

Towards a Conceptual Framework for Requirement Gathering and Roadmapping in the Design of Learning Technologies – an Activity Theoretical perspective on Nonaka & Takeuchi's SECI model and its use in a Roadmapping Project

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Tore Hoel,
Oslo University College
tore.hoel [at] hio.no

Introduction

The domain of learning technologies is far from stable, even if these technologies have been developed for more than a decade. Several European Union funded projects are established to come up with best practices on the use of standards¹, and they are faced with an emergent field where there is no consensus on which technologies to promote to support which pedagogical practices (Hoel and Hollins, 2007; 2008). With so many moving targets to describe the design process of new learning technologies has become very complex, and the need to future proof the design decisions have created a market for roadmapping methodologies. As Yrjö Engeström has observed “activity systems that are not well-bounded are a challenge to our theoretical frameworks” (Engeström, 2008b). It is not surprising, that some of the theoretical underpinnings of the activity of roadmapping need to be re-examined.

Business redesign is a huge market, which has created a need for simple models that are easy to sell and brand. This leads to a flurry of concepts and models, often summarised in simple diagrams suitable for sales presentations. Also European projects are searching for ways to better inform design decisions, and are therefore likely to subscribe to some of the methodologies originating from the enterprise world. When applied to Learning, Education and Training we should ask how these methodologies relate to learning theories and to design as a learning activity, and how theoretically well-founded they are.

This paper will focus on the use of *roadmapping as knowledge creation process*. The context is roadmapping used in ICOPER, a European eContentplus Best Practice Network. The ICOPER project² integrates roadmapping methodologies from a number of earlier EU projects, e.g., Bridges (1999 – 2002)³, Rocket (2001 - 2003)⁴, Time2Learn (2002 - 2004)⁵, and Prolearn (2003 – 2007)⁶. The last project, Prolearn, defined a roadmap as strategic tool for planning, and included the SECI framework of Nonaka and Takeuchi (1995) to model the knowledge creation process. A new feature of ICOPER was the emphasis on needs analysis and requirement gathering. ICOPER will

Develop a conceptual model of the Roadmapping process, bringing together the requirement gathering activities (analysing needs and providing recommendations for further development) and the gap analysis (analysis existing specifications identifying strength and weaknesses, providing recommendations for standards improvement) (...) A new and integrated conceptual Roadmapping

1 See eContentplus programme http://ec.europa.eu/information_society/activities/econtentplus/

2 ICOPER was kicked off in September 2008 and is a 30 month project – www.icoper.org

3 BRIDGES project (2002), (IST 14038 working group), Deliverable 8 “Roadmap for digital business”

4 ROCKET (2002), (IST-2001-38245), (Roadmap to communicating knowledge essential for the industrial environment), Deliverable D2.2 “The state -of-the-art of Roadmapping”

5 Time2Learn was a thematic network under the European Commission IST, FP5, aiming at drawing up a R & D roadmap for European professional eTraining

6 Prolearn was a European Commission IST FP6 project

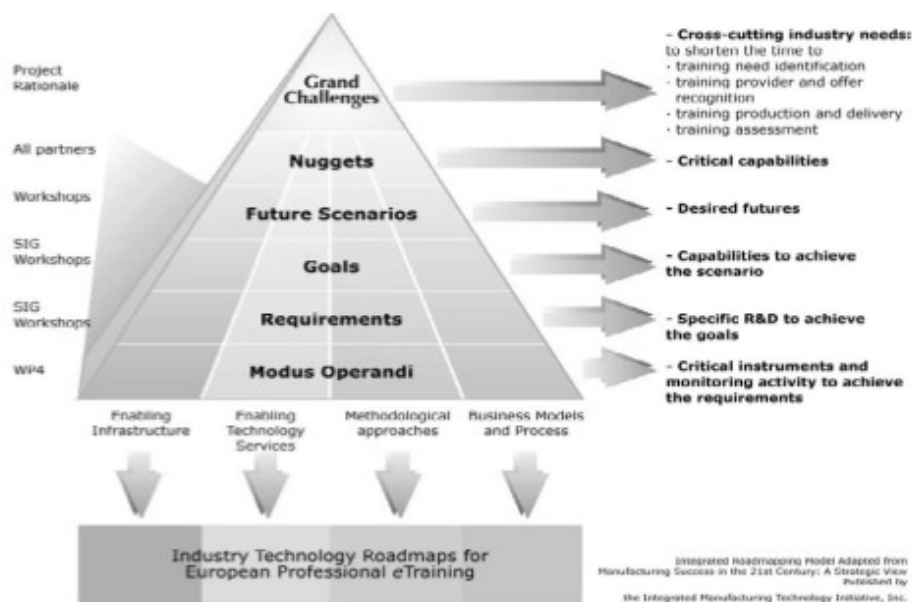
Model will contribute to a better integrated standards development process, outlining the different feedback loops a learning technology specification has to go through to become an adopted standard. (ICOPER, 2008)

The Need Analysis is a under-theorised aspect of the standardisation process (LIFE, 2006), and the the question we ask ourselves is whether the roadmapping methodology of ICOPER's predecessors really is able to grasp the *runaway objects* (Engeström, 2008b) of learning technologies⁷.

The rest of this paper is organised as follows. First, we give a brief introduction to the roadmapping process used in some EU projects previous to ICOPER. Then we present the SECI model of Nonaka and Takeuchi and look into some of the theoretical groundings of this model. We will use the Cultural-Historical Activity Theory (CHAT) and the theory of Expansive Learning of Yrjö Engeström to put the SECI model to a “test”. Using the ICOPER project as a case, we ask if the SECI model and theory are sufficient to capture the elements necessary to build an action plan for design of future learning technologies. Finally, discussing our findings we look towards the work of Yrjö Engeström on expansive learning and expansive visualisation for ideas to come up with an improved roadmapping model.

