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Communicative Modelling of Cultural Transmission and Evolution by Using Abstract Holographic Cognition

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Abstract: This article addresses the problems of specialization and fragmentation that are presently threatening the future of human civilization as we know it – with the aim to contribute towards enabling a more informed and unified perspective on the 'big' questions that confront us today, the answers to which will determine our future. We present communicative ways to model the transmission and evolution of the processes and artefacts of a culture as the result of a sequence of interactions between its members - both at the tacit and the explicit level. The overall purpose of communicative modelling is to create models that improve the quality of communication between people, and we try to do so here by providing a set of semantically rich conceptual 'placeholders' for modelling the intra-, inter-, and supra-actions of any organizational or cultural entity that is considered to be "important enough to deserve attention" within a certain context. In order to capture the subjective aspects of Gregory Bateson's definition of information as "a difference that makes a difference," the article adds novel features to holographic cognition by abstracting away from the underlying neurophysics of Karl Pribram's Holonomic Brain Theory. Instead we introduce an abstract Holographic Cognition Model that uses holography exclusively as a metaphor or analogy for human cognition - with the object beam of holography corresponding to the first difference (the situation that the cognitive agent encounters), and the reference beam of holography corresponding to the subjective experiences that the agent brings to the situation, and which makes the second difference - the "holographic interpretation pattern" - unique for each agent. Hence, we do not assume the in-brain existence of counterparts of the patch holograms in Pribram's model, but we note that the metaphor of patch holograms provides a basis for modelling human biases and limitations in noticing things, as well as in recalling the memories of those things, at the individual, organizational and cultural levels. This inclusion of both individual and collective human biases increases the scope and the psychological plausibility of the present models. Moreover, by combining our abstract HCM with a semantically rich and recursive form of process modelling, based on Ikujiro Nonaka's SECI theory of knowledge creation, we arrive at a way to model cultural transmission and evolution processes that is consistent with Wolfgang Hofkirchner's Unified Theory of Information and the related Triple-C model with its emphasis on intra-, inter- and supra-actions.

Keywords: Communicative Modelling, Culture as Process, Difference That Makes a Difference, SECI Theory of Knowledge Creation, Learn-Err Model, Unified Theory of Information, Cognition, Communication, Cooperation

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1. Introduction, Background, and Contributions of This Article

1.1. The Problems of Specialization and Fragmentation

Around the turn of the last century, there was a sudden explosion of abstraction which had an enormous impact that is still being felt throughout modern civilization. In fact, this "intellectual supernova" marks the beginning of the present age of specialization. Today it is impossible for any single mind to even begin to comprehend the totality of what is going on in our culture in order to obtain some kind of scientifically based 'world-view' in the sense that motivated the thinkers of the 19th century. Instead, we have to content ourselves with much more humble ambitions in our understanding of the human condition.

Unfortunately, this age of specialization has fostered an attitude where the attempts of interdisciplinary understanding have been largely abandoned - giving way to the opposite attitude, the well-known way of the 'specialist'. In one of his philosophical essays, *Science and Humanism*, Erwin Schrödinger (1951) discusses, among other things, the problems of specialization. He refers the reader to an article of the Spanish philosopher José Ortega y Gasset, called *La barbarie del especialismo*, where he paints the picture of the specialized scientist as the typical representative of the brute ignorant rabble - the *hombre masa* (mass-man) - who endangers the survival of true civilization. In the translation of Schrödinger (ibid., 110), Ortega writes:

> *He is a person who, of all the things that a truly educated person ought to know of, is familiar only with one particular science, nay even of this science only that small portion is known to him in which he himself is engaged in research. He reaches the point where he proclaims it a virtue not to take any notice of all that remains outside the narrow domain he himself cultivates, and denounces as* dilettantist *the curiosity that aims at the synthesis of all knowledge.*
>
> *It comes to pass that he, secluded in the narrowness of his field of vision, actually succeeds in discovering new facts and in promoting his science (which he hardly knows) and promoting along with it the integrated human thought - which he with full determination ignores. How has anything like this been possible, and how does it continue to be possible? For we must strongly underline the inordinateness of this undeniable fact: experimental science has been advanced to a considerable extent by the work of fabulously mediocre and even less than mediocre persons.*

Schrödinger closes his discussion of the specialist-generalist dilemma with the following words: (ibid., 112):

> *Never lose sight of the role that your particular subject has within the great performance of the tragi-comedy of human life; keep in touch with life - not so much with practical life as with the ideal background of life, which is ever so much more important; and, Keep life in touch with you. If you cannot - in the long run - tell everyone what you have been doing, your doing has been worthless.*

In the opening statement of the first chapter of his book "Wholeness and The Implicate Order" (Bohm 1980, 1), the theoretical physicist David Bohm has the following to say about the problems of fragmentation:

> *It is especially important to consider this question today, for fragmentation is now very widespread, not only throughout society, but also in each individual; and this is leading to a kind of general confusion of the mind, which creates an endless series of problems and interferes with our clarity of perception so seriously as to prevent us from being able to solve most of them.*

The worries expressed in these citations from Schrödinger and Bohm are strongly related to the *Unified Theory of Information* (Hofkirchner 2009; 2010), which also addresses the potentially lethal problems of specialization and fragmentation. According to Hofkirchner (2010, 6):

> *There has been a qualitative change in the role information can play for the development of society, and this change is unprecedented in the history of humanity. Information has become the bearer of survival, the key to our future.*
>
> *[…] In a word, the continued existence of humanity has shaped up as impossible without conscious and cautious intervention in the process of its own development. This intervention that is moving towards the reconnection of our disintegrating world – which is falling apart owing to a process of heterogenization, fragmentation and disintegration – is informational in nature, but as it extends from the human sphere to the living sphere to the material sphere, it necessitates a deep understanding of the information processes going on in the world we inhabit.*

1.2. Culture as Process

> *There is often a temptation to treat culture and cultural differences as a "thing". However, research in cultural social psychology and related disciplines has demonstrated that culture is better thought of as a process. Social psychologists have demonstrated that, even when cultural patterns appear to be relatively stable over time, culture is continuously produced and reproduced in the dynamic interaction between individuals and their social and natural environments.*[1]

Praslova (2006) reviews several approaches to understanding culture and introduces an integrative model of *Culture as Unfolding Process* (ibid., 53). She also gives an overview of the struggles with the concept of culture, and on page 50 she cites Lonner (1994), who claims that there are over 200 definitions of the term 'culture', none of which have been embraced by a substantial number of scientists. On the same page, Praslova also cites several sources as evidence that "psy-

[1] Quoted from the *Call for Papers Special Issue of Social Psychology on "Culture as Process: Dynamics of Cultural Stability and Change"* with deadline June 30, 2011. Accessed June 27, 2012. http://recherche.univ-lyon2.fr/greps/spip.php?article270

chologists increasingly tend to see culture as a dynamic process rather than as an index or an entity". However, the expressive power of Praslova's CUP model is rather weak, mainly because of two reasons. First, the model has no visual semantics, and second, it has no explicit time dimension, which means that temporal aspects of the cultural unfolding process cannot be expressed in the model.

1.3. Contributions and Structure of This Article

The present article introduces a semantically rich and temporally explicit way to model the process of cultural transmission and evolution - based on a set of modelling techniques that is called *communicative modelling* (Naeve 2011). Some of these techniques have been described in various earlier publications[2], but the present article represents an attempt at bringing several of them together into a coherent whole.

Towards this aim we present a de-linearized version of the SECI model of knowledge creation (Nonaka 1994) and connect this model to the Triple-C model, which was introduced by Hofkirchner (2002), and which is described by him in the following way (Hofkirchner 2010, 18):

We come across information in three areas of society:

- *In the area of cognition, where the content of consciousness are produced by individuals.*
- *In the area of communication, where common understanding is produced by interactions (individuals), and;*
- *In the area of cooperation, where sense embodied in societal structures is produced collectively by individuals acting in a balanced way.*

An important strength of the Triple-C model is that it connects the concepts of *intra* (looking downwards), *inter* (looking 'widewards'), and *supra* (looking upwards) with the relative position from which one is looking at the acting systems, as depicted in Figure 1. This makes the corresponding concepts of *cognition*, *communication*, and *cooperation* recursively applicable at every level of human and organizational activity. In section 2.3 we will see how to take advantage of this recursiveness by modelling it explicitly.

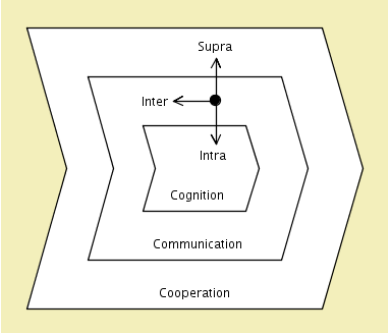


Figure 1: The Triple-C model from a process perspective.

It is this pragmatic focus on the *uses* of information – for respectively "intro-spection", "inter-spection" and "supra-spection" - that provides the UTI with the representational power to model concepts such as the *intention*(*al stance*)[3] of the agent/agency behind a certain approach to the concept of information itself. This is needed in order to integrate and unify such diverse views on information as those of Shannon (1948) and Bateson (1972; 1978). Shannon intended to account for the complexity involved in transmission of information by machines, whereas Bateson, with his definition of information as "a difference that makes a difference," intended to capture the subjective aspect of information, the "making" of the (second) difference, from the perspective of a human subject.[4]

[2] Notably Naeve (1997; 2005) and Naeve et al. (2007).

