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Learning How to Innovate as a Socio-epistemological Process of Co-creation. Towards a Constructivist Teaching Strategy for Innovation

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Context: Radical constructivism (RC) is seen as a fruitful way to teach innovation, as Ernst von Glasersfeld's concepts of knowing, learning, and teaching provide an epistemological framework fostering processes of generating an autonomous conceptual understanding. The proposed investigated course design incorporates these concepts: the course setting is understood as a framework to guide understanding; students work in teams and are subjective constructors of their own knowledge; instructors take on the role of coaches, guiding students through an innovation process as co-creators. Such a framework facilitates dynamic processes of assimilation and accommodation, as well as perturbation through the "other," which potentially lead to novel, and viable, conceptual structures crucial for sustainable innovation.

Problem: Classical educational approaches do not meet the requirements for teaching and learning innovation because they mostly aim at students' competent performance, not at students' understanding and developing their creative capabilities.

Method: Analysis of theoretical principles from the constructivist framework and how they can be used as a foundation for designing a course in the field of innovation. The empirical results are based on qualitative journal entries that were coded and categorized according to Charmaz's grounded theory approach.

Results: 1. It is shown that there is a close relationship between learning and innovation processes. 2. An RC-based course design for an innovation course that is based on constructivist principles. 3. Insights from empirical research and experiences from the course regarding the influence of course design and instructors.

Implications: Implications for a more general context of knowledge creation in educational settings

Constructivist Content: The paper argues in favor of RC principles in the context of teaching and learning. The proposed course setting is oriented at von Glasersfeld's understanding of knowing, learning, and teaching (vs. training). It outlines theoretical and practical aspects of these principles in the context of a course design for innovation. Furthermore, it shows the importance of von Glasersfeld's concept of intersubjectivity for processes of accommodation and the generation of (novel) autonomous conceptual structures. The interplay between creating coherence, perturbation, and irritation through interacting with the "other" (in the form of co-students and instructors) is assumed to be vital for such processes, as it leads to the

creation of not only novel but also viable conceptual structures, therefore re-establishing a relative equilibrium critical for sustainable innovation.
Key words: Innovation, teaching and learning, course design, co-creation, Enabling Space, Radical Constructivism.
Paper type: Empirical
Background: innovation, cognitive science, philosophy of science, education
Perspective: Radical Constructivism

Introduction

1. Innovation is omnipresent in various discourses: in economy, in science, in technology, and even in cultural and social systems ("social innovation"). Even in political and economic strategies one can find innovation at the forefront (e.g., European Commission 2004, 2008). Innovation has turned out to be one of the main drivers in these fields, especially if one looks at them from the perspective of knowledge-based economies and the knowledge society.

2. However, taking a closer look at our educational systems reveals that we are not very well-prepared for an innovation-driven society or economy. Education in management, strategy, or even in science very much follows the classical regime of control, management, projection, extrapolation from the past, testing hypotheses, adaptation, etc. rather than taking the new into account In contrast to that, innovation, and in particular, radical innovation, requires rather different approaches and attitudes that are more focused on creating conditions enabling the creation of new knowledge (Peschl & Fundneider 2014).

3. As innovation always includes the creation of new knowledge, it represents an exceptional challenge for educational settings, in particular from the radical constructivist perspective. One has to take into account that it is always open-ended in the sense that there is no single "true" or "best" solution or answer. Assuming a radical constructivist perspective on innovation, this paper makes the following points:

- Innovation and knowledge creation require a special epistemological framework and attitudes accounting for processes of creating new knowledge and meaning.
- Innovation is understood as a socio-epistemological process.
- Radical constructivism (RC) provides an epistemological framework both for innovation processes and for a didactical approach to teaching innovation processes.
- By applying Ernst von Glasersfeld's approach to learning we claim that processes of innovation and learning are closely related to each other, and that – from an RC perspective – several guiding principles for a didactical design can be derived for this field.
- We present a concrete course design as an illustration of how to teach a constructivist-inspired innovation process. It integrates theoretical and practical work in a project-based design.
- We conclude the paper with selected empirical results regarding the course setting and role of instructors, as well as further implications.

What is innovation?