Roadmapping, as used in the previous EU projects

The Time2Learn project adopted a roadmapping method developed by the US The Integrated Manufacturing Technology Initiative (IMTI)⁸. This was an industry/government partnership facilitating collaborative development of critical manufacturing technologies. The IMTI model (Figure 1) consists of six levels in a top-down pyramidal structure, which begins from the identified *grand challenges* that are worked into sets of *critical capabilities*, proceeds to concrete *goals* and *requirements*, and finally gives the answers to the *R&D questions* the EU eTraning project Time2Learn were searching for (Koskinen, 2004).



⁷ Engeström defines runaway objects as objects that “have the potential to escalate and expand up a global scale of influence”; objects that are “poorly under anybody's control and have far-reaching, unexpected effects”; objects that “are contested (...) that generate opposition and controversy” (Engeström, 2008, p. 3). Learning technologies seems to be an example of runaway objects according to this definition.

⁸ For the IMTI website, go to www.imti21.org

Figure 1: The Roadmapping model from The Integrated Manufacturing Technology Initiative, adopted in Time2Learn (Koskinen, 2004)

The first step of this IMTI roadmapping process is to identify the critical capabilities for the fulfilment of the desired grand challenges. The process is guided by providing answers to the following questions: What challenges will we face in the future? What capabilities will we need to meet these challenges? How can these solutions be developed? How can we shape and speed the outcome? The IMTI Roadmap is meant to be a “living plan” (Kamtsiou, 2008).

According to Koskinen (2004), the value of roadmapping lies “largely behind its capabilities to enhance consensus building”. However, as he describes the roadmapping process in the Time2Learn, it seems that the roadmap as a general agreement is a result of a top-down analytical exercise where the chosen critical capabilities are extrapolated from a number of scenarios through a gap analysis between the future state and the current state assessment. “The aim of scenario planning was to describe what professional eTraining might be like for ordinary people in 2010 “ (Koskinen, 2004; Stergioulas, 2004).

The Prolearn project developed its own roadmapping methodology, based on Time2Learn and a number of other projects. They found a set of common features in all roadmapping approaches:

- Timelines: The scope of the roadmapping is between 7 and 8 years. The future timeline is divided into 3 segments (present, short, medium and long term).
- All projects have used scenarios in order to define desired futures (Where we want to be?)
- All projects start with the current state assessment (Where we are today?)
- All projects have performed Gap Analysis by comparing the desired future with the current state assessment in order to identify the bottlenecks of evolution (What we need that we don't have today?...)
- All projects have developed hierarchical topic maps for the phenomena studied. The terminology varies but the core principle remains the same. (Sectors, Scenario components, Paradigms, Nuggets, Critical capabilities, ...)
- All projects have used some kind of maturity level assessment (number of maturity levels and their description varies)
- All projects have used survey and analysis tools (SWOT, etc.) (Prolearn, 2005, D12.6, p. 24)

This analysis ended up in the following Prolearn conceptual model of the roadmapping process (Figure 2).

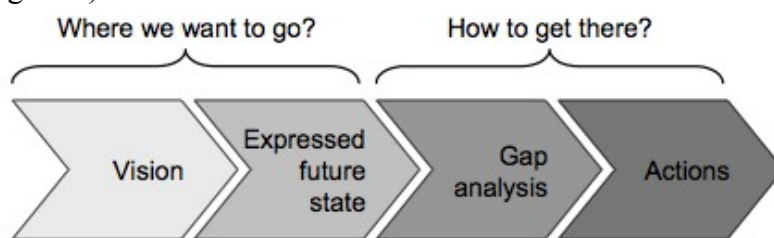


Figure 2: Prolearn conceptual model of the roadmap components

Prolearn also added another component to its methodology, the SECI framework of Nonaka and Takeuchi (1995).

[The] application of SECI spiral of Knowledge creation framework helps in a) developing a value accumulating roadmapping process which is dynamic and has high potential for sustainability and b) promote a knowledge network of roadmapping that amplifies the efforts of various groups and crystallizes them at the European level. (...) This is an especially important enhancement, since the

roadmap is a commonly agreed and accepted vision, and not a mechanically derived result. (Prolearn, 2005, D12.6, p. 24)

Prolearn extended the roadmapping activity to go beyond strategic planning, i.e., to include knowledge creation. The learning process spiralling from the individual level to group and organisational levels (Figure 3), was adapted to inform the Prolearn dissemination process.

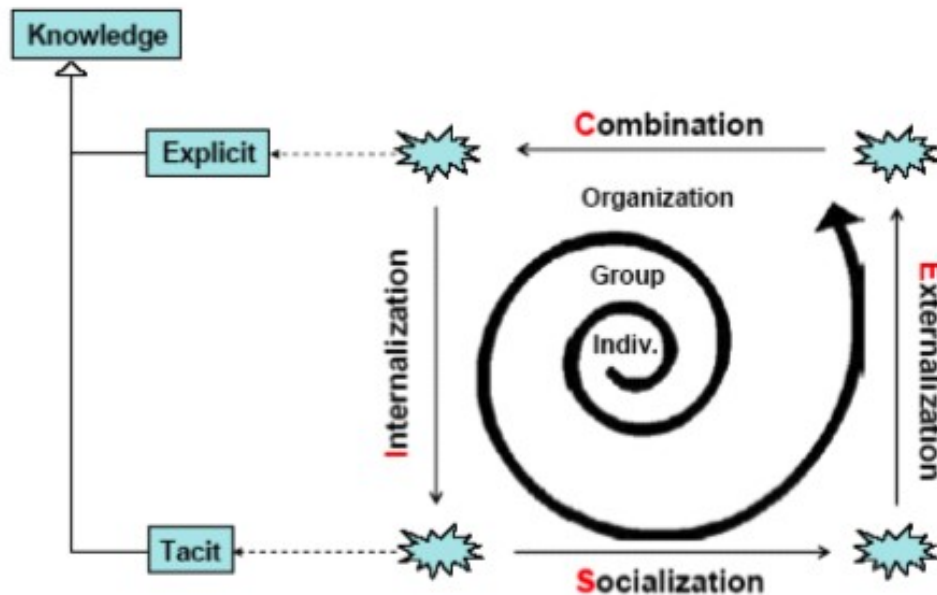


Figure 3 The SECI spiral of knowledge creation (from Naeve (2005)).