[3] To use a term coined by the philosopher Daniel Dennett for the level of abstraction in which we view the behavior of a thing in terms of mental models. See http://en.wikipedia.org/wiki/Intentional_stance (Accessed on 27 June 2012).

[4] These two intentions are more or less mutually exclusive, and by naming his seminal paper "A Mathematical Theory of Communication", Shannon (1948) in fact introduced a hitherto unfamiliar connotation of the term 'communication'.

The present article is structured as follows: Section 2 introduces the SECI modes of knowledge conversion (Nonaka 1994) and shows how to 'de-sequentialize' the original SECI model and align it with the Triple-C model. Section 3 introduces the *learn-err model*, which models learning as driven by errors or surprises, i.e., differences between theoretically *expected* and experimentally *inspected* phenomena. This section also discusses the OADI-SMM model of Kim (2004), which builds on the concepts of *single-loop* and *double-loop* learning (Argyris and Schön 1978) and connects these two forms of learning between the individual and the organizational level[5]. Section 4 reviews the basics of Pribram's Holonomic Brain Theory and introduces an abstract Holographic Cognition Model, which maps human cognition to holography and compares subjective interpretation of a given situation with "holographic interference patterns" between an external "object beam" and an internal/subjective "reference beam" that consists of individual and collective experiences, beliefs, and assumptions. Section 5 assembles the pieces and explains how to model cultural transmission and evolution in a communicative way. Finally, Section 6 presents conclusions and future work.

2. Modelling Individual and Organizational Intra-, Inter-, and Supra-action

2.1. The SECI Modes of Knowledge Conversion

According to Nonaka (1994) the key to the creation of new knowledge lies in the following four (SECI) modes of knowledge conversion, which occur when tacit and explicit knowledge interact with each other[6]:

- *Socialization*, which is the process of sharing experiences (tacit knowledge), thereby creating new tacit knowledge.
- *Externalization*, which is the process of articulation and conversion of tacit knowledge into explicit knowledge.
- *Combination*, which is the process of restructuring and aggregating explicit knowledge into new explicit knowledge.
- *Internalization*, which is the process of reflecting on and embodying explicit knowledge into tacit knowledge.

As illustrated in Figure 2, which is taken from Naeve (2005), a knowledge-creating spiral occurs when these modes of interaction between tacit and explicit knowledge are elevated from the *individual*, to the *group* and *organizational* levels. Organizational knowledge creation, therefore, should be understood as a spiralling process that organizationally amplifies the knowledge created by individuals and crystallizes it as a part of the knowledge network of the organization. This process takes place within an expanding "community of interaction" which crosses intra- and inter-organizational levels and boundaries.

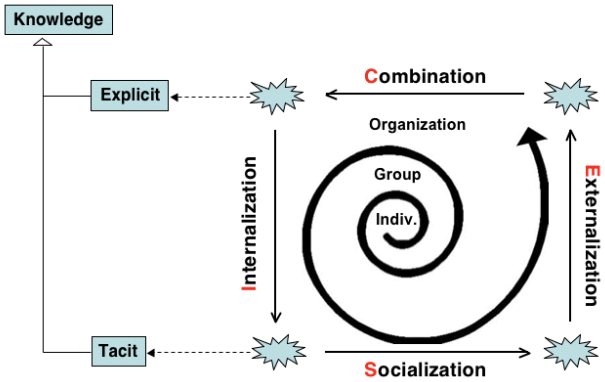


Figure 2: The SECI spiral of knowledge creation. [7]

[5] Organizational double-loop learning is a characteristic of the *Learning Organization* (Senge 2006).
[6] The concept of *tacit knowledge* was introduced by Polanyi (1967).
[7] The triangle-shaped arrow connecting 'Explicit' and 'Tacit' to 'Knowledge' is a UML-like notation for *specialization*. Hence, explicit knowledge and tacit knowledge are modelled as two different kinds of knowledge (Rumbaugh et al. 1999).

2.2. Combining the SECI Theory With Process Modelling

By combining learning process modelling (Naeve et al. 2005; 2008b) with the SECI theory of knowledge creation, we can create a *SECI process framework* (*abstract model*) for the description and classification of knowledge-creating learning processes. In Figure 3 we have introduced the four different kinds of *ba*,[8] as well as their corresponding tools of support. *Socialization* occurs in *originating ba*, where *experiencing* and *empathizing* activities are supported by *community-building tools*. *Externalization* occurs in *dialoguing ba*, where *articulating* and *conceptualizing* activities are promoted by *discussion supporting tools*. *Combination* occurs in *systemizing ba*, where *connecting* and *deducing* activities are supported by *conceptual modelling tools*. *Internalization* occurs in *exercising ba*, where *reflecting* and *embodying* activities are supported by *reflective analysis tools*.

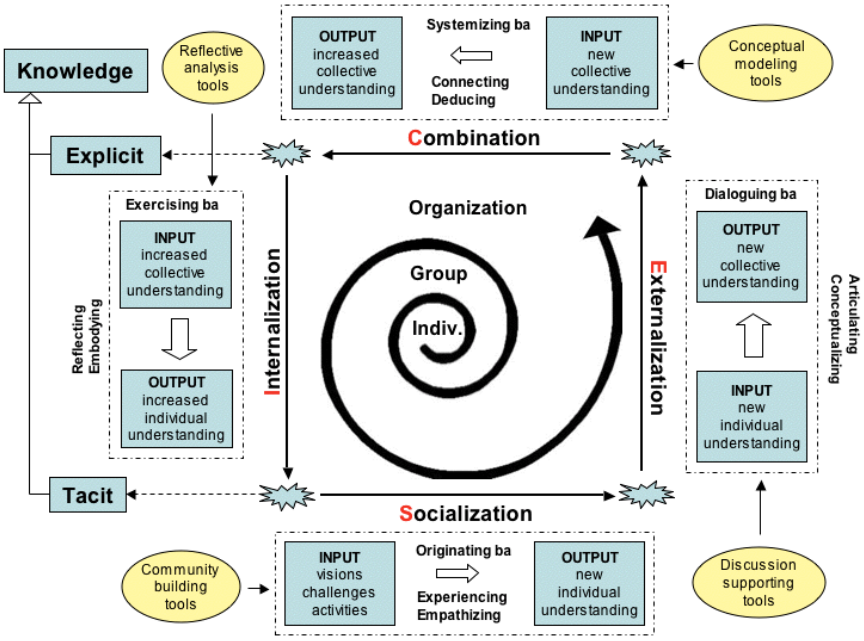


Figure 3: The SECI process framework.

In each of the four SECI knowledge conversion stages a learning process takes place. As shown in Figure 3, which is taken from Naeve et al. (2005), sharing experiences in the socialization process, with input from *visions*, *challenges* and *activities*, produces *new individual understanding* of the issues at stake. This new individual understanding is then externalized and articulated into *new collective understanding* of the same issues. Then the combination process deductively produces *increased collective understanding*, which is then internalized by reflection and embodied into *increased individual understanding*.

As described in Naeve et al. (2005; 2008a), the SECI process framework provides a methodology for researching the structure of knowledge-creating learning processes and how to best support them with various tools. An attempt at such a classification, based on the SECI process framework, has been carried out by Yli-Luoma and Naeve (2006).

2.3. Aligning the SECI Model With the triple-C Model[9]

The sequential nature of the SECI model is not well adjusted to describing what is actually going on in knowledge creation. Nonaka et al. (2000, Figure 5) indirectly acknowledge this problem when they describe the knowledge-creating process as a collection of intertwined SECI spirals of various sizes that interact with each other.

[8] Nonaka and Takeuchi (2005) introduce the Japanese concept of *ba* (which roughly means “place for interactions”) as a crucial enabler for effective knowledge creation. The Japanese word ‘ba’ is a concept that unifies *physical* space (such as e.g., an office space), *virtual* space (such as e.g., e-mail), and *mental* space (such as e.g., shared ideas). Within an organizational context, it is the role of middle managers to maintain the necessary manifestations of such ba in order to support the knowledge creation spiral and make it efficient for the purposes of the organization.

[9] This section is based on Naeve et al. (2007)

Figure 4 shows a non-sequential, SECI-based way to model the communication process at two different organizational levels, called *intra* and *inter*. An important aspect of this model is that it is *recursive*, i.e., applies to communication across any boundary level of an organization, as well as between different organizations. For example, the intra-level could refer to two individuals communicating at the inter-individual (= group) level, or two groups communicating at the inter-group (= department- or organizational) level, etc. We will return to this topic below.

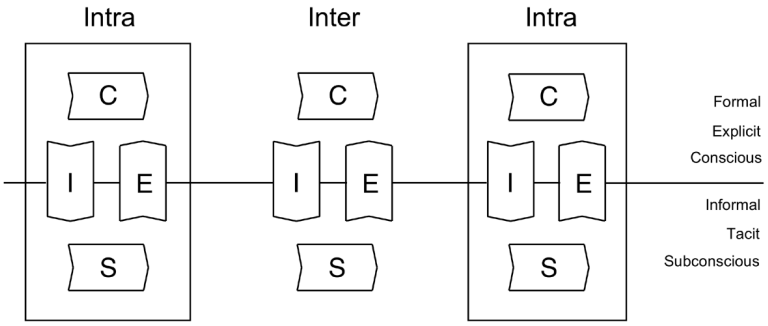


Figure 4: SECI-based inter- and intra-action processes.