Innovation and change

4. In order to define innovation, it is useful to distinguish between *creativity* and *innovation* (Amabile 1996; Dodgson & Gann 2010; Drucker 1985; Kaufman & Sternberg 2010; Sternberg 2005). Whereas creativity is composed of (domain-)specific traits – according to Teresa Amabile (1996) they are (a) expertise, (b) creative thinking skills, and (c) motivation – innovation is a more general concept emphasizing not only the processes of creation but also of *successful application* and *implementation* in the market or the environment (Schumpeter 1934, 1947). However, it not only encompasses products but also new services, processes, business models, organizational changes, new production methods, etc. (Dodgson & Gann 2010; Fagerberg, Mowery, & Nelson 2006; Schumpeter 1947).

5. At its core, innovation is about *change.* The process of innovation in an organization, society, or an individual is similar to the processes of learning described by von Glasersfeld (1991a, 1989a, 1989b):

> "From the constructivist perspective, 'learning' is the product of self-organization. […] Knowledge is never acquired passively, because novelty cannot be handled except through assimilation to a cognitive structure the experiencing subject already has. Indeed, the subject does not perceive an experience as novel until it generates a perturbation relative to some expected result. Only at that point the experience may lead to an accommodation and thus to a novel conceptual structure that re-establishes a relative equilibrium." (Glasersfeld 1989a: 136)

6. For innovation, this means that an innovation can be successful, in the sense that it produces change, only when it leads to something new by accommodation. This "new" can be perceived as such only in relation to already existing structures, and it can only be implemented as a sustainable innovation when the system (subject, organization, society) can manage to establish dynamic equilibrium. Innovation can, therefore, be described as a process of change driven by ongoing reciprocal relations between assimilation and accommodation that tend towards dynamic equilibration. In this sense, innovation is *sustainable* change that is both *fundamentally new* and *organically fits* into existing structures.

Innovation as a socio-epistemological process

7. Innovation research shows that innovation is not a one-dimensional phenomenon, but always emerges as a result of a highly complex network of interactions, dynamics, and constraints. It is intrinsically *social* and *epistemological* and – in most cases – is *not* something that is accomplished by an individual or a *maverick* (Dodgson & Gann 2010; Gloor 2006; O'Connor & McDermott 2004). Rather, it is the result of well-orchestrated teams, of formal and mostly informal social networks, as well as of intense collaboration processes with a tradition of prior knowledge (Weisberg 1993).

8. Most importantly, innovation is not primarily a static concept or only about a result; rather, what is of interest (not only for us) are the *processes* leading to an innovative outcome. When we talk about processes in the context of innovation, the focus is on the *epistemological/knowledge* as well as *social* processes taking place in the course of creating and implementing something new.

Epistemological/knowledge/ processes: When we talk about epistemological or knowledge processes, we do not assume a traditional epistemic perspective, but take a radical constructivist perspective. Von Glasersfeld points out that "knowledge serves to organize experience" (Glasersfeld 1991a: xix); it is not a representation of an experiencer-independent reality. According to this, knowledge is not seen as a static content that can be discovered in an outside reality or transferred from one individual to another, but an active process of an experiencing subject. Every innovation process is a process of change within the structures of a subject's constructions and is therefore an epistemological process.

Social processes: Apart from epistemological issues, innovation is primarily a *social* process, in the sense of the radical constructivist concept of intersubjectivity (sensu Glasersfeld 1995). On the one hand, the construction of the "other" helps us to stabilize our constructions and create coherence (Glasersfeld 1995). On the other hand, the construction of the "other" is the major source of *perturbation*, causing the change we aim for in innovation processes (Glasersfeld 1991b, 1989a). As is shown by many researchers and practitioners in the field of innovation (Dodgson & Gann 2010; Fagerberg, Mowery & Nelson 2006; Fagerberg &Verspagen 2009; Kelley 2004; Weisberg 1993), innovation is mostly rooted in a social context and a complex network of interactions.

9. Following a radical constructivist perspective (rather than a social constructivist approach), it is clear that it is always the constructing subject, its personal experience, that brings forth new knowledge at a particular moment in time. It is also clear that the subject constructs the "others" as externalized concepts of itself. Nevertheless, the processes of interaction with the "other" cause the perturbations crucial for innovation.

10. Hence, we are primarily interested in the *processes* of innovation and how these processes ought to be organized on both an epistemological and a social level in order to bring forth high quality and sustainable innovative outcomes.

