide insights into processes of innofusion (Fleck, 1988). The innovation and newness of an idea can be found at least at two locales. Firstly, an innovation can be a new methodology or tool that mediates an activity. Or secondly, it can be formulated as the object motivating an activity if it is intangible, such as an idea. The aspects of communication and social system are portrayed by the contextual factors norms, community and

division of labour. Finally, the time factor can be analysed retrospectively by shifting horizontally to analyse preceding activities. Given these premises, activity theory is potentially valuable in studying the diffusion of innovation. To demonstrate the utility of activity theory, a historical analysis of an industrial research project is reported in the next section.

3 Context and methodology

This research undertaken follows a case study approach as it investigates the ongoing development and implementation of a supply network decision support system (SNDSS) in one single organisation, a company in the German automotive industry. The SNDSS is a complex expert system intended to provide strategic planners in supply and production networks with a tool to consistently model and assess these networks in order to reduce the level of uncertainty and risk around decisions. The development environment is conditioned by a co-configurational setting involving multiple groups and a fluctuating development team. Currently, the SNDSS (referred from this point on as the 'tool') is in the stage of implementation in different business units throughout the company.

The majority of the data was collected through participant observation over a period of 5 months. A peculiar attribute of this studywas the strong participation during the implementation stage. The author evaluated training needs of new users, created contents for training workshops, trained users in training workshops, and assisted the project manager in other tasks, for example, managinguser-related data. Bringing forward the idea of putting together the pieces in a community of practiceresulted inbeing an unofficial community manager. In summary, the contribution served directly the progress of the diffusion of the tool. Thus,the contribution can be regarded in parts as an action research approach. Due to these circumstances it was possible to conduct an insightful investigation including a thoroughgoing observation. In this case, thoroughgoing observation is interpreted in wider context and comprises phenomena observed in everyday activities as well as data gathered in many informal and short dialogues with other members. Further data was collected in seven in-depth interviews, including the research project manager, other researchers andusers. Additionally, document analysis enriched and validated the empirical data collection.

4 Analytical narratives: A story about contradictions

Data collection has produced a rich data set relating to the development and implementation of the tool, including information about people, events, artefacts and incidents. As the data collection is still ongoing an intermediate analysis was conducted to derive findings about the development and diffusion of the technology concerned. An activity theoretical lens was adopted both to guide the data collection and to analyse the data in order to structure the information.Eventually, modelsof activity systems were sketched. From these models, analytical narratives were developed reflecting the trajectory of the innovation. It is necessary to point out that the activities depicted are simplified and generalised abstractions of reality summarising activities observed during each stage. This compact view, however, facilitates the creation of an analytical narrative describing the entirety of the research project to the point where it is today. The narratives describe three stages: the conceptualisation, the manifestation and the diffusion of the tool. Each stage represents the activity system of the industry project from the perspective of the industrial research team. In the analysis, the first activity is portrayed in its entirety. Subsequent activities evolving from the first activity are described by emphasising the differences from the previous activity. Most elements remain as they are. Significant changes are found as instruments are utilised and goals set to accomplish the objective. Each activity is illustrated with a figure depicting elements and contradictions identified.

4.1 Conceptualisation of the innovation

This initial activity depicts the conceptualisation of the yet cognitive innovation (see Figure 2).

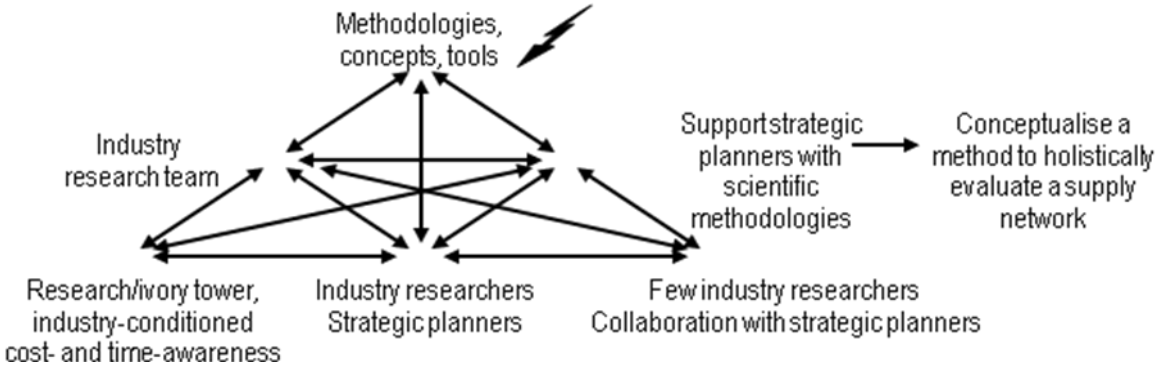

Figure 2 First activity: conceptualisation of the innovative method

The activities of the industry research team are motivated by their objective of supporting practitioners accomplish their objectives by applying scientific methodologies. To carry out the objective of the industry research team, a goal was set to create a holistic methodology for a monetary evaluation of a supply network. The methodology was anticipated to be a technological tool informed by business and engineering studies. Members of the 'community' comprised the industry researchers and the strategic planners. Work was divided among a few single individuals in the industry research team and included collaboration with strategic planners. The work environment of an industry research department is by nature contradictory. Researchers enjoy the freedom of working far away from the everyday activities of the automotive business. At the same time they are exposed to cost-efficiency and time pressure due to their dependence on their industrial clients.