Note that the SECI spiral has been modified in such a way that the S- and C-parts (Socialization and Communication) are going on *in parallel*, while the I- and E-parts (Internalization and Externalization) are feeding information back and forth between the explicit (= formal = conscious) and tacit (= informal = subconscious) knowledge levels. Moreover, the intended semantics of the model is that also the I- and E-parts are considered to be going on in parallel. This is shown more clearly by the notation, which is introduced in Figure 5. The C- and S- parts run in parallel, and so do the I- and E-parts. As mentioned above, the Triple-C model identifies the intra, inter, and supra levels of action with respectively cognition, communication, and cooperation.

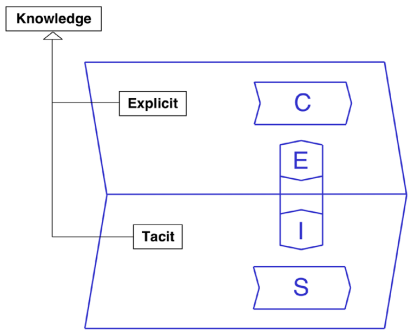


Figure 5: Combination and Socialization correspond to the Explicit and Tacit parts of a process.

In Figure 6 we show how to make use of the modified SECI-model in order to model cognition within, communication between, and cooperation among two groups within the same organization. The vertical (dotted) lines refer to the *environmental interfaces* of the groups and the organization, while the horizontal lines refer to the *cultures* (= meaning and memory) of the groups respectively the organization. These cultures represent the shared mental models (“world view”) and routines (“the way we do things”), respectively within the organization and within the groups. The filled dots refer to dominant stakeholders, while the unfilled dots refer to sub-dominant stakeholders.

As described in more detail in Naeve et al. (2007), the interpretation of the model of Figure 6 is that the group to the left is driven mainly by some overall organizational goals and to a lesser extent by its own group-specific goals, while the opposite is true for the group to the right. Also, the left group is drawing its main support for its actions from the organizational culture, while the right group is drawing its main support from within its own group culture. Hence, the model implies that the left group is acting more for the overall benefit of the organization, while the right group is acting more in its own self-interest.

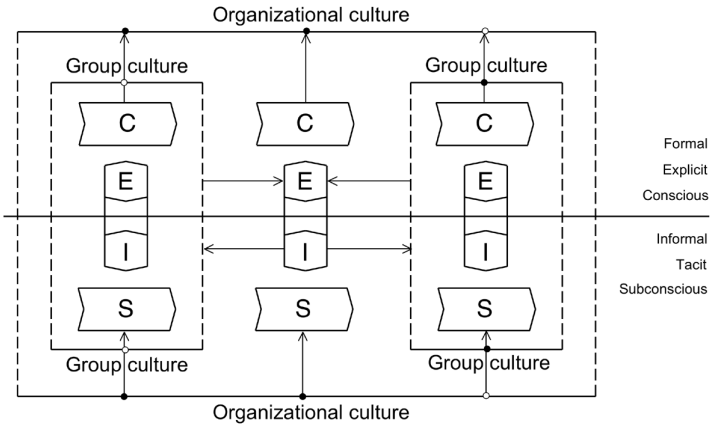


Figure 6: A recursive SECI-based model of a 'unselfish' and a 'selfish' group that are intra-, inter-, and supra-acting within the same organization.

There is an aspect of this model that requires clarification. Although only individuals are capable of internalization and externalization, these processes can take place in different contexts (at different levels)[10]. The E- and I-parts in the centre of Figure 6 represent what is externalized and internalized (by individuals) at the inter-group level, e.g., in a meeting between the two groups. The left and right E- and I-parts represent what is externalized and internalized at the intra-group level (by individuals) in meetings within each separate group. The horizontal arrows between the E-parts indicate that what is externalized at the meeting depends on what has been externalized by each separate group before the meeting, i.e., what each group has discussed in advance and decided to express at the meeting. The horizontal arrows at the I-level indicate that although some internalization goes on at the meeting, each group also brings back "something to think about" from the meeting.

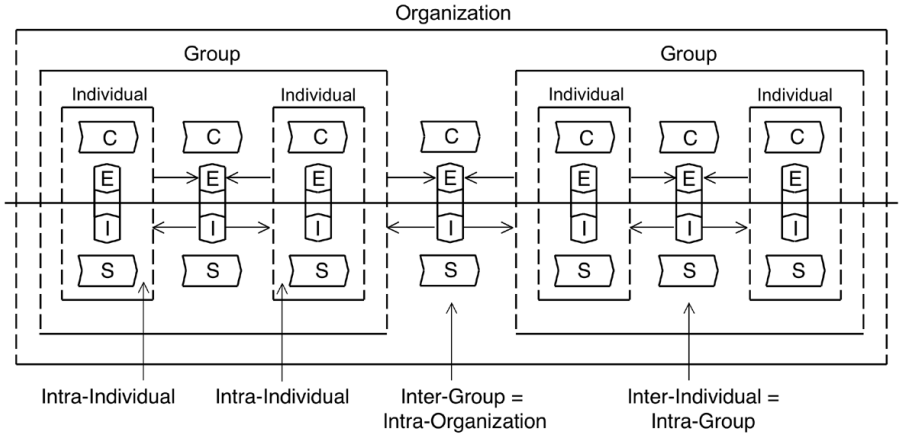


Figure 7: Individual, Group, and Organizational levels of the recursive SECI-based model.

As mentioned above, a great merit of the non-sequential SECI-based model presented here is that it applies recursively to intra-, inter-, and supra-actions at any level. As we have seen, this is consistent with the relativity of the intra-inter-supra perspective that underpins the Triple-C model of the Unified Theory of Information. In Figure 7 these actions have been expressed at three different levels, the individual level, the group level and the organizational level.

2.4. Simplifying the Notation of the Modified SECI Model

It is important to note that the model allows for socialization and combination to go on within a single individual. This makes it easier to handle refinements of ideas that take place in solitude.

[10] A dynamic model of the interplay between these processes in the context of creating and transforming organizational culture is presented in Figure 10 (Section 3.2).

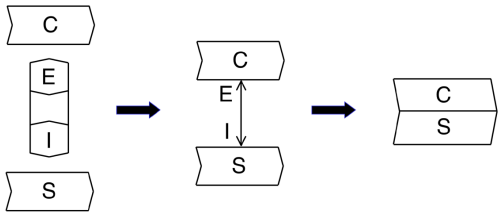


Figure 8: Simplified notation for the recursive, SECI-based model.

Having established a precise notation for the modified SECI-model, a simplification will now be introduced in order to allow us to concentrate on the elements of interest. It is often desirable to suppress the E- and I-parts of a process and focus on the C- and S-parts. In a work process there is always a formal part, which represents the production of some product or service, and an informal part, which represents the supporting (tacit) context within which the formal production process takes place.

Figure 8 displays this simplified notation. The basic idea is to divide the traditional process symbol into an upper and a lower part, and let the upper (C) part represent the formal (explicit) part of the process and the lower (S) part represent its supporting informal (tacit) part. Moreover, the E- and I-parts are assumed to go on during the entire C/S process and to transform knowledge between the tacit and explicit levels whenever this is needed.

3. Modelling Individual and Organizational Learning

3.1. The Learn-Err Model

To *err* is to *make mistakes*. According to Senge (2006, 143), Edwin Land, the creator of Polaroid corporation, had a sign on the wall of his office that read: "*A mistake is an event the full benefit of which has not yet been turned to your advantage"*. This statement highlights the idea of the mistake as a learning opportunity, which is the essence of *the learn-err model* depicted in Figure 9[11].

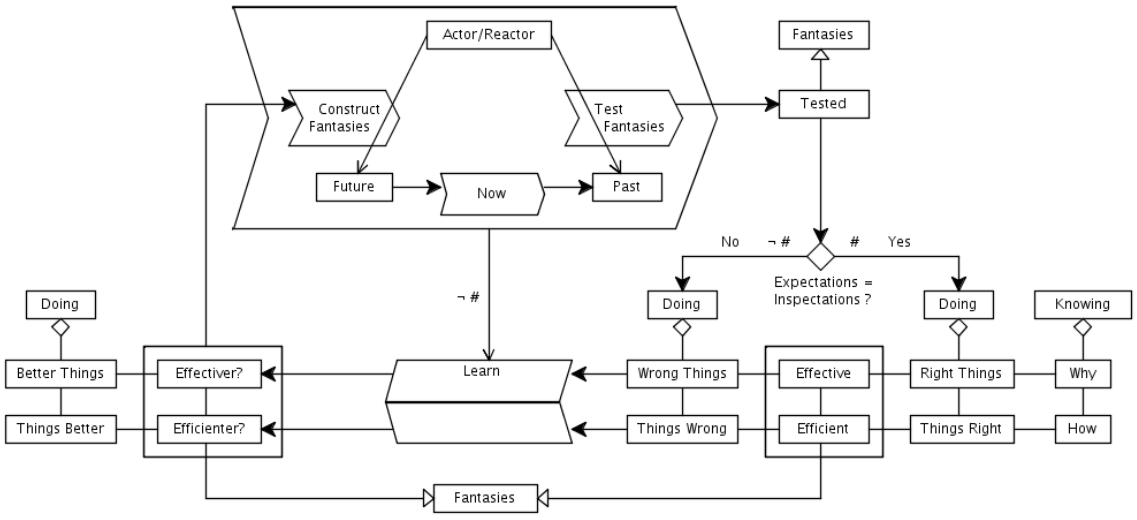


Figure 9: The learn-err model.