Strategies of innovation

Classical approaches

11. Most approaches to innovation (Dodgson & Gann 2010; Ettlie, Bridges & O'Keefe 1984; Fagerberg, Mowery & Nelson 2006; Fagerberg & Verspagen 2009) follow the strategy of generating a high quantity of (low quality) ideas and subsequently pushing these ideas through a rigorous selection process in order to filter out the ideas that look promising for being realized and may lead to successful innovations in the market.

12. One of these classical approaches applied in most cases is the so-called *stage-gate* process (Cooper 1990; Dodgson & Gann 2010: 99ff): it operates as a well-structured sequence of stop/go decision points throughout the knowledge creation and implementation process. Starting with an idea, this new knowledge has to go through several screening procedures ("gates") moving the potential innovation from one stage to another. It has turned out that this approach is quite powerful for creating *incremental* innovation (i.e., innovation in small steps).

13. As these classical approaches are usually limited to incremental innovations, they do not allow for completely new ideas, or radical innovations, to be created.

Innovation as "learning from the future"

14. Following a completely different strategy, an alternative approach proposes to understand innovation as "learning from the future" instead of projecting and extrapolating the past into the future. It is partly based on Scharmer's (2001, 2007) theory-U and presencing approach. Peschl and Fundneider (2008a, 2008b, 2013) have developed a stable and well-tested innovation process that is inspired by that approach: it is referred to as *Emergent Innovation*.

15. It can be characterized as "*profound innovation from within*": The process of Emergent Innovation focuses on seeing and observing, profoundly understanding, reflecting, and respecting what is already there, whether it consists of internalized or externalized existing conceptual structures of the constructing subject. That is why the process emphasizes uncovering hidden assumptions and core beliefs of individuals, as these internalized concepts frame the construction of the subject's experiential reality. This is why a profound innovation process has to challenge those concepts in the first place. Nevertheless, it is the (history of) interaction(s) between the cognizing subject and its externalized concepts that enables stimulation, inspiration, and perturbation as a kind of boot-strapping co-creation and co-fertilization process leading to the emergence (Corning 2002; Stephan 2006) of new knowledge. Already constructed concepts are seen as an opportunity rather than an obstacle. Instead of imposing external and/or inadequate patterns or "wild ideas" to the object of innovation, Emergent Innovation tries to respect and at the same time explore and develop the most radical and unforeseen potentialities lying at the core of a situation or of a concept. In other words, it explores the space of potentialities, of what is present in a latent manner and what wants to emerge. In this sense, Emergent Innovation is a kind of "radical innovation from within." Innovation is not considered a new feature, which is somehow added or incorporated from the outside, but something that emerges intrinsically from the inside. The section on our course design gives an example of how such an innovation process can be realized.

Teaching and learning about innovation in a constructivist framework

16. While most classical educational settings aim at the presentation of content/knowledge (by a teacher) and the repetition of this content by a student or, in a seminar setting, the presentation of an author's position (plus some reflection) by a student, the course design presented in this paper follows a rather different strategy. The topic of this course is *innovation*; it is not so much about the theoretical approaches to innovation, but about the reflected practical application of innovation processes and strategies to a concrete project (Schön 1983). Hence, the goal of this course is not the reproduction of knowledge in the sense of competent performance (Glasersfeld 1991a: 3), but to *create new knowledge* and to transform it into a *prototype* in the sense of understanding (ibid). In this section we lay out the epistemological foundations for such an RC approach to teaching and learning.

Constructivism and innovation

17. Von Glasersfeld (1989b: 162) states two basic principles: (i) that knowledge is not passively perceived, but actively constructed, and (ii) that cognition is responsible for organizing the experiential world. It turns out that these principles are very important in the context of innovation: they open up the space for subjective knowledge construction and creation of new concepts and relationships. Thus, innovation is about functioning/viable knowledge that has come about in a process of construction.