The Prolearn project used the SECI model to explain how knowledge creation spanned several levels of organisations, transforming the project results from the core project group, to the groups of associates, and further to the scientific community and industry as a whole (Figure 4).

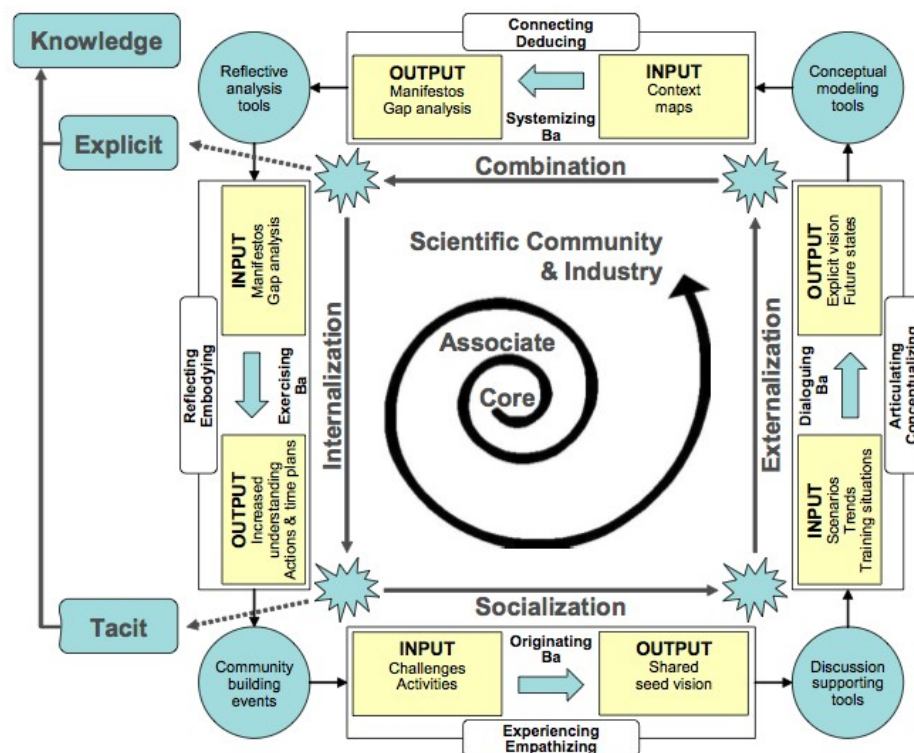


Figure 4 The PROLEARN Roadmapping Process Framework (Prolearn, 2005, D12.6)

The immediate question would be to ask how this expansion of the model is possible, – to cover not only intra-organisational knowledge creation, but also to cover inter-organisational and cross-level knowledge creation? We will touch on that later when discussing the unit of analysis of the roadmapping studies.

Furthermore, it is out of scope of this paper to analyse how successful the amalgamation of the top-down, linear roadmapping process with the circular SECI knowledge creation process has been in the Prolearn project. At this stage, we note that a new dimension is added to the roadmapping methodology; and our goal with this paper is to examine if the added SECI model really alleviate the problems of understanding the nature of what we earlier referred to as runaway objects.

The SECI Model

The SECI model was introduced by Nonaka and Takeuchi in their book *The Knowledge Creating Company* of 1995. The empirical grounding of their theory of organisational knowledge creation is case studies of big Japanese companies and a survey of Japanese managers (Nonaka & Takeuchi, 1995; Gourlay, 2004). In spite of its non-Western origin, the SECI model has become one of the most cited theory of knowledge management.

Gourlay (2004) identifies two phases in the development of the theory of Nonaka and Takeuchi. Initially they proposed a two dimensional theory of knowledge creation through the conversion of tacit and implicit knowledge (Nonaka & Takeuchi, 1995, pp. 57 – 60). Four modes of knowledge conversation take place (Figure 3): tacit to tacit (Socialisation); tacit to explicit (Externalisation); explicit to explicit (Combination); and explicit to tacit (Internalisation). After Internalisation the

process continues at a new level, and knowledge is build in a spiralling development. This is the original SECI model. Later, this first “epistemological” element of the model was supplemented with two other “ontological” elements or layers: “*ba*”, the shared context for knowledge creation; and *knowledge assets*, the inputs, outputs and moderators of the knowledge-creating process (Nonaka et al., 2000).

Gourlay (2004) finds the theory to have a strong individual and subjective focus, and even have a somewhat mystical bias, describing knowledge creation as a “self-transcending process by means of which one transcends the boundary of the old self into a new self” (Nonaka et. al. 2001B: 16, cited in Gourlay, 2004). The mystical, or should we say syncretistic edge to the writings of Nonaka is manifested in this figure of “knowledge created through a spiral”:

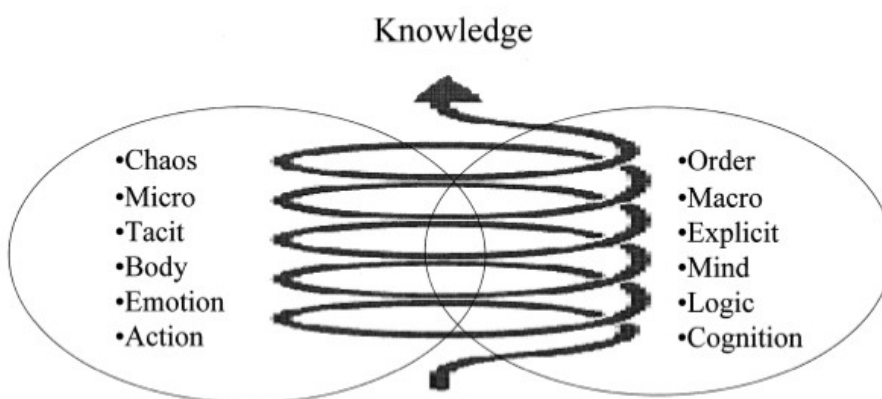


Figure 5 Knowledge created through a spirial (from Nonaka et al., 2000)

The following text explains the figure:

Knowledge is created in the spiral that goes through two seemingly antithetical concepts such as order and chaos, micro and macro, part and whole, mind and body, tacit and explicit, self and other, deduction and induction, and creativity and control. We argue that the key in leading the knowledge-creating process is dialectical thinking, which transcends and synthesises such contradictions (Nonaka et al., 2000, p. 3).