At the top of this diagram there is a large process symbol, which represents the scientific process. Inside the scientific process, the *Now* is modelled as a process that takes the *Future* as input

[11] In the learn-err model, the horizontal division of the process symbol of the Learn process does **not** indicate a separation between explicit and tacit levels of communication. Instead, this division should be interpreted as a separation between *effectiveness* (knowing why) and *efficiency* (knowing how). In this article, the learn-err model represents the only exception to the semantics behind the notation of the modified SECI model (Figure 8).

and gradually transforms it into the *Past*. Above this process there is an Actor/Reactor agent representing a scientist, which in our time is a role model for acting and reflecting human beings in general.

As scientists we *construct fantasies* (normally called *theories*) about the workings of the world that surrounds us. If we want our fantasies to have predictive power, they must always be directed towards the future, and try to answer questions such as "What would happen if …?" Such fantasies naturally create *expectations* that lead us to construct experiments that can *test* our *fantasies* in order to verify or falsify them. This experimental process is always directed towards the past and tries to answer questions such as "What happened when …?" The results of this experimental "inspection process" are referred to as *inspectations*[12].

If things turned out (= were 'inspected') exactly as expected, i.e., if the inspectations agreed with the expectations, then this lack of surprises strengthens the tested theory. In this case, the diagram representing the scientific process is said to *commute* (or be *commutative*)[13], a fact which is expressed by the # sign in Figure 9. In contrast, if things did not turn out to have become exactly as expected, then there were some surprises occurring. Either something unexpected happened (= was inspected), or something that was expected did not happen (= was not inspected). In this case, the scientific process diagram does not commute, which is expressed by the ¬# (not commutative) sign in Figure 9. In the learn-err model, this is when the need for learning arises and the Learn process "kicks in".

In this context, *making mistakes* is equated with *generating surprises*, i.e. not creating expected results, or creating unexpected results. Hence, *the* learn-err *process loop is driven by surprises*, i.e., the lack of agreement between *expectations* and *inspectations*. This fact is represented by the decision-box to the right. As long as there is a difference, i.e., as long as there is an 'error' in our expectations, then there is something to learn in order for our fantasies to become improved. Here 'effective' means *doing* (= fantasizing about) the *right things*, and 'efficient' means *doing* the *things right*, i.e., fantasizing about them in the right way. Hence, effectiveness is concerned with goals/impact efficacy (*knowing why*), while efficiency is concerned with process efficacy (*knowing how*)[14].

As modelled in Figure 9, improving our knowledge of *why*, hopefully leads to *doing better things*, and improving our knowledge of *how*, hopefully leads to *doing things better*. Any one of these improvements will inform the scientific process and help us to construct more effective (*effectiver?*) and/or more efficient (*efficienter?*) *fantasies*. The 'hopefully' part is modelled by the question marks, which can only be eliminated by testing of the updated (and hopefully improved) fantasies.

The learn-err process stops when the testing of our fantasies does not produce any more surprises. Then we experience that we are doing the *right things right*. Of course, there is a pragmatic element involved in the testing of the fantasies. In practice, the learn-err process stops when we are experiencing that we are doing *enough right things right enough*.

3.2. Single- and Double-loop Learning for Individuals and Organizations

The OADI-SMM[15] model (Kim 2004) incorporates the concepts from Argyris and Schön (1978) of *single-loop* and *double-loop learning* - on both the individual and the organizational levels. In contrast to single-loop learning, which only involves applying previously acquired knowledge and skills to dealing with the problems that are encountered by an individual or an organization, double-loop learning also involves surfacing and challenging deep-rooted beliefs and assumptions that have previously been inaccessible, either because they were unknown, or because they were known but undiscussable.

Individual double-loop learning is traced out in Figure 10 as the process through which an individual's learning affects the individual's mental models that in turn affect the individual's future learning. Organizational double-loop learning occurs when changes in individual mental models become incorporated into the organization through shared mental models, which can then affect organizational action. In both cases, double-loop learning provides opportunities for discontinuous steps of improvement where reframing a problem can bring about radically different potential solutions. In the formulation of Kim (2004, 48):

> *As mental models are made explicit and actively shared, the base of shared meaning in*

[12] to emphasize the duality with the expectations created by a theory.

[13] Compare http://en.wikipedia.org/wiki/Commutative_diagram (Accessed on 27 June 2012).

[14] These definitions are consistent with Peter Drucker's distinction between efficiency and effectiveness, cited in Haas Edersheim (2007, 13): "Efficiency is doing things right, effectiveness is doing the right things".

[15] Observe, Assess, Design, Implement – Shared Mental Models.

an organization expands, and the organization's capacity for effective coordinated action increases.

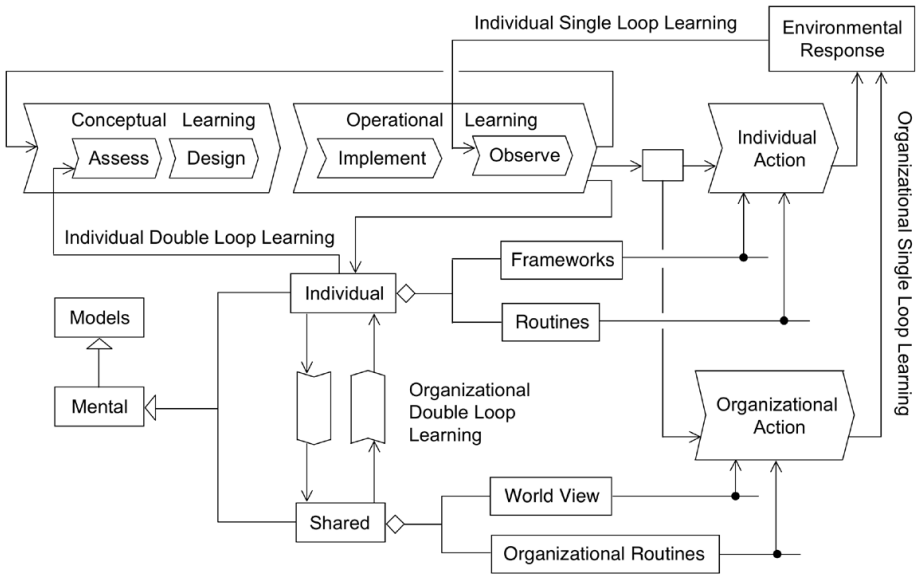


Figure 10: Individual and organizational single-loop and double-loop learning[16].

4. Physical and Abstract Holographic Cognition

As mentioned above, Gregory Bateson (1972; 1978) defined information as "a difference that makes a difference". The making of that difference is the key to the workings of the process of *ex-formation* (Nørretranders 1991; Lefrère 2011), which is the process of disregarding what is unimportant (inessential) in a given situation. This process is always biased, i.e., it depends on some form of pre-judgements (= experience = prejudice). We will now introduce a powerful and intuitive way to model such human biases in terms of a Holographic Cognition Model.

4.1. What is Holography?

As described by Wilber (1982, 6):

Holography is a method of lensless photography in which the wave field of [coherent] light scattered by an object is recorded on a plate as an interference pattern. When the photographic record – the hologram – is placed in a coherent light beam like a laser, the original wave pattern is regenerated. A three dimensional image appears. Because there is no focusing lens, the plate appears as a meaningless pattern of swirls. Any piece of the hologram will reconstruct the entire image[17] .

4.2. The Holonomic Brain Theory

The renowned brain researcher Karl Pribram has proposed a *Holonomic Brain Theory* (Pribram 1987; 2007) for brain processes, including memory storage and retrieval, which implies that the deep structure of the brain is essentially holographic[18]. Instrumental in helping Pribram to arrive at his theory was the theoretical physicist David Bohm, who had speculated that the nature of the universe might be analogous to a hologram, a realm of underlying frequencies whose interference patterns create the experience of concrete reality (Bohm 1980, 144-147). According to Wilber (1982, 7-9):

[16] Modelled from Kim (2004, Figure 2.7).

[17] This process was first described mathematically by Denis Gabor in 1947, for which he received the Nobel price in physics in 1971. Making use of the newly invented laser, the first realistic holographic images were created by Emmeth Leith and Juris Upatnieks in 1964.

[18] For more details on the HBT (described in non-specialist terms) see the online interview with Karl Pribram by Daniel Goleman (2007). Accessed on 27 June 2012 at http://www.sybervision.com/Golf/hologram.htm#memory

An impressive body of research in many laboratories has demonstrated that the brain structures see, hear, taste, smell and touch by sophisticated mathematical analysis of temporal and/or spatial frequencies. An eerie property of both hologram and brain is the distribution of information throughout the system, each fragment encoded to produce the information of the whole. […] Karl Pribram's research and theory encompass the whole spectrum of human consciousness: learning and learning disorders, imagination, meaning, perception, intention, paradoxes of brain function.