18. It was clear from the very outset that a classical "realist" framework or the concept of "learning/teaching as knowledge transfer" (Baumgartner & Payr 1999; Baumgartner 2003; Foerster 1972) is completely inappropriate for a course design having innovation as the focus of its learning outcomes. A course in innovation design should be intrinsically *open-ended*, and there is not a single best solution or predefined answer to a given problem or question. Innovation is about bringing forth something new and realizing it successfully in a (market) environment (Dodgson & Gann 2010; Drucker 1985; Fagerberg, Mowery & Nelson 2006; Johannessen, Olsen & Lumpkin 2001; Schumpeter 1934). Hence, it is clear that there is no explicit and already-known outcome (except that it has to function in a market-like environment). In a way, this can be compared with the situation (natural) science finds itself in most of the time. It constructs (new) hypotheses about a phenomenon that is difficult to access or to understand, and tests these hypotheses in an experimental setting (Kuhn 1970; Popper 1962). Forming new hypotheses in science matches the creation of new knowledge or ideas in the innovation process whereas externalizing this new knowledge in the form of prototypes, products, or services can be compared to the process of conducting an experiment and verifying/falsifying this new knowledge.

19. Both in the field of innovation and in science the criterion of "success" is *viability* (Glasersfeld 1974, 1989a, 1996). If we are interested in creating something radically new that is "viable" (sensu von Glasersfeld), we will have to assume an epistemological position that allows for (radical) semantic shifts to create new meanings of artifacts (Krippendorff 2006; Krippendorff & Butter 2007), and changing interaction patterns (Clark 2008; Kirsh 1995; Krippendorff 1989; Menary 2010; Norman 1991). In fact, RC has already been influential in science education (Kemp 2012), and we claim that it is well suited for education in the field of innovation as well.

Constructivist principles in the context of innovation

20. From a constructivist perspective, it is clear that we have to give up the idea of knowledge being a rather static object. Knowledge is a *process* that is permanently changing and highly dynamic. This implies that learning cannot be understood as "knowledge transfer" in the sense of handing over "objects of knowledge" from one brain to another (e.g., drill-and-practice learning; Foerster 1972).

21. Rather, learning is always embedded in a circular *feedback-loop*, establishing an "epistemological equilibrium" between internalized and externalized conceptual structures/processes (in the sense of viable knowledge). Apart from the constructivist paradigm, these learning-loops can be found in a wide variety of theoretical approaches, such as David Kolb's (1984) approach to learning, single-loop learning (Argyris & Schön 1996; Peschl 2007; Senge 1990), learning in neural networks (Bechtel & Abrahamsen 2002; Clark 2001; Friedenberg & Silverman 2006; Rumelhart &

McClelland 1986), system theoretic/cybernetic approaches (Scott 2001), cognitive psychological, biological, and evolutionary and adaptation approaches, etc. From such a perspective, innovating and learning means entering and establishing new states of epistemological equilibria.

Learning as creating (radically) new knowledge

22. Learning and bringing forth innovation are closely related to each other, as they are both processes of change resulting in new knowledge. In the context of learning and teaching innovation, the particularity is that new knowledge is not only new for the students, but also for the teachers (and ideally new in general). Since the knowledge the students have to create and the possible problems (and far more the possible solutions) are open-ended, students cannot be "trained" to perform (Glasersfeld 1991a) in the field of innovation. Innovation as creation of (radically) new knowledge must derive from a profound understanding. Following von Glasersfeld, this means knowing how and why with the aim of "generating autonomous conceptual understanding" (Glasersfeld 1991a: xix).

23. In classical educational settings, the student's construction of new knowledge may consist of finding subjective, and maybe new, paths to predefined solutions indicated as learning goals by the teacher. In the case of teaching and learning innovation, the solutions (innovative prototypes) are per definition not yet knowable, neither by the students, nor by the teachers. Therefore "training" is not an option. A course design for innovation must be based on the concept of teaching as a framework to guide understanding (Glasersfeld 1991a).

Learning as creating innovation artifacts

24. As is argued in Peschl & Fundneider (2014), innovation always implies the creation of an *artifact* "[…] that has been modified over the history of its incorporation into goal directed human action" (Cole & Derry 2005: 212). This is closely related to what Humberto Maturana and Francisco Varela (1980) consider as a basic requirement for understanding and for an explanation. They look at an explanation as "a reformulation of a phenomenon in such a way that its elements appear operationally connected in its generation" (Maturana & Varela 1980: 136). Hence, understanding or knowing something is closely coupled to making, producing, or generating this phenomenon.