As the activity aimed at producing both a methodology and a tool, it is obvious that the activity was prompted by the lack of these in the first place. Therefore, the research activity was driven by this initial contradiction in the tool set of strategic planners. Future activities are variations developed from this initial activity. The core objective, to support practitioners, does not change over time. It is the consequent adaption of the goal according to the current situation which indicates the progress of the overall project.

4.2 Manifestation into a prototype

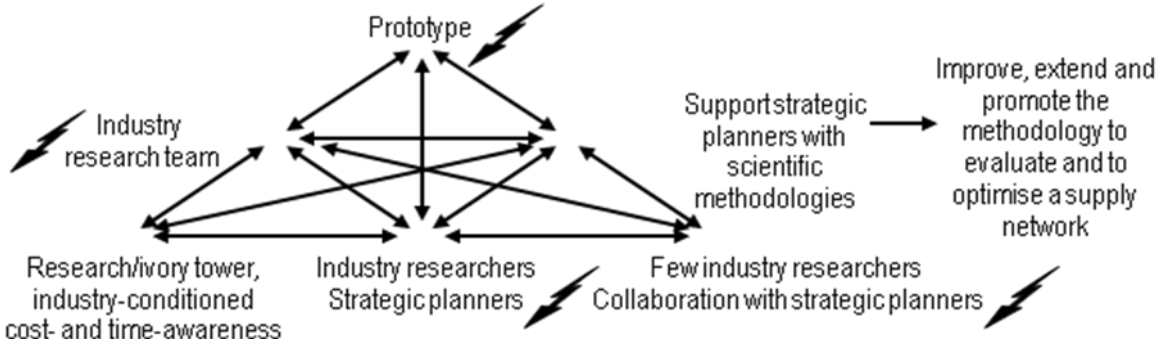

Figure 3 Second activity: manifestation into a prototype

The transition from the cognitive to the material world takes place in this activity (see Figure 3). The project proceeded well and experienced successful application in pilot projects. The activity did not change significantly. The objective remained as it was, however, the goal was adjusted towards a further development and the beginnings of a diffusion of the methodology produced and manifested in a technological prototype. First applications of the prototype revealed technical and methodological deficiencies. At some point the progress of the co-design process with strategic planners became more challenging due to the emergence of further requirements for the tool, eventually resulting in a tool of

greater complexity than initially envisaged. Difficulties also originate in the fact that the research team changed over time. Initial researchers switched to other departments within the company handing the project over to new researchers. In general, the research department is strongly affected by fluctuation as, for example, many key researchers are doctoral students who finish their studies and leave in most cases. Additionally, it became apparent that the circle of strategic planners involved had to be widened in order to find more stakeholders to support the growing development activity.

4.3 Diffusion of the decision support system

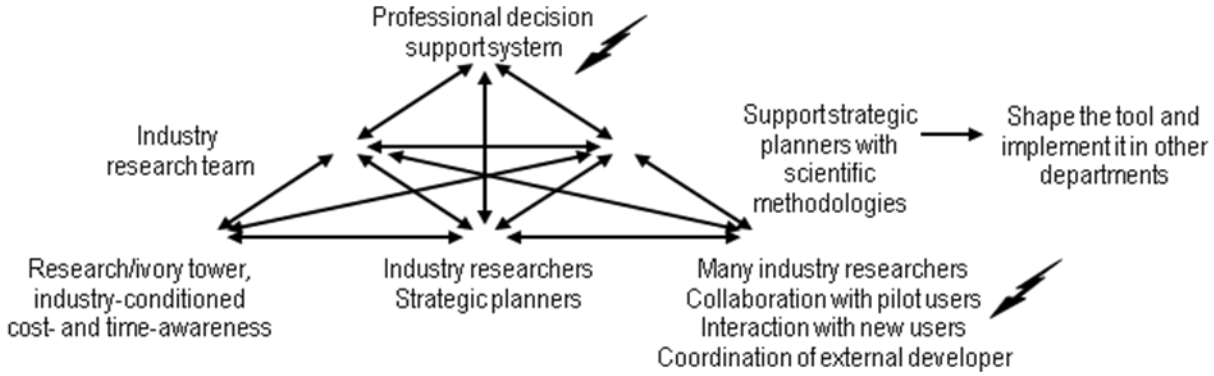

Figure 4 Third activity: diffusion of the tool

Finally, the innovation is fully manifested in a technological artefact (see Figure 4). Solving the tool-related contradictions resulted in a newly-created professional decision support system which was developed externally by a software company. Meanwhile, the community gained more strategic planners from other organisational units. The goal of the continuing activity was set to shaping the system including debugging and refining it according to user requirements. Additionally, diffusing the instrument became a more important aspect of the activity. Contradictions were still apparent in the technological tool as it still contained bugs. Also, new user requirements continued appearing fueling a continuous process of development. The important integration of new users required the development of further instruments and methods such as a training concept including materials or minor neighbouring activities such as training workshops.