In one of his more recent formulations of the HBT, Pribram (2007) writes:

The Holonomic Brain Theory describes a type of process that occurs in fine fibered neural webs. The process is composed of patches of local field potentials described mathematically as windowed fourier transforms or wavelets[19]*. The fourier approach to sensory perception is the basis for the holonomic theory of brain function. Holonomy, as its name implies, is related to the unconstrained Fourier co-ordinate system described by holography.*

4.3. Introducing an Abstract Holographic Cognition Model

We will now abstract away from the underlying neurophysics of the HBT and introduce a purely conceptual and non-physical *Holographic Cognition Model.* In this abstract HCM, the second difference in Bateson's definition is modelled as a holographic interference pattern – a personal *interpretation hologram* – created by the human observer by applying his/her personal "reference beam" of past experiences (mental models) to the "object beam" of the present situation (Figure 11).

The key feature of this model is that different observers will interpret the same situation in different ways, because they bring different reference beams to the same object beam, thereby creating different interpretation holograms. Hence, the abstract HCM provides an intuitive way to model "the making of the second difference" in Bateson's definition of information. However, as most analogies, the holographic analogy does not conserve the validity of all of its connotations when it is applied to human cognition.

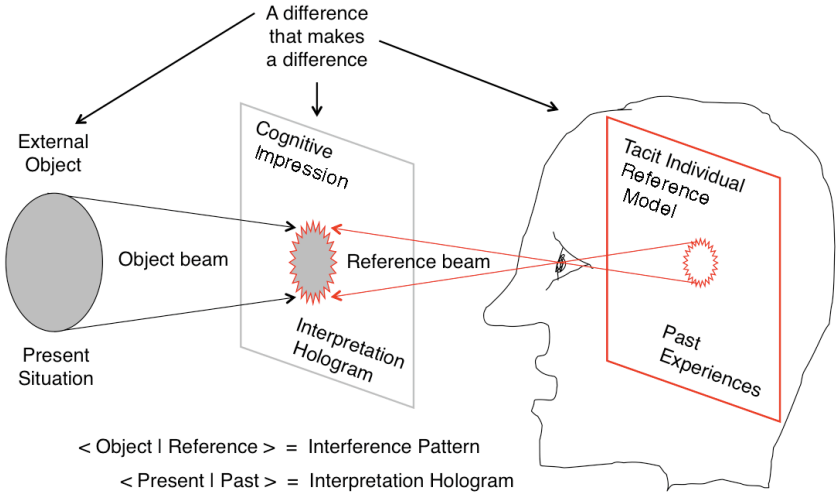


Figure 11: Interpreting an object through a tacit reference model

By making use of a holographic analogy for the cognitive process, the abstract HCM in fact maps the cognitive process to the holographic process. Then some useful aspects or properties of the holographic process can be "pulled back" and used to model the cognitive process[20].

[19] [Comment by the present author]: In this context, the term 'or' should be interpreted as an "*exclusive or*" (a so-called *'xor*'), since, from a mathematical point of view, fourier transforms and wavelet *transforms* (as the latter should be properly called) represent two different methods of creating a holographic interference pattern by *summing* (or *integrating*) a *very* large number of 'primitive' waves - in fact, a *continuous infinity* of such waves. Fourier transforms use the trigonometric functions sin( ) and cos( ) as primitive building blocks, while wavelet transforms use *wavelets* – also called "brief oscillations" - which are smoothly oscillating functions that 'live' (= deviate from zero) only within a finite time interval. For more details on wavelets, see http://en.wikipedia.org/wiki/Wavelet_series (Accessed on 27 June 2012).

[20] This is an illustrative example of a general method of "*analogic mapping*" from a lesser known into a better known area. Such analogic mapping is carried out in the following two steps:

For example, the interference property of holography is pulled back to the subjectivity property of cognition: Just as different reference beams give different holograms when mixed with the same object beam, different agents experience the same situation in different ways since they bring different reference beams to evaluate it.

Moreover, the reconstruction aspect of holography is pulled back to the 'remembrance' aspect of cognition, i.e., the process of remembering "by reconstruction". However, in this case not all of the properties of holographic reconstruction are conserved. For example, an optical scene can be uniquely reconstructed from a hologram of it, while an experienced situation cannot be uniquely reconstructed from an impression or memory of it[21].

In section 4.4 we will demonstrate how this non-uniqueness of reconstruction can be turned into a feature of the abstract HCM by introducing tacit cultural reference beams on top of which the individual reference beams are superposed, and over which the individuals involved have little or no conscious awareness or control. Such a tacit cultural reference beam can be thought of as a form of *cultural background,* which tacitly frames and situates the cognition of each individual that participates in the corresponding culture[22].

Figure 12 sums up the abstract HCM on the individual level. A cognitive agent, called the *signator*[23], assigns different *relevance* to the *properties* and *behavior* of different *aspects* of the *situations* it encounters[24].

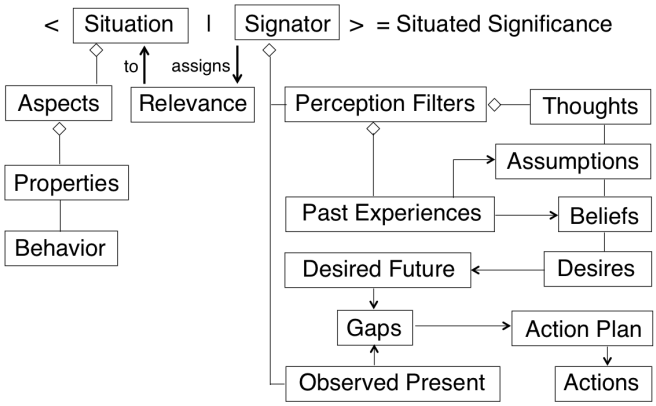


Figure 12: A signator evaluates a situation by assigning relevance to its different aspects

The assigned relevance depends on the *perception filters* (biases) of the agent/signator, which are related to its *past experiences*, *thoughts*, *assumptions*, *beliefs*, and *desires*. This evaluation process creates *gaps* between the *observed present* and the *desired future*, leading to an *action plan* according to which the agent will apply different *actions* that attempt to modify the present situation according to its wishes and expectations for the future.

4.4. Introducing Tacit Cultural Reference Beams into the HCM

We will now revisit the interaction between the individual and the shared mental models that is indicated by the process loop marked "organizational double-loop learning" in Figure 10. Since our Holographic Cognition Model is abstract, we are free to regard the individual reference beams as being part of – or embedded within - various organizational or cultural reference beams - as depicted below in Figure 13 (which only shows one such beam). This "cultural embedding" of individuals

(1) Find a mapping that takes the less familiar domain into some better known area that can be considered to be analogous (or *homomorphic* as one says in mathematics) to the original domain. For example, when we say that *human cognition is a bit like holography*, we are in fact perfoming an analogic mapping – assuming that holography is a more familiar and better known area than the domain of human cognition.

(2) When such an analogic mapping has been established, we try to pull back different concepts and properties of the better known area into the lesser known domain. Such pulled-back entities are then examined as potential candidates for new concepts and properties that can be applied within the lesser known domain.

[21] In fact, brain research has demonstrated that memories are *dynamic*, in the sense that whenever we access them we are also liable to change them.

[22] These tacit cultural backgrounds are closely related to the tacit support functions of a culture that are introduced in section 5.3 below.

[23] In accordance with Hofkirchner (2010, 70).

[24] We introduce the notation "< Situation | Signator > = Situated Significance," which is inspired by the Bra-Ket notation introduced by Paul Dirac into quantum mechanics.

captures the fact that individual tacit reference models do not arise in isolation, but are formed within a multitude of different organizational and cultural contexts. In the abstract HCM, each such context can be thought of as adding its own specific reference beam to the interpretation hologram that is formed by an individual within this context.

The feedback loop between the individual and the shared mental models in Figure 10 corresponds to the feedback loop between the tacit individual and the tacit cultural reference models in Figure 13. The latter figure also contains two other feedback loops that model (i) that the individual reference models are updated by cognitive impressions, and (ii) that the cultural reference model is updated by explicit expressions generated from these impressions. This is consistent with the modelling of the "Press" process in Figure 17, which outputs im-pressions that are externalized into ex-pressions[25].

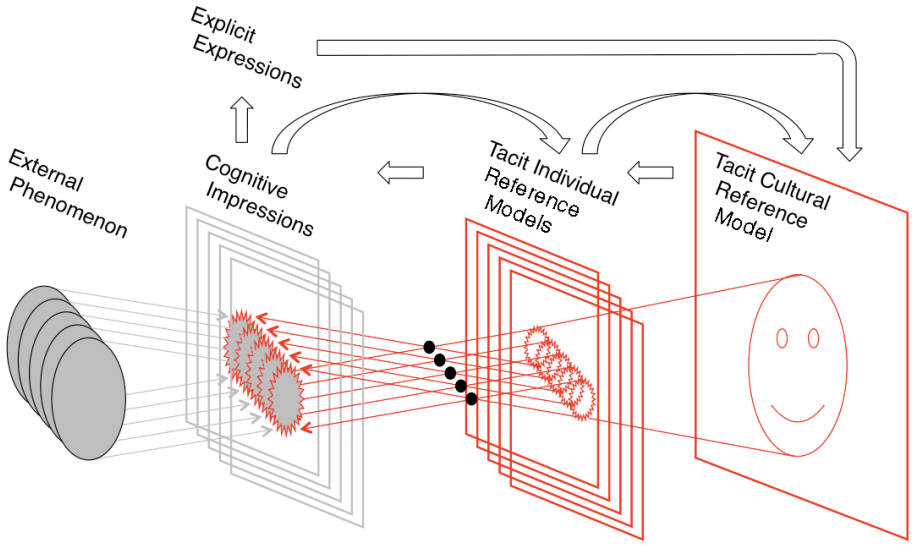


Figure 13: Evolving a tacit cultural reference model

In summary, the main advantage of disregarding the neurophysics in Pribram's Holonomic Brain Theory is that the metaphor/analogy of patch holograms provides a basis for modelling our biases and limitations in noticing things - and then recalling and processing our memories of those things – against an implicitly present cultural background of which we are largely unaware. This inclusion of culturally embedded human biases increases the scope and the psychological plausibility of the abstract HCM.