25. This is in line with von Glasersfeld's (1989a) perspective on knowledge:

> "Over and over [Giambattista Vico] stresses that 'to know' means to know how to make. He substantiates this by saying that one knows a thing only when one can tell what components it consists of." (Glasersfeld 1989a: 123)

26. If an artifact resembles something new and is useful for its creator (or in general), this artifact can be considered an innovation(-artifact). Furthermore, when a cognizing subject has created and successfully applied this artifact, he or she also "understands" it (Glasersfeld 1989a). This is the important point for our course design: by creating something (new), students start to understand and make sense of the phenomenon they have created as well as of their own process of (knowledge) creation:

> "However, making sense always entails a bit of a paradox between the aim of making something new and different from what was there before, and the desire to have it make sense, to be recognizable and understandable. The former calls for innovation, while the latter calls for the reproduction of historical continuities." (Krippendorff 1989: 9)

As innovation is not only the creation of new knowledge on a conceptual level but also its "realization" in the form of an artifact with the potential to be successfully implemented in an environmental context, learning innovation in the sense of understanding is only possible by actually creating such innovative artifacts. Therefore, in our course, the student's task is to create an innovation-artifact, which we refer to as a "prototype."

Learning and the social dimension

27. If perturbations are one main source of creating or learning something new, "it is necessary to emphasize that the most frequent source of perturbations for the developing cognitive subject is the interaction with others" (Glasersfeld 1989a: 136). In many cases, innovations are brought forward by (informal) *communication* (Allen & Henn 2007; Dodgson & Gann 2010; Fayard & Weeks 2007; Kelley 2004; Peschl & Fundneider 2008a; Reiter-Palmon, Wigert & Vreede 2012; Sailer 2011). It is important to be clear about the epistemological premises on which our understanding of language and communication is based. One of the reasons why communication plays such an important role is its "inspirational" and *irritative* character to the listeners. What does that mean? In listening and asking questions to others, ones own semantic framework sometimes becomes perturbated and, by that, questioned. As we have seen above, these perturbations are triggering processes of learning and re-organizing and re-establishing the epistemological equilibrium. These processes result in new knowledge and are, in many cases, the source of an innovation.

28. The constructivist approach to language provides a good theoretical and epistemological foundation for understanding and designing such social processes of knowledge creation, as

> "language […] cannot transfer concepts or conceptual structures from one person to another, it can only call up, in the listener, the re-presentations of experiences that the listener has associated with the particular words and word combinations that are being said. Nevertheless language can serve teachers to *orient* the students' conceptual activity and thus suggest certain directions and help to preclude others." (Glasersfeld 1991b: 34).

Language is no longer considered as denotative, but as connotative (Maturana & Varela 1980) and, thus, does not transmit information; it is an *orientation behavior*:

> "It behooves the orientee, as a result of an independent internal operation upon his own state, to choose where to orient his cognitive domain; the choice is caused by the 'message,' but the orientation thus produced is independent of what the 'message' represents for the orienter […] the listener creates information by reducing his uncertainty through his interactions in his cognitive domain." (Maturana& Varela 1980: 32)

29. If the orienter cannot determine the meaning of the orientee, this will inevitably lead to what we would refer to as "misunderstandings." In a creative or innovation context, it is, however, exactly this mismatch in semantics that might lead to new insights: the listener chooses from his/her conceptual framework what is triggered by the message, and, thus, might get pushed into a new semantic trajectory that might evoke new concepts and contribute to the creation of new knowledge. From this perspective, it becomes clear that innovation and learning processes become very powerful, if we design them as *socio-epistemological processes* (Peschl & Fundneider 2008a; Peschl 2009). In our course design we therefore emphasize social interaction through didactic methods (dialogue, thematic fields, world café) and establish a team-working context (knowledge creation teams).

Learning as adaptation and teaching as co-creating new solutions

30. As a consequence of the constructive character of knowledge as well as of the notion of functional fitness, knowledge is always open to change and to offering new perspectives on a specific phenomenon, i.e., "…no matter how viable and satisfactory the solution to a problem might seem, it can never be regarded as the only possible solution" (Glasersfeld 1996: 310). This point is important for one of the design principles in our course: it is inherently *open-ended* and allows students to create solutions and results that are not at all known at the beginning of the course, neither by themselves nor by the teachers.