5 Discussion

This paper argues that activity theory is a helpful framework to cross the boundaries between the cognitive and the material world.The analytical narrative above demonstrates that activity theory is capable of unravelling some of the intricacies of a trajectory of innovation, from its apparent point of creation through the various diffusive practices. Thanks to the focus on the holistic dynamics of an activity it helps the researcher to confront the gap between the material and the cognitive world. The case study explores the evolving transformation of an innovation from an idea and its evolution into an increasingly tangible manifestation as a technological artefact. Finally, the application of activity theory follows the call of Kling (1992) who argues for rich narratives about technology, and the analysis of the trajectories surrounding the evolution of information technologies in their social settings.

In the case study presented the evolution of a decision support system for strategic planners in the German automotive industry is examined applying activity theory. The project started over eight years ago. In this time, the industry research team changed completely more then once. Also other internal partners joined the project for a short period and left afterwards. Thus, essential information about the technology, people and events dispersed over time. Creating narratives according to the activity

theoretical framework helped recollecting and centralising information, which seemed to be lost, in a structured form. This methodology does not directly intend to capture personal knowledge, although it is a side effect to some extent. Rather it aims at linking activities with people, events, relations and tools, and putting them together in one coherent narrative. With this information at hand several benefits can be achieved generally. First of all, only a holistic understanding of the origin of the tool legitimates the proposition of understanding the magnitude of a technological project and of being in full control of its further progress. This implies having the awareness about weaknesses and threats accompanying a project. Analytical narratives offer the chance to learn from lessons learned and to derive best practices in order to avoid making wrong decisions (for a second time). An area of interest for the application of analytical narratives is knowledge management where, for example, the methodology of storytelling is a common instrument to convey a message. Project management is another potential field because creating a narrative could be a routine performed to close a project.

The future direction for this work comprises, among others, addressing a not yet mentioned limitation of this study. The activity system presented reflects an abstract picture of the industry research project. Although a rich data set was collected a thoroughgoing analysis has yet to be conducted particularly in regard of the focus of the doctoral research. Further data analysis will investigate the role of expectations of decision makers on the development and implementation of a technological artefact.

6 References

Engeström, Y. (1987). *Learning by expanding: an activity-theoretical approach to developmental research*. Helsinki: Orienta-KonsultitOy.

Engeström, Y., &Miettinen, R. (1999). Introduction. In Y. Engeström, ReijoMiettinen, & R.-L. Punamäki (Eds.), *Perspectives on Activity Theory* (pp. 1-16). Cambridge: Cambridge University Press.

Engeström, Y., &Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review*, *5*(1), 1-24.

Fleck, J. (1988).*Innofusion or diffusation?The nature of technological developments in robotics*. Edinburgh PICT Working Paper No. 7, Edinburgh University.

Kling, R. (1992). Audiences, narratives, and human values in social studies of technology.*Science, Technology & Human Values*, *17*(3), 349–365. Sage Publications.

Kuutti, K. (1996). Activity theory as potential framework for human-computer interaction. In B. A. Nardi (Ed.), *Context and consciousness: activity theory and human-computer-interaction* (pp. 17-44). Cambridge: The MIT Press.

McLoughlin, I. (1999). *Creative Technological Change: The Shaping of Technology and Organiations*. London: Routledge.

Miettinen, R. (1999). The riddle of things: activity theory and actor-network theory as approaches to studying innovations. *Mind, Culture, and Activity*, *6*(3), 170–195. Routledge.

Pinch, T. J., & Bijker, W. E. (1984). The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Sociology of Technology might Benefit Each Other. *Social Studies of Science, 14*(3), 399-441.

Popper, K. (1972). *Objective knowledge*. Oxford: Oxford University Press.

Rogers, E. M. (2003). *Diffusion of innovation* (5th ed.). New York: Free Press.

Sætnan, A. R. (1991). Rigid politics and technological flexibility: The anatomy of a failed hospital innovation. *Science, Technology & Human Values*, *16*(4), 419-447. Soc Social Studies Sci.

Williams, R., & Edge, D. (1996). The social shaping of technology.*Research Policy*, *25*, 856-899. Institute of Physics Publishing.