4.5. Emergent Stability of an Organizational or Cultural Reference Model

The cultural reference model introduced in the last section represents the world-view and the behaviour of an organization or culture. The question then arises: How can we account for the stability of such organizational or cultural behaviour? According to Rocha (1998):

> *Heinz von Foerster [1965; 1969; 2003] equated the ability of an organization to classify its environment with the notion of* eigenbehavior*. He postulated the existence of some stable structures (*eigenvalues*) which are maintained in the operations of an organization's dynamics. Following Piaget [von Foerster 2003], he observed that any specific instance of observation of such an organization, will still be the result of an indefinite succession of cognitive/sensory-motor operations. This reiterated the constructivist position that observables do not refer directly to real world objects, but are instead the result of an infinite cascade of cognitive and sensory-motor operations in some environment/subject coupling. Eigenvalues are self-defining, or self-referent, through the imbedding dynamics – implying a complementary relationship (circularity, closure) between eigenvalues and cognitive/sensory-motor operators: one*

[25] See section 5.2 below.

implies, or defines, the other. "Eigenvalues … represent the externally observable manifestations of the (introspectively accessible) cognitive [operations]" (von Foerster 2003, 265)[26].

Eigenbehavior can be thought of as a kind of "dynamic attractor" of the cognitive feedback loop model that is presented in Naeve (2011, section 13.4). However, elaborating on this relationship is outside the scope of the present paper.

5. Modelling Cultural Transmission and Evolution

5.1. Abstracting the Cultural Transformation Process

The abstraction that will be presented in this section starts by realizing that culture is strongly connected with the past. Of course, this does not imply that cultures cannot be "future-oriented," or "celebrating the future of …" etc. What it does mean however is that the idea of culture is strongly linked to the idea of *preservation* of certain artefacts and behaviours that are deemed by the "cultural curators" to be worth preserving. Moreover, the idea of culture is strongly linked to the idea of working to pass this information on to future generations[27], both in the form of theories (= world views) and practices (= organizational routines).

The 'skeleton' of the abstract evaluation-transformation model is given by the following fundamental observation:

The *past* is evaluating the *present* with respect to its *plans* for the *future* based on its *wishes* and *expectations* (Figure 14), while, at the same time, the *present* is transforming the *future* into the *past* (Figure 15)[28].

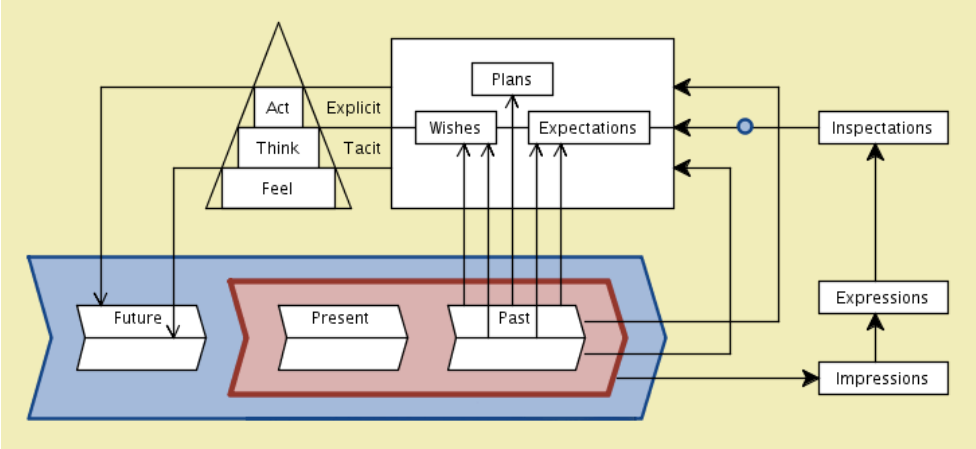


Figure 14: The Past is evaluating the Present with respect to its Plans for the Future (inner contour process).

In accordance with the < Situation | Signator > notation of Figure 12, the notation < Present | Past > denotes the evaluation part of this process. Note that we often refer to the present as a 'situation' (as in the expression "the present situation")[29].

In this model, the *Past* plays the role of an abstraction of the biases/experiences of the *Signator* of Figure 12. From the arrows pointing downwards into the Future process, we can infer that the

[26] [Comment by the present author]: Organizational eigenvalues and eigenbehaviors are rooted in quantum mechanics, where each *observable* (= measurable physical entity) is *assumed* to be associated with a so-called *hermitian operator*. Such an operator always has a set of *real eigenvalues*, and in quantum mechanics these eigenvalues correspond to the set of values that can result from measuring the physical entity in question. Moreover, when such a measurement is undertaken, the underlying *wave function* of the measured entity is 'disturbed' and forced into a new state, which is an *eigenvector* (or *eigenstate*) of the operator of the measured entity, and this eigenvector corresponds to the eigenvalue that was measured for the entity. Such an eigenvector is the quantum-mechanical equivalent of an organizational eigenbehavior.

[27] In Swedish this activity is called 'tradera'. Unfortunately, the English term 'trade' has totally different semantics.

[28] In fact, the present acts as a hyper-plane in "past-future space". Just as you cannot pass from one side of a plane in space to the other side of it without actually passing through the plane, no part of the future can turn into the past without passing through the present.

[29] In Figure 14 and Figure 15 the transformation of the future into the past by the present is implicitly modelled by the fact that the "future process" feeds into the "present process," which feeds into the "past process".

Past has both explicit and tacit wishes and expectations for the Future, which underpin its explicit plans for the Future.

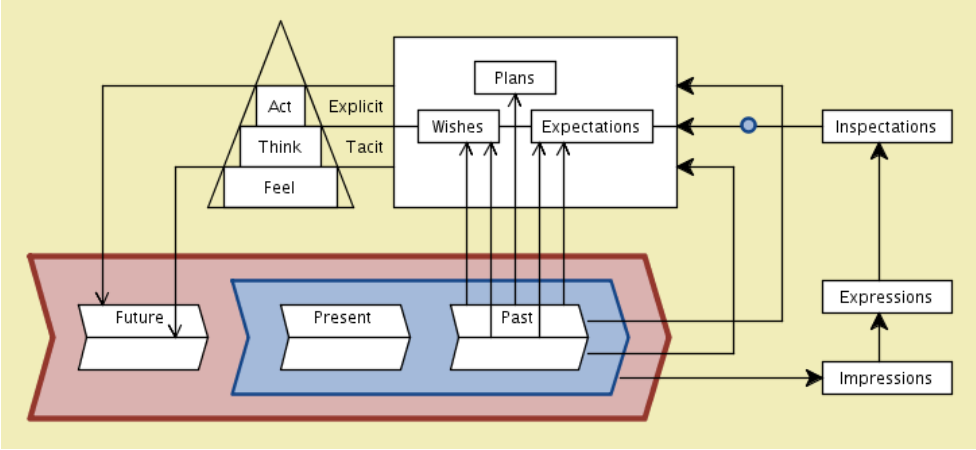


Figure 15: The Present is transforming the Future into the Past (outer contour process).

In terms of the contour notation introduced in Figure 1, the *Past* is cooperating with the *Present* to evaluate the *Future* (inner contour), while the *Future*, *Present*, and *Past* are cooperating to transform the *Future* into the *Past* through the *Present* (outer contour). Moreover, the result of the < Present | Past > evaluation process is modelled as tacit output in the form of *Impressions*, which are then externalized to form *Expressions*, which are presented in the form of *Inspectations*[30].

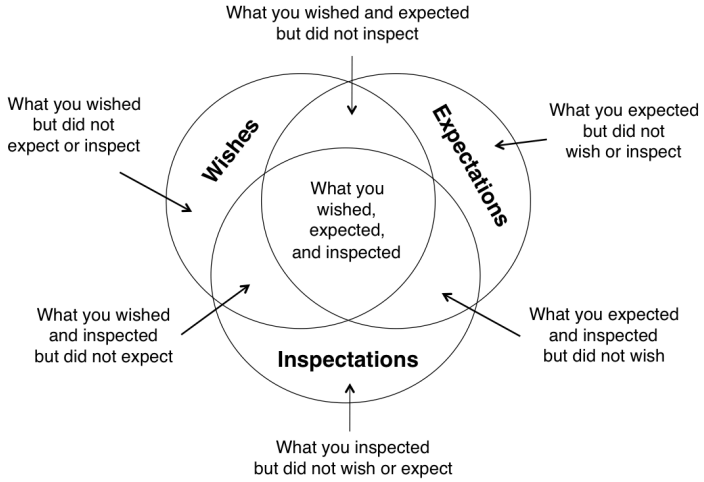


Figure 16: Different combinations of wishes, expectations, and inspectations

The outcome of the < Present | Past > evaluation process involves all possible combinations of *wishes*, *expectations*, and *inspectations*. Hence, it consists of seven different parts[31], which are depicted in Figure 16. Of course, the relative significance of these different parts depends both on the context and on the psychological disposition of the agent. For example, a notorious optimist would often find that many of her/his wishes and positive expectations would not be inspected in reality, whereas a ingrained pessimist would tend to find that many of her/his negative expectations (= fears), would in fact not be inspected.