31. As an implication, the role and the epistemological position of the teacher changes dramatically: he/she does not have the "correct solution," but

> "the teacher would come to realize that what he or she presents as a 'problem' may be seen differently by the student. Consequently, the student may produce a sensible solution that makes no sense to the teacher […] constructivist teachers would tend to explore how students see the problem and why their path towards a solution seemed promising to them." (Glasersfeld 1989a: 137)

Hence, the teacher takes the role of a *coach* (Baumgartner & Payr 1999; Baumgartner 2003), accompanying and guiding the learner's thought processes and epistemological results. The boundary between learning and teaching begins to blur and the whole process becomes a process of *co-creation*. Hence, "the teacher's art – and I am using the word 'art' quite deliberately – resides in getting students to *generate problems of their own* that are conducive to the ways of thinking that are to be taught" (Glasersfeld 1991b: 37). This not only changes the way in which a course is designed and which epistemological principles are applied, but also how to assess the students' performance (e.g., a grade cannot only be given by "objective standards," but also includes a peer-to-peer aspect).

The role of constraints in learning and innovation processes

32. Creating new knowledge does not mean that "anything goes" (Feyerabend 1975). Rather, it is necessary to provide a structured process and space that acts as a container for such epistemic activities. "We shall have to create at least some circumstances where the students have the possibility of experiencing the pleasure of finding that a conceptual model they have constructed is, in fact, an adequate and satisfying model in a new situation" (Glasersfeld 1989a: 137). We refer to such circumstances or such a space as an *Enabling Space* (Peschl & Fundneider 2012, 2014). Such Enabling Spaces not only consist of physical spaces but also of the social context (teachers and other students) and the educational environment, including the didactical setting and the teacher's views and beliefs. As von Glasersfeld points out,

> "no organism is free to construct any reality he might wish to construct and that, instead, there are certain constraints with regard to all construction; […] the constraints, therefore, must be formulated in terms of the availability of single, as yet uncoordinated signals (i.e., particles of experience) and of the regularities or interdependence of these signals which the knowing organism, as a result of his own cognizing activity, singles out from his initially undifferentiated continuous stream of experience." (Glasersfeld 1974: 6)

33. Von Glasersfeld's suggestion that constraints are important in creative processes and in processes of knowledge creation and learning (cf. also Amabile 1996; Onarheim 2012; Stokes 2005, 2009) seems counterintuitive because constraints are normally seen as limiting our creativity. However, as Patricia Stokes points out,

> "artistic freedom consists solely in the choice of one's own constraints […]. All artists/innovators begin as novices in a domain; skill acquisition depends on mastering existing constraints that define currently accepted solutions. Only with mastery is choice – and true novelty – possible." (Stokes 2009: 179)

34. Taking such a perspective overcomes the classical view, which sees constraints as barriers or strictures. In problem solving, however, they are paired:

> "One of the pair retains its function as stricture, limiting or precluding search in some parts of a problem space; the other directs or promotes search in different parts. Novel solutions follow from precluding reliable, existing responses and promoting riskier, often opposite ones." (Stokes 2009: 175)

Hence, it is necessary to define such constraints in order to give the process of knowledge creation some orientation. The course design we are proposing is understood in such a manner: it is an Enabling Space, providing epistemological, social, and spatial constraints limiting and promoting certain directions that support the processes of bringing forth new knowledge.

An empirical investigation into teaching and learning innovation

35. We argue that RC is a fruitful approach to teaching and learning innovation, which we understand as a socio-epistemological process of co-creation. Taking this into account, a course design was created and implemented. This course was subject to an empirical investigation, following the main research interest of how innovation processes actually happen in the created setting, as well as what factors influence them. One crucial influencing factor turned out to be the course design itself, in terms of applied radical constructivist principles, as well as the role of instructors.

Teaching and research setting

36. Three university courses addressing philosophy of science and knowledge creation were combined from two universities. Students conducted a practical knowledge creation/innovation project based on the process of Emergent Innovation and Theory U[1] (Scharmer 2001, 2007). The process was lead by four instructors with various disciplinary backgrounds.

37. Throughout the course, students reflected upon the innovation process via a so-called "learning journal." In total, each student had to make seven entries. The journal entries not only required the students to reflect on the process, regarding both the group dynamics and their individual knowledge creation, but also encouraged them to provide elicited texts on the innovation process and their personal lessons learned and epistemological experiences.