The SECI model has been criticised both from a theoretical and an empirical position (Gourlay, 2004; McAdam & McCreedy, 1999; Engeström, 2008a). In *The Knowledge Creating Company* Nonaka and Takeuchi do a tour the force through Western philosophy to explain why they resort to Japanese business culture to overcome the stale Cartesian dualism. We would think, it will not be difficult to pinpoint shortcomings in the more philosophical justifications for the theoretical concepts of the Dynamic Knowledge Creation theory. More serious is the claim that the model is not validated by empirical studies, and that the key concepts (like combination and internalisation) are not clearly described (Gourlay, 2004, p. 8; Engeström, 2008a, p. 121-128).

The key attraction of the SECI model as an ingredient in a roadmapping theory is the dynamic knowledge creation cycle. Engeström (2008a) has, on an empirical basis, questioned this part of the SECI theory. Nonaka and Takeuchi's theory of knowledge creation is based on a matrix of conversions between tacit and explicit knowledge.

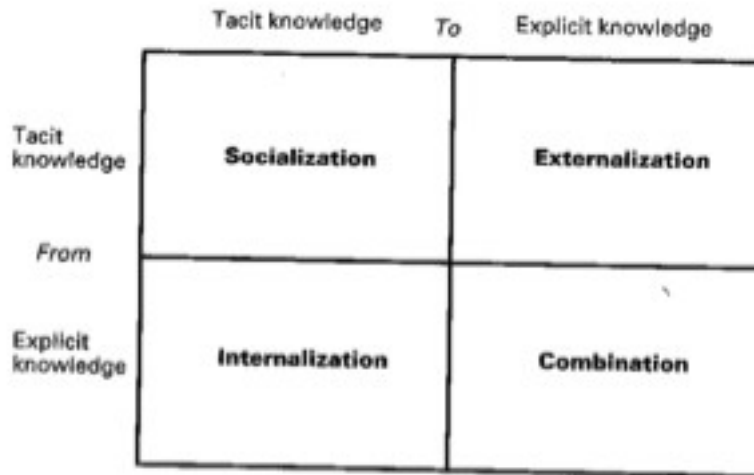


Figure 6 Matrix describing Nonaka & Takeuchi's four modes of knowledge conversation, from Nonaka & Takeuchi (1995, p. 62).

Engeström (2008a) uses Nonaka and Takeuchi's categories to analyse transcripts of two meetings, and find that two types of sequences could not be categorised within this conceptual framework, – sequences Engeström calls *formulating/debating a problem* and *analysing/debating a problem systematically*. “In the framework of Nonaka and Takeuchi, there seems to be no place for this type of discourse” (Engeström, 2008a, p. 127).

Nonaka and Takeuchi constructed a dynamic knowledge creation cycle out of a static matrix of four fields, based on the basic distinction between tacit and explicit knowledge.

The crucial question is: Are such representational modes of knowledge an appropriate basis for discerning phases and recurrent sequential patterns in processes of knowledge creation? In other words, is Nonaka and Takeuchi's leap from a matrix to a cycle justified? (Engeström, 2008a, p. 127)

Engeström's answer to his question is no. “Although Nonaka and Takeuchi's construct their cycle in a logical fashion, they offer little empirical evidence or compelling theoretical support for it” (p. 127). He suggests it would be wise to search for and test alternative cyclic models of knowledge creation, and offers his own theory of expansive learning as a candidate.

For our purpose the evaluation of the SECI model takes another perspective. Of course, we want a process model to be both theoretical and empirical sound. But more so, we want the methodological approach to guide us towards the most productive questions and processes in the roadmapping activities where the SECI model is supposed to add value. A model is a process template. If the template starts with the wrong questions or avoids certain perspectives, it does not help how much whether it prescribes spiralling movements or use dialectical concepts.

Roadmaps as a learning and knowledge creation process – what questions to ask?

In the Prolearn context roadmapping

is both a learning activity and a knowledge creation process for the community that builds the roadmap. The knowledge creation process in roadmapping is a continuous process where individuals and groups transcend their boundaries by acquiring a new context, a new view of the subject domain, and new knowledge. (Kamtsiou et al., 2006)

This describes the context for roadmapping in the Best Practice Network ICOPER as well. To see if the SECI model “adds value” to the roadmapping methodology (Kamtsiou et al., 2006), we will put the Prolearn model “to a test” by asking the questions that synthesizes the Theory of Expansive Learning and Developmental Work Research by Yrjö Engeström (Engeström, 1987; 2001; 2005).

In an introduction to a collection of studies within Developmental Work Research Engeström (2005) used four heuristic questions put forward by a Danish researcher, Bent Flyvbjerg, as a starting point to characterise the Activity Theoretical approach.

1. Where are we going?
2. Who gains, and who loses, by which mechanisms of power?
3. Is it desirable?
4. What should be done?⁹

The first question is exactly the same as the one starting a roadmapping process (Figure 2). Also the rest of Flyvbjerg's questions strike a cord of the concepts used in roadmapping, e.g., gap analysis, future state, action plan, etc. Engeström note that the guidelines Flyvbjerg lay out “are similar to those adhered to by researchers who apply cultural-historical activity theory (...) But there are also important differences” (Engeström, 2005, p. 11).

The first difference is how historical analysis is used as a point of departure. Often there are no clear cut answer to the question where we are going. Multiple conflicting directions, ambivalence and uncertainty are the rule, not the exception. Then the crucial question is: *Where do we come from?* “In other words, the roots of confusion and uncertainty need to be discovered and traced step-by-step by means of historical analysis” (Engeström, 2005, p. 12).

The first question to the SECI model is therefore, how is historical data used in the analysis?