5.2. Storing Im-Pressions and Ex-Pressions of Encountered Situations

The holographic cognition model is part of the cultural evolution model depicted in Figure 17, which has a cylindrical (= wrap-around) connectivity[32]. A *judgement* is modelled as consisting of

[30] Compare the learn-err model (section 3.1).
[31] Combinatorially speaking, the eighth part is the 'empty' combination, which has no counterpart in this model.
[32] Expressed by the fact that the concept *Judgement* appears both to the left and to the right in the model.

ex-pression(s) and *im-pression*(s). They are produced in the im-*press/ex-press* process to the right and stored in the im-*store/ex-store* process to the left, where it becomes *history*. *Judgement* also consists of *sign*(s), which have explicit *signifier*(s) and tacit *signified*(s) in the semiotic sense of Saussure.[33]

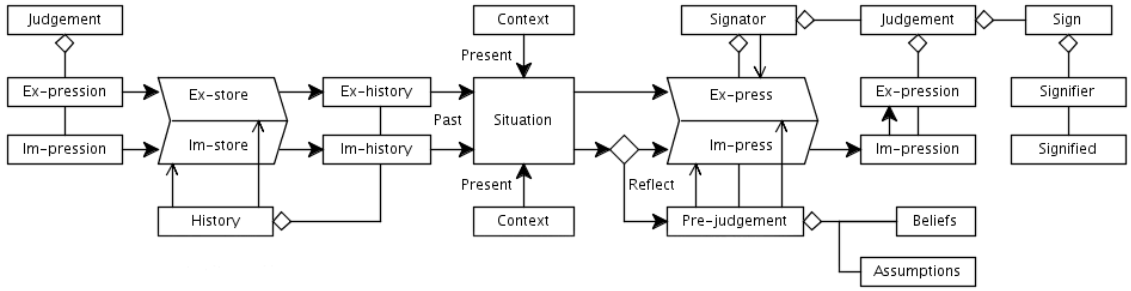


Figure 17: Cultural evolution by storing im-pressions and ex-pressions of encountered situations

As is seen by comparison with Figure 8, the press- and store-processes are divided into explicit and tacit parts. The past, i.e., the *history* (of a culture), is represented by its explicit part, the *ex-history*, and its tacit part, the *im-history*. They are the explicit respectively the tacit outcomes of the *store* process. An encountered *situation* is influenced by the *present context* and the *past history* of the culture. The *situation* is judged (evaluated) by a *signator* who first *reflects* on the different aspects of the *situation* and conjures up its appropriate *pre-judgement*(s), which are based on its *beliefs* and *assumptions*. The *signator* then passes *judgement*(s) on the *situation* and creates a 'cognitive hologram' (in the form of an *im-pression* of the *situation*) by using its *pre-judgement*(s) as a mental reference beam. The *im-pression*(s) are then externalized and expressed in the form of *ex-pression*(s), and then both the im-pressions and the ex-pressions become ex-*history* respectively im-history, which together make up the history of the culture, which represents the cultural (collective) memorization process.

It is important to observe that *ex-pressions* can be stored in externally accessible ways, while *im-pressions* can only be stored in the tacit memory of living persons. In fact, the tacit part, i.e., the *im-history*, of the *history* of a culture consists of the collection of all the mental models of its members. Hence, the *im-history* of a culture is always 'stored in' (= resides in) the aggregated memories of all the living members of this culture.

5.3. The Tacit Support Functions of a Culture

The *Tacit Intersection Support Function* (TISF) of a culture C consists of the *shared mental models* of the people living within C. The TISF of C guides the attention of the people of C and helps them to interpret the relevance of the *im-pressions* and *ex-pressions* that they encounter in collectively relevant situations. The im-pressions originate only from the living, while the ex-pressions can originate both from the living and from the dead.

The TISF represents the mainstream tacit part of the culture, which consists of the stored im-pressions that "make sense" for *all* members of the culture. If instead we look at the *Tacit Union Support Function* (TUSF) we get a tacit support function each of whose concepts makes sense for *some* member(s) of the culture[34].

5.4. Tacit and Explicit Knowledge Transfer

When the active life spans of two individuals overlap, they have the possibility of sharing both ex-pressions and im-pressions (Figure 17) of a situation in terms of *direct* (*explicit and tacit*) *interaction* between them[35]. In contrast, when their active life spans do not overlap, there is only the possibility of knowledge transfer from the earlier (past) to the later (future) individual. In this case there are two possibilities: (1) *explicit knowledge transfer* via *recorded knowledge*, and (2) *indirect*

[33] See e.g., http://en.wikipedia.org/wiki/Sign_%28semiotics%29 (Accessed December 7, 2011).

[34] See Naeve (2011, section 14) for a discussion on how these support functions influence the 'inter-operations' between different cultures.

[35] This corresponds to socialization in the sense of the SECI model.

tacit knowledge transfer via a tacit chain of interactions, i.e., a sequence of people whose active life spans overlap consecutively and connect the two initial (non-overlapping) life-spans.

Figure 18 shows two examples of recorded knowledge transfer: (1) without tacit support (top), and (2) with tacit support (bottom). The top example corresponds (for instance) to a company that changes its management team in such a way that the old and the new teams never meet and interact, but instead the old team only leaves written instructions (recorded knowledge) for the new team about how best to run the company and what issues that are the most important ones to address.

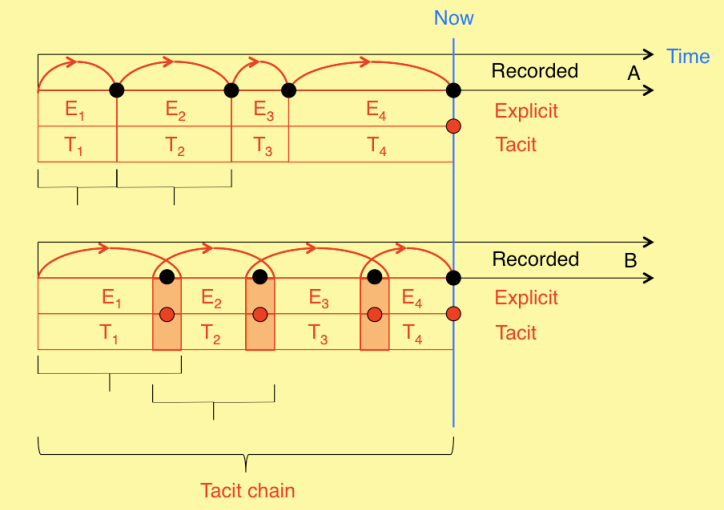
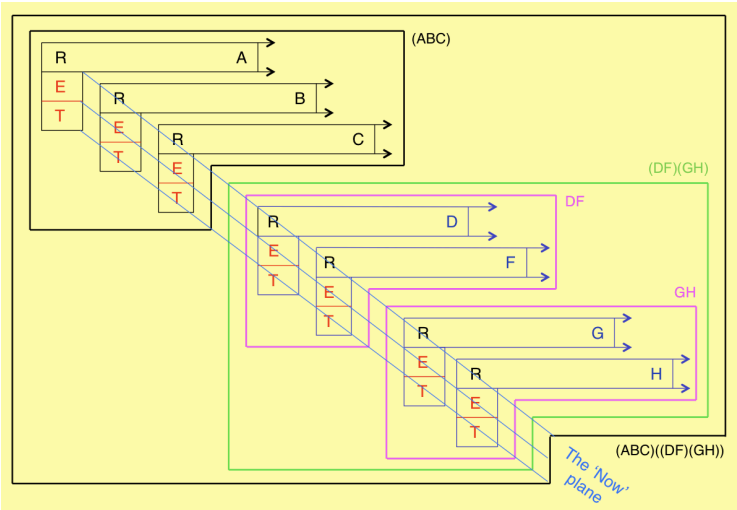


Figure 18: Recorded and tacit knowledge transfer

In contrast, the bottom example of Figure 18 shows a "tacit overlap" between the old and the new management teams, where the recorded knowledge is supported by both tacit and explicit interactions between the two teams.

5.5. Assembling the Pieces into a Cultural Transmission and Evolution Model

Figure 19 depicts a situation where different groups of agents are cooperating on different levels. The agents A, B, C form the cooperating group (ABC), the agents D, F form another cooperating group (DF), and the agents G, H form a third cooperating group (GH). Moreover, the 'internal' groups (DF) and (GH) form a group ((DF)(GH)) that is cooperating with the group (ABC)[36].



[36] Figure 19 should be thought of in 3D with the 'pistol-shaped' contours of the agents being located in parallel planes. The three blue lines are located in a plane, called *The Now Plane*, which is perpendicular to these planes. The Now Plane represents the present moment of time, and as time passes, this plane is translated towards the right.

Figure 19: Cooperation between the groups (ABC) and ((DF)(GH)).

Combing this model with the recursive SECI-based model of section 2.3 (Figure 7), and introducing coherent colouring with Figure 19, the interactions within the group ((DF)(GH)) are modelled recursively in Figure 20.

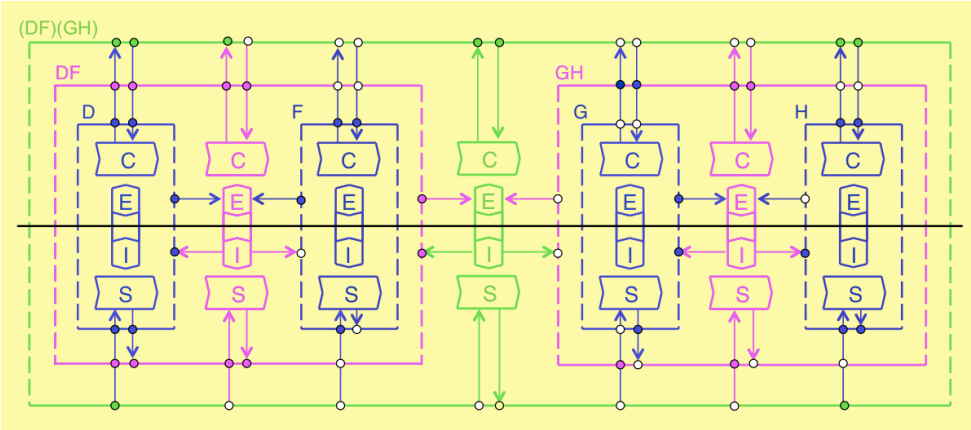


Figure 20: Interactions within the group ((DF)(GH)).

The result of combining the models of Figure 19 and Figure 20 is shown in Figure 21. If we think of the recursive (SECI-based) "conversations plane" as representing all conversations that are going on in a culture at a certain moment of time, then the model depicted in Figure 21 represents the evolution of these conversations over time[37].

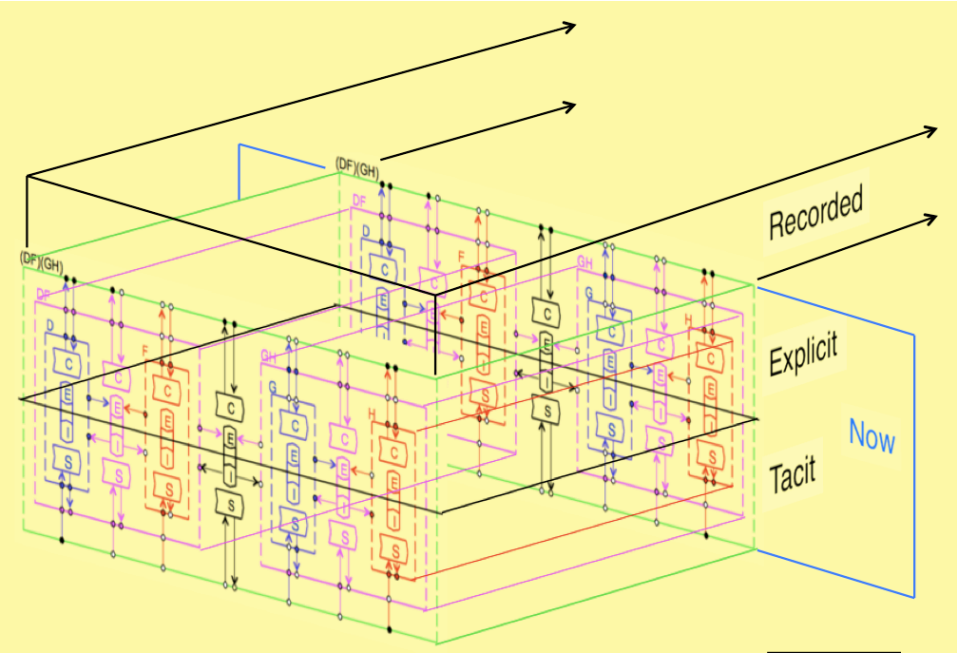


Figure 21: Cultural intra-, inter-, and supra-conversations over time

In principle – but, of course, not in practice – we are now in a position to model the (tacit and explicit) transmission and evolution of a culture, since the model in Figure 21 has 'hooks,' i.e., conceptual placeholders, that can capture both the tacit and explicit interactions that take place within the culture – as well as the resulting records of these interactions. The model of Figure 21 is sup-

[37] The results (= records) of these conversations (the black dots of Figure 18) are not shown in Figure 21.

ported by the models of: Figure 11 and Figure 13 (the abstract Holographic Cognition Model), which describe the (cognitive) intra-actions of each agent; Figure 17 (storing im-pressions and expressions of encountered situations), which describes the collaborative version of the HCM; and Figure 20, which describes the (communicative) inter-actions and (cooperative) supra-actions of the agents taking part in a "cultural discourse" that is translating and transforming the corresponding culture.

Moreover, the dynamics of the model of Figure 21, i.e., *when* the conversational activities of the culture are activated, is controlled by the learn-err model of Figure 9. This model should be thought of as "sitting on top" of the cultural conversation model of Figure 21 and initiating new cultural conversations whenever important expectational errors/surprizes are encountered[38]. Two examples of such surprises are the present financial and ecological crises, which are currently sparking off a lot of confused conversational activities. Hopefully, the modelling techniques presented in this article can contribute towards reducing this conceptual confusion and improve the conversational clarity and relevance of the inter-cultural discourses and supra-cultural actions and activities on which our future critically depends.

6. Conclusions and Future Work

It has been the overall aim of this article to provide a set of modelling techniques that can help to create overviews of "the big picture" - overviews that are vital for addressing the problems of specialization and fragmentation that threaten the future of civilization as we know it. This aim has been addressed by introducing a set of semantically rich communicative modelling techniques - notably the modified SECI model for non-sequential and recursive knowledge creation (Figure 6) and the learn-err model for learning "by surprize" (Figure 9). Moreover, in order to model the subjectivity of human perception, an abstract Holographic Cognition Model was introduced (Figure 11) and elevated to the collective level (Figure 13). Finally, it was demonstrated how these models can be integrated into a model of *cultural evolution* (Figure 17) by *cultural conversations* (Figure 21). The resulting overall model provides conceptual placeholders for capturing any part of a cultural evolution process that is deemed to be important enough to be captured - within a specific context, for a specific purpose, and with respect to a specific target group[39].

The models presented in this article represent an initial attempt to capture and structure the elusive concepts involved in cultural evolution by conversations, and they need to be elaborated and refined in various ways. For example, they would benefit from being connected with the theory of *learning conversations* initiated by Pask (1976; 1996) and elaborated by Laurillard (2002), as well as from deepening their connection with the theory of the *learning organization* (Senge 2006).

The abstract Holographic Cognition Model should be augmented by a model of the cognitive feedback loop - in order to better describe the formation of mental models, as well as the connections between will, skill, action and reflection[40]. It would also be desirable to expand the HCM to include von Foerster's ideas of organizational eigenbehavior (section 4.5), as well as to include the idea of alter-ego-tuning (Hofkirchner 2010, 122-123).

Moreover, as outlined in Naeve (1997; 2011), the cognitive, communicative and cooperative activities discussed in this article have profound connections to an area of abstract algebra called *Category Theory*. For example, as discussed in Naeve (2011, section 14), the *limit concepts* of CT can be used to model the interoperability aspects of different cultures. However, in order to make these ideas more widely applicable, they need to be carefully 'metaphorized' and elaborated in ways that are accessible outside the highly specialized community of abstract mathematics.

In order to overcome the problems of specialization and fragmentation and deal effectively and efficiently with the social, economic and environmental problems that humanity is facing, we have at our disposal the fundamentally important "intellectual forces" of *transparency* and *accountability*. It is my ambition to make use of these forces by combining the communicative modelling techniques presented in this article with the opportunistic collaboration and negotiation techniques presented in Naeve (2005; 2010) and apply this combination of modelling techniques to global problems where increased transparency and accountability are necessary in order to provide sustainable solutions.

[38] However, the complexity of drawing the interaction between these models has prevented me from trying to integrate them in the same diagram.

[39] As discussed in Naeve (2011, 4), *context* (= 'where'), *purpose* (= 'why'), and *target group* (= 'for whom') are fundamentally important in order to determine the appropriate scope and structure of a communicative model.

[40] As mentioned at the end of section 4.5 (p.17), such a model is presented in Naeve (2011), section 14.4. Its connections to the models presented in this article will be the subject of a future article.

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About the Author

Ambjörn Naeve
has a background in mathematics and computer science, and in 1993 he received his doctorate from KTH within the field of computer vision. Today he mainly works as a researcher within the field of networked and personalizable learning environments. In this capacity he heads the Knowledge Management Research group, which he founded in 2001, and which is based at the school of Computer Science and Communication at KTH and at Uppsala Learning Lab at Uppsala University. Ambjörn Naeve has contributed widely within the fields of Knowledge Management, Technology Enhanced Learning and Semantic Web. His main contributions have taken the form of articles for international research conferences and journals, book-chapters, co-edited books, and thematic (special) issues of international research journals. Moreover, Ambjörn Naeve is the editor-in-chief of the International Journal of Technology Enhanced Learning (IJTEL). During later years, the KMR-group has specialized in methods and tools for communicative modelling, disagreement management and unplanned (ad-hoc) collaboration. This work has mainly been financed by various EU projects. The most recent among these projects are H-net, which is building a professional knowledge network for lifelong and personalizable learning within the European hematological community of practice, ROLE, which is concerned with configuring and supporting personalizable and responsive learning environments, and TEL-Map, which is creating a dynamic roadmapping platform to support collaborative future-gazing and awareness-building for Technology Enhanced Learning in Europe and beyond.