Sample description

38. In total, 30 students took part in the course in the summer term 2013. Most of them were completing their PhD studies (n=20) or the Middle European interdisciplinary

[1] Theory U is an innovation methodology for triggering change in patterns (e.g, of behavior and thinking), developed and successfully applied to organizational settings (business innovations). As it turned out to be well-suited for our purpose we partially adopted methods and concepts (precensing, prototyping) for an educational setting (see course design).

Master program in Cognitive Science (n=9). The students were enrolled at the University of Vienna (n=17), the Vienna University of Technology (n=11), the Medical University of Vienna (n=2), and the University of Ljubljana (n=1). The predominant mother tongue was German (n=20), followed by Serbian (n=3), Slovenian (n=3), Bulgarian (n=1), Greek (n=1), and Persian (n=1). The language used throughout the course was English. The disciplinary background of the students varied considerably from cognitive science (n=10), management (n=5), business studies (n=3), international marketing (n=2), applied linguistics (n=1), business informatics (n=1), energy economics (n=1), mechanical engineering (n=1), medicine (n=1), philosophy (n=1), and psychology (n=1). Two thirds of the participants (n=19) were males whereas one third (n=11) were females. The mean age was 27.96 years (*SD*=4.66; *Md*=27).

Three levels of intervention

39. We designed and observed our innovation process on three levels:

- Course level (whole class plus instructors)
- Group level (innovation teams)
- Individual level

These three levels cannot be seen as separate from each other; rather, they are highly recursive and in permanent interplay throughout the whole innovation process.

The course level: creating an explorative learning atmosphere

40. On the course level, we as instructors provided the students not only with the organizational and structural setting, but also with a safe, trustful, and explorative learning atmosphere – an Enabling Space. Practically, this means that beyond physical and organizational spaces, the instructors also have to provide a socio-epistemological space that enables innovation by being *role models* for the culture we want to establish in this course. The instructors have to be coherent in thinking, talking, and acting to form a psychologically safe environment for the students. In our course, an interdisciplinary team of open-minded instructors provided a culture of openness, trust, and respect, appreciating individuality and differences and communicating in a dialogue-like (Bohm 1996; Schein 1993) manner. The instructors served as space for reflection during the innovation process.

41. Thus, following constructivist principles, the instructors' task is not to provide right answers or solutions for the students, but "[…] to educe, to draw out what is potentially there" (Peterson 2013: 888). One possible way of accomplishing this, in the sense of Heinz von Foerster (1972), is to ask legitimate questions and encourage the students themselves to formulate such questions in order to elaborate their "truths" within their specific projects. Another way is to trigger *irritations* in the sense of perturbations as a starting point for learning and constructing (radically) new knowledge.

The group level: setting up a space for collaboration

42. On the group level, students are no longer seen as passive receivers. In our course, this led to a learning-by-doing approach, where students had to co-create new knowledge actively by creating something new in the form of a prototype. As pointed out above, we assume that the social dimension is crucial for innovation processes, as innovation is not primarily an individual activity but rather a social one (Weisberg

1993). Therefore, the students passed through the phases of our innovation process as teams and collectively created new knowledge. These teams were also seen as an Enabling Space for the knowledge creation process. The teams were asked to communicate and negotiate constantly about working structures, decision-making, use of technology for communication, and process documentation. Thus, a reflection of the course culture should be depicted within the teams. We consider the quality of these Enabling Spaces on the group level to be one crucial factor in the innovation process.

The individual level

43. A basic principle of the constructivist paradigm is the subject as constructing agent. Therefore, the personal mindset and the individual knowledge creation process are very important. They are particularly challenged in the *presencing phase* (see below). Since the construction of knowledge is subjective, it is necessary for the individual to construct "the others" and trigger new constructions through the perturbation of others (Glasersfeld 1995). The students' worldviews were constantly challenged by the perturbations of their colleagues and instructors. Consequently, communication has to be on a very profound level in order to help the students uncover their sets of premises and worldviews. In order to gain viability, the concept of intersubjectivity is valuable as it allows one to stabilize and assure one's own constructions of the world and leads to a more coherent experiential reality (Glasersfeld 1995). This underlines once more the necessity to refer to the innovation process as a socio-epistemological process.