The second question relates to power and draws on Foucault key notion of governmentality. “For developmental work research, a key notion is instrumentality. Thus, my alternative to Flyvbjerg's second question would be: *'What are the tools and signs available for different participants and how are they used to construct the object of the activity?'*” (Engeström, 2005, p. 12)

Engeström do not reject the question of who gains and who loses. However, he points to the mediating artefacts that make the power relations visible for the researcher. In the SECI model the instrumentality is limited to the movement between externalisation and internalisation. The oscillation of externalisation and internalisation is central to the theory of expansive learning, too (Engeström, 2008b; 1999a, p. 34).

The second question to the SECI model will therefore be, how it allows for analysis of the mediated acts in the development of the knowledge creation process?

Flyvbjerg's third question addressed the normative aspects of social research. Engeström finds the question of desirability “somewhat useless” (Engeström, 2005, p. 12). The crucial third question in his opinion is instead: *'What are the inner contradictions of our activity?'*

Roadmapping deals a lot with foreseeing the desired future. The SECI model depicts a upwards

⁹ These were the questions that make up the “phronetic science” outlined in Flyvbjerg's book *Making Social Science Matter* (2001).

turning spiral, indicating an inevitable progression of knowledge creation. However, it is unclear from where this development is getting its energy.

The third question to the SECI model is therefore, how do we trace the driving force for development, and how is object orientation built into the model?

Flybjerg's last question was 'what should be done?'. This addresses the feedback loops from research back to the community under study. Engeström is of the opinion that Flybjerg stops too early; that developmental work research is about “actual formation of new material patterns of life and practices (...) This is not a step of dissemination and dialogue after the research, it is at the very core of research itself” (Engeström, 2005, p. 13). Engeström's alternative fourth question is therefore: *'What can and will be done'?*

The Prolearn SECI enhanced roadmapping process ends up with an action plan.

The fourth question to the SECI model is therefore, is the action plan an integrated part of the roadmapping process that is further developed, or is it just a teleological end point?

ICOPER Best Practice Network as a case

ICOPER will build a technological roadmap for standards development in the domain of Learning, Education and Training, especially focussed on what has given the project its acronym, Interoperable Content for Performance in a *Competency-driven Society*. This will be done within the framework of a Best Practice Network, which is defined by the European Commission as a network engaged in *consensus building, awareness raising, and large-scale implementation* (EU eContentplus, 2007). Through the roadmapping activities ICOPER will work on models describing how community requirements are fed into the specification design process and valorised in the standards consensus process. These models will also describe how specifications and standards are disseminated to the community and adopted, hopefully leading to large-scale implementations.

Question 1: What is the Unit of Analysis?

The ICOPER project could be viewed as a large scale formative intervention project. As such it is a 30 months effort to change the design of learning technologies. It picks up a number of loose ends and it will leave many threads untied. The roadmapping activities may be geared towards coming up with a action plan, e.g., a ICOPER Reference Model for competency-driven learning. However, the activity systems that come into play here are so vastly complex and continuously changing, that dreaming of a process that obey any laws of linear causality is methodologically flawed.

If ICOPER choose to build on the top-down approach of the Time2Learn project it risks to fall into this trap. ICOPER is organised and driven by a pedagogical model where competency needs lead to development of instructional content, which is delivered through learning activities, which then are assessed and in turn lead to new competency needs. If the “grand challenges” are derived from these categories as a starting point for the roadmapping process, without asking any questions as to the validity of the pedagogical model, the resulting action plan could be built on sand.

The SECI model as such does not resist any unfounded, top-down, politically driven¹⁰ process. As Engeström observes,

A central problem with Nonaka and Takeuchi' s model, and with many other models of organizational learning, is the assumption that the assignment for knowledge creation is unproblematically given from above. In other words, what is to be created and learned is depicted as

¹⁰ The ICOPER project is in fact EU policy driven, as the emphasis on Competencies is coming from the European Quality Framework process passed by the European Council in 2008.

a management decision that is outside the bounds of the local process (see Engeström, 1999b). This assumption leads to a model in which the first step consists of smooth, conflict-free socializing, the creation of 'sympathized knowledge' as Nonaka and Takeuchi (1995) call it. (Engeström, 2001, p. 151)

We are here addressing the issue of *the unit of analysis* of the roadmapping process, – the first thread of Engeström's "argumentative grammar" of formative interventions (2008b). (The other threads being, causality and agency, change and development, and generalization.) We are also touching our first question about the SECI model, the historical contextualisation of the unit of analysis.

The *objects* of ICOPER are specifications and standards used in learning technologies to enhance learning, education and training. These objects are shared by several *activity systems*. Third generation Activity Theory (AT) has two activity systems with a partially shared object as a minimal unit of analysis, as shown in Figure 7 (Engeström, 2001;2008a).

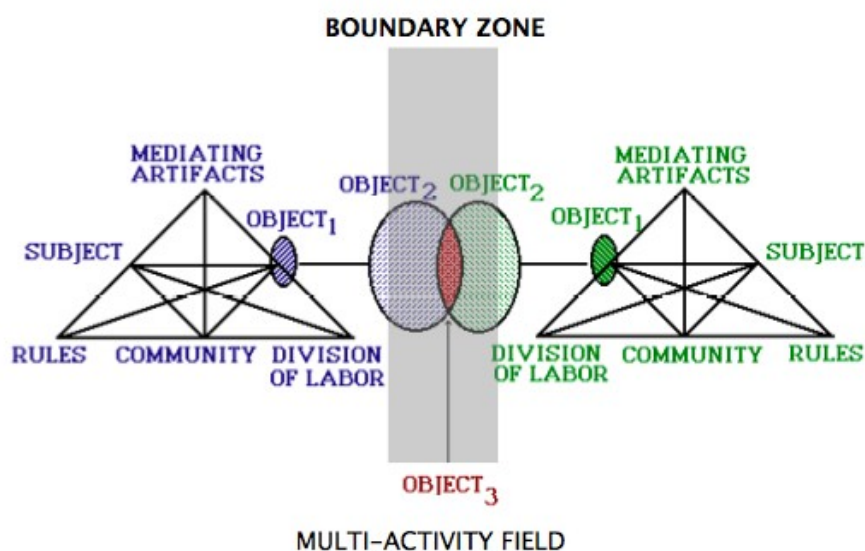


Figure 7 Third generation activity theory: two activity systems with a partially shared objects as minimal unit of analysis (Engeström, 2008c)

For roadmapping in ICOPER to be successful it is of vital importance to identify the different activity systems at play. In the case of learning technologies it might turn out that we are dealing with what Engeström has termed *runaway objects*, i.e., objects that are contested and generate opposition and controversy, but have the potential to escalate and expand up to a global scale of influence (Engeström, 2008a), see figure 8.