The course design

44. Students were asked to conduct a practical knowledge creation/innovation project in their interdisciplinary teams to foster experience learning and a deep understanding of the theoretical basis, i.e., Emergent Innovation and Theory U. Contrary to classical educational approaches, and in favor of the radical constructivist perspective, students must not be seen as a white canvas. They always enter the educational setting with their individual mindset and experiences, and their subjective worldviews. As von Foerster (1972) points out, every new knowledge construction has to be related to the student's pre-existing world construction. Taking this seriously, we based the whole process on "questions that really matter" for the students. The process was organized in several phases described below, which are interlinked and recursive in nature (see Figure 1 for an overview).

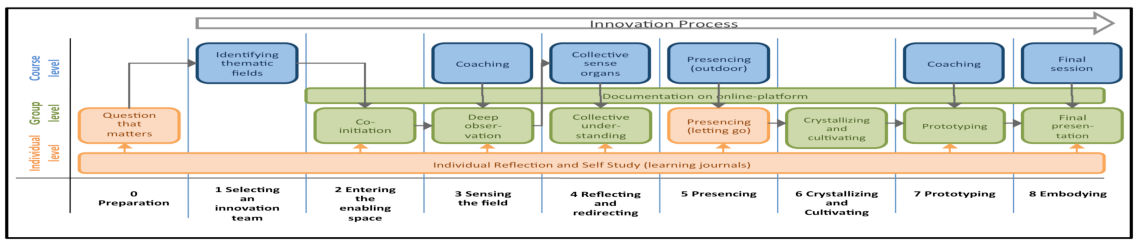

Figure 1: Overview of the course design

0 Preparation: Questions that really matter

45. Each student has to reflect and think about a "question that really matters" to him/her (individually). We consider the high personal involvement as a pre-requisite for successful innovation processes.

1 Selecting an innovation team

46. The process starts with uncovering the hidden core beliefs and basic assumptions behind the questions that really matter to the students. Consequently, semantic maps of their core beliefs and assumptions are produced (cf. "Strukturlegetechnik"; Dann 1992). In doing so, they have to negotiate a space of common meaning of symbols. As a result of this phase, *thematic fields* arise from these semantic maps. Innovation teams are formed around these emergent thematic fields, ensuring that each student works on a subject he/she is really interested in. These thematic fields act as (semantic) containers within which the innovation project should be developed in the next phases. Although the topic seems defined now, the formulation of the teams' goals and visions is constantly refined and negotiated in the subsequent phases.

2 Entering the Enabling Space

47. To enter the Enabling Space (on the group level), we start with community-building activities and co-initiation of establishing a "consensual domain" (Glasersfeld 1991a) within the innovation teams. The innovation teams are intended to sharpen their thematic field, discuss their interests, and find a common vision. This phase is essential for the social coherence of the team (e.g., team-building purposes, establishing trust between the team members, etc.).

3 Sensing the field – learning to see and observe, and becoming aware

48. The goal of this phase is to observe the thematic field. The teams are asked to develop a sketch of an observation strategy that helps the team to understand more deeply various aspects of the chosen thematic field. In a dialogical setting, teams and instructors reflect on the observation strategies. This strategy aims at a process of total immersion for the innovation teams: i.e., they should totally immerse into the chosen thematic field by exploring it with a variety of methods for deep observation (e.g., Laurel 2003). Furthermore, the innovation teams are encouraged to explore the *unobvious areas* of their chosen fields by, e.g., finding analogies in totally different contexts.

4 Reflecting and redirecting through dialogue-creating "collective sense organs"

49. To integrate the separate "knowledges" (sensu Peterson 2013) of individuals (i.e., students and instructors), the students report and discuss their so-far-experiences and observation results in a world café setting[2] (Brown & Isaacs 2005). The innovation teams try to construct a rough, initial *collective understanding* of their observations by establishing a consensual domain. Furthermore, the students experience an introduction

[2] World café is a workshop communication method enabling manifold exchanges of perspectives.

in the dialogue technique[3] (Bohm 1996) to foster appreciation and respect for the others' (ideas).

5 Experiencing potentialities and presencing – deep knowing and profound understanding

50. "Presencing" is the crucial point where students are asked to liberate themselves from the past ("letting go") and listen to "what wants to emerge from the future" (Scharmer 2007). The solutions they search for cannot be found in the past, but in the future (Foerster 1972: 38). In a not-too-stimulating environment