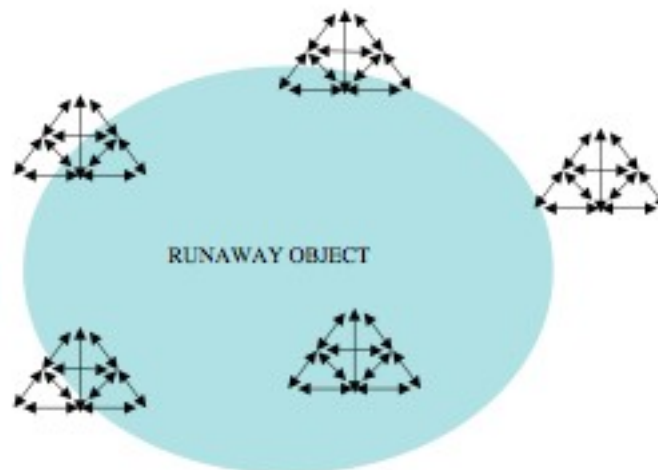


Figure 8 Large runaway object and activity systems (Engeström, 2008c)

We would suggest that one of the reasons for the apparent lack of a clearly defined unit of analysis, other than the broad concept categories in the roadmapping tradition of Prolearn is *due to a non-historical analytical approach*. By focusing on the future and trying to build tracks back to the present state-of-art, the historical dimensions of the activity systems are under-analysed.

Thus, it seems that the roadmapping methodology proposed for ICOPER will fail the first “test” from a CHAT perspective, as the unit of analysis seems to be inadequately defined and not historically constructed.

Question 2: How are tools and signs used?

The second question relates to how the different participants are allowed to construct their object of activity, observed by their use of tools and signs. For the ICOPER project the focus is on how the competency gaps are dealt with within higher education and life long learning. A historical analysis of the concept of competency in this context will show that the very idea of competency-driven education is strongly contested in higher education and just in its infancy in life long learning. The idea is pushed hard from the political establishment (EC, 2008). A top-down design of technologies supporting this idea is bound to fail. So the challenge for ICOPER will be to explore the boundary zones where the learners' current practices meet with the competency demands of the workplace and educational institutions.

The SECI model as such seems not to have any built-in mechanisms for questioning the point of departure of the knowledge creation process. Nonaka seems to suppose that answers somehow are embedded within the tacit knowledge of the companies and organisations that use the SECI approach for their business reengineering (Nonaka, 1994, Nonaka et al., 2000). Through the movement of Socialisation, Externalisation, etc. this knowledge will be transformed and brought up to speed with the current challenges. The model has no “battle zones”, no conflicts exposure mechanism; – it is more characterised by ying-yang and harmony (ref. Figure 5 above).

Consequently, the SECI model did not pass the second “test”, neither. We see that the model will have problems capturing the perspectives of the prospected end-users of the learning technologies to be developed. These users are not organised in well defined communities of practice. They have to be constructed analytically by the researchers themselves, in order to take part in the knowledge creating process.

This leads to the third “test”: Where does the model get its energy; what are the driving forces

bringing the process forward?

Question 3: What are the driving forces?

Activity Theory is object-oriented. According to Leont'ev, one of the founding fathers of AT, there is no activity without an object. As Engeström explains “the object gives durable direction and purpose to activity: it is the true motive of activity (not reducible to conscious goals); the object is a moving target, never fully accomplished: a horizon of possible actions; and the object is multi-faceted, a mosaic of multiple interpretations, voices and positions. The object resists and kicks back” (Engeström, 2008c).

AT sets up a triangular relation between the subject, the artefacts (tools) and the object. This model is extended on a system level and multi-system level (what Engeström terms third generation activity theory). What brings agency into this model is contradictions. Contradictions are within and between objects, and between the different parts of the activity system. The notion of contradictions is inherited from dialectical materialism in the Karl Marx and Friedrich Engels tradition. When Engeström uses the concept as the prime mover and mother of all development his writings get a somewhat metaphysical touch¹¹ (Engeström, 2008b). However, through empirical studies in Developmental Work Studies Engeström and colleagues have demonstrated that the concept of contradictions is a very strong analytical tool.

What drives the roadmapping analysis using the SECI process model? It seems that the roadmapping is driven by the development of the top level concepts themselves (e.g., grand challenges and critical capabilities). The application of the SECI model does not change this. For the ICOPER project it is therefore an immanent threat that the analytical work will be done within an analytical-theoretical framework that is detached from the contradicting objects with which the end users struggle.

Therefore, it seems that the SECI model also fails our third “test”.

The last question was about process termination. Does it have an end point? How does it deal with the results of the process?

Question 4: How is the process terminated?

The Prolearn project translated the SECI spiral of individual → group → organisational learning to describe the project dynamics of dissemination from Core group → Associates → Scientific Community and Industry (Figure 4). This seems to be a spiralling process with limited feedback looping. This is an “endemic” problem with EU projects. They have a limited time scale, and this shapes also the conceptual development of the projects. The development of learning technologies is, however, an ongoing and never-ending process, and the models of knowledge creation have to take this into consideration.

Looking at the SECI model itself, we don't see anything that should indicate that the model forces a too early closure to the knowledge creation processes. *Therefore, we would conclude that the model passed our last “test”, – with a question mark.*

Discussion

Roadmapping as an activity has a dual nature. “Roadmaps are both forecasts of what is possible or

¹¹ An example is Engeström's use of statements like “The primary contradiction of activities in capitalism is that between the use value and exchange value of commodities.” (Engeström, 2008b)

likely to happen, as well as plans that articulate a course of action” (Kappel, 2001). This duality roadmapping has in common with a lot of other activities that are related to individual or organisational learning, and this is why it is so relevant to see roadmapping as a learning activity. Due to the inherent weaknesses in the current roadmapping techniques there is a need to come up with a roadmapping theory and methodology that resist the temptation to base the maps or plans on wishful thinking. Kappel (2001) found in an extensive survey of the use of roadmaps within the manufacturing industry that roadmapping has the following boundaries (Table 1):

Roadmapping has a . . .	Roadmapping is weak fit for . . .	Roadmapping most useful when . . .
Linear tendency	> anticipating technology or market disruptions (e.g., architecture)	growth phase of a product or market
Technology bias	> considering non-technology alternatives and non-numerical factors	product or process technology is the recognized basis of competition
Technical/rational focus	> dealing with organizational/political problems	organizations that fit their environment
Implicit certainty	> exploring scenarios and alternatives	predictable regimes or strong influence on external environment
Persistence prejudice	> encouraging creativity	existing markets and architectures experiencing sustained (perhaps rapid) progress
Complex problem fit	> simple problems	coordination is otherwise difficult
External orientation	> what strategy is best for us?	customer voice needs strengthening

Table 1: Roadmapping Boundaries – strengths and weaknesses (Kappel, 2001)

What we find striking about these points is the lack of “fit” for activities that are related to *disruptions, emergence, creativity, exploring scenarios* and *alternatives* – activities that are an integral part of the learning movement Engeström had termed *expansive swarming* and *multi-directional pulsation* and that is part of today's social production where we deal with runaway objects through reflective communication (Engeström, 2008c).

Kappel (2001) observes that “the standard templates used for roadmaps are optimized around extrapolation techniques, and the practitioners who use them apply their internal perspective”. If we want to improve the roadmapping techniques and make sure they are fit for the rapidly developing field of learning technologies, we have to make sure that these techniques are informed by a knowledge creation theory that is able to describe both the situated practice of the actors and their disruptive environment.

We will touch upon some of the critical issues we have identified analysing how the SECI model of Nonaka and Takeuchi is used in roadmapping.

Where does the process start?

We realise that roadmapping has to be more than just extrapolations. Furthermore, we see the inherent danger in SECI that the knowledge creation process starts with premises given from outside, e.g., from “the top” or the management. What more than carefully choosing the unit of analysis and doing a historical analysis of the actants (to use the terminology of Latour (1996)) is needed to feed the right input to the roadmapping process?

In the ICOPER project (2007) requirement gathering is written into the description of work as an activity that should be explored both theoretically and practically. In flow diagrams of the development life cycle of learning technology standards a “Needs” box is supposed to provide input to the process. However, such diagrams seem to be more focussed on describing the relation between the different process components than ensuring that the process at large addresses the appropriate challenges. If the the Needs box is going to be expanded we must define what questions to ask to get the process started. That leads us on to the next issue:

What drives the knowledge creation?

Engeström has noted that "there is a new wave of attempts to build a theory of learning and cognition on dialogue and communication as opposed to object-orientation¹²". Roadmapping based on "smooth, conflict-free socializing" and creation of 'sympathized knowledge' (ref., discussion above) will not bring us anywhere. According to the CHAT perspective, we have to identify the objects that the activities are directed towards, and by that map out the motivations or what drives the processes. The key to identify the "energy fields" in the data collected through roadmapping is to look for disturbances, contradictions and disruptions, carrying out what Yrjö Engeström has called an "ethnography of trouble" (Engeström, 2000, p. 153). "Disturbances and ruptures involving negation, rejection and destruction are often the first decisive indications of significant developmental processes" (ib.id., p. 166).

So, when starting the roadmapping knowledge creation process we would ask questions that would tease out the disturbances within the activity systems we explore. We need to go for the contradictions embedded in the systems themselves, not only conflicts and gaps between the roadmapping stakeholders and their environment.

Development is local qualitative reorganisation, or re-mediation, of activity systems, attempting to resolve their historically evolving inner contradictions. (...) Decontextualised prescriptions typically lead to solutions alien to the local system's developmental dynamics and are thus rejected or unpredictably altered in practice. (Engeström, 2000, p. 164)

One technique to make the learning or knowledge creation happen is to mirror the conflicts in the activity systems themselves (Engeström, 2000) to the participants doing the roadmapping.

How to assess the gaps?

Contradictions, disturbances and disruptions are not the same as *gaps* identified in a roadmapping process. In Activity Theory the key metaphor for development is that of a zone (Engeström, 2008b), and we think that the gap analysis used in roadmapping could be enhanced using the theories of Zone of Proximal Development in the tradition of Vygotsky (ref.).

Often the zone of proximal development is interpreted as a vertical step which leads to a higher stage or level. I find it more useful to think of the a zone as a terrain of activity to be dwelled in and explored, not just a stage to be achieved or even a space to be crossed. The zone is explored by moving in it. The movement may take various directions and patterns. In craft activity, the dominant pattern was from the periphery toward the center. In mass production, the dominant pattern is linear. At present, we see the emergence of patterns of pulsation, swarming, and multidirectional criss-crossing. (Engeström, 2008b)

To move around in unmapped territory you need mapping tools. This leads us to the question of what tools we use.

Role of modelling

Both the SECI framework and Activity Theory share the view on how important the tools mediated externalisation/internalisation process is for the knowledge creation. The Prolearn project, which integrated the SECI model in their roadmapping process, used modelling extensively to help the learning process applying the Conzilla¹³ tool (Kamtsiou and Naeve, 2008; Kamtsiou et al., 2006). However, modelling in itself does not expand learning if it is not integrated in a expansive learning process.

Engeström (1999) has pointed out that CHAT offers a conceptual and methodological basis for what

¹² Lecture notes, November 2008, Intermedia, University of Oslo

¹³ www.conzilla.org

he calls *expansive visibilization*. “By expansive I mean an approach in which the linear and socio-spatial dimensions of work actions are seen in the broader perspective provided by a third, *developmental dimension* of work activity. Expansive visibilization aims at integrating the three dimensions of representing work (Engeström, 1999, p. 64).

If the roadmapping start out with a ahistorical or too limited view of the unit of analysis we would find that the analysis would cover just the linear and socio-spatial dimensions of the analytical space. In such a context, the modelling exercise risk to be limited to linear or spatial extrapolations of trends and activities identified in the surrounding activity systems. The different dimensions play a role in representing the work going on within a activity system struggling to meet future challenges through a roadmapping process. We just have to make sure that we have them all in our process model.

It is not enough to come up with a model of the current state-of-affairs. We have to model a new solution, and also to implement the new model to complete a circle knowledge creation (Engeström, 2001). We find that the roadmapping methodologies discussed in this paper have not fully addressed the developmental dimension of validating the maps that are produced.

How do the process model look like, and how does the process end?

When further developing a roadmapping methodology we would offer Engeström's theory of expansive learning (1987, 2001) as a good model to make sure that the concerns we have identified with the current approach (e.g., in the ICOPER project) are met. Figure 9 explains outlines the different steps in a cycle of expansive learning according to Engeström (2001).

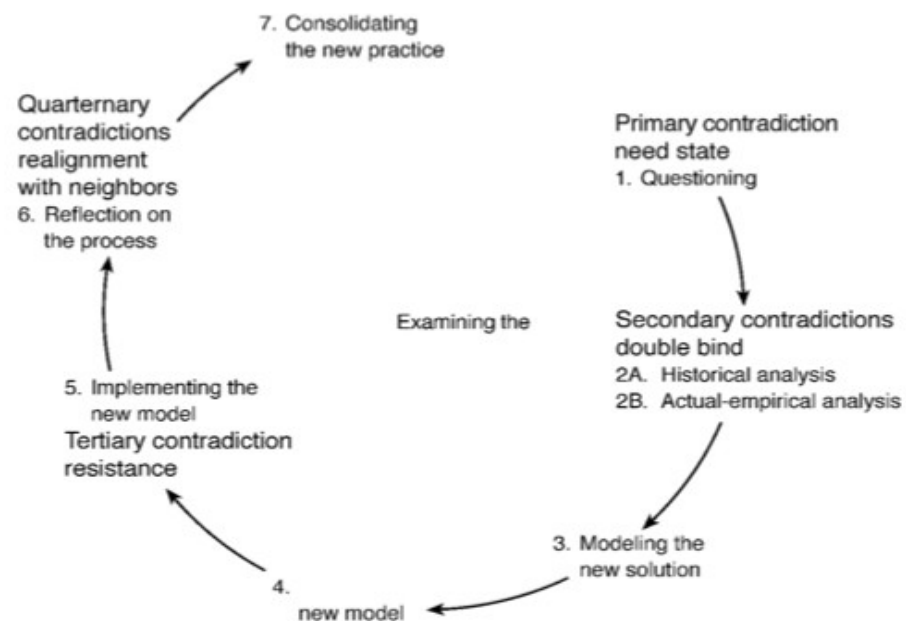


Figure 9 Strategic learning actions and corresponding contradictions in the cycle of expansive learning (Source: Engeström, 2001, p. 152)

This cycle of expansive learning might be completed, or it might also be broken. What is important in a roadmapping perspective is that there is no teleological bias in this model, portraying development as a linear progression to a higher level. This model might lead to consolidation of new practices (step 7), or it might lead to a break out in step 6, new contradictions and further cycles of expansive learning.

Conclusions

If roadmapping as an organisational learning method is to be used in large cross-national projects to inform European policy development it should have a sound theoretical grounding. Looking into the methodology used in a number of large projects the last ten years it seems that the same methodology is reused in different contexts. The European Prolearn project added the SECI framework of Nonaka and Takeuchi (1995) and an extensive modelling component to the methodology, indicating that there was a need for improvements. Our analysis of this new model showed that the application of the SECI model in Prolearn was flawed, partly due to lack of clarity in the definition of their unit of analysis. However, the SECI model could be an interesting starting point for further development of a roadmapping process model and methodology, as it targets some of the crucial activities in a knowledge creation process, e.g., externalisation/internalisation and modelling of new solutions.

In this paper we have identified a number of issues that have to be addressed in robust roadmapping methodology. First and foremost, we need a better understanding of the unit of analysis. With blurred boundaries between the organisations making roadmaps and the environment, the opening for understanding the full historical-cultural context of the activities is more difficult to find, and the access to what drives the activities (the object-orientation) tend to be blocked (or simply delegated to forces external to the roadmapping actors).

Furthermore, we have identified an important issue concerning the use of the tools that should mediate the roadmapping process. It is not enough to apply good modelling tools if the modelling process itself is not fed by the “right” questions. Here we see a big difference in the point of departure between Nonaka and Takeuchi's *sympathized* processes, and Engeström's “invisible battlegrounds” (1999), only accessible through hunting for disruptions, contradictions and disturbances.

Lastly, we have seen how the inherent weakness of some of the roadmapping strategies – the leaning towards linear extrapolations of current trends – could be counteracted by applying a more elaborate model than Nonaka & Takeuchi's oscillation between externalisation and internalisation. We have pointed to Engeström's model of expansive learning (1987, 2001) and expansive visibilisation (1999) as promising input to further development of a theoretical well-founded roadmapping methodology.

This short paper is written as part of the preparations for a Conceptual Model of the Roadmapping process, to be delivered by the European ICOPER project. Obviously, there is a need for more work to come up with such a model. We need to understand better the historical roots of roadmapping and how the methodology is used in different projects. Could we use the same methodology developed for manufacturing industries in loosely coupled multinational ICT development for Best Practice projects? We also need to understand how roadmapping stands apart from other knowledge creation or organisational learning activities to see how Activity Theory could be used to inform a new Conceptual Model of Roadmapping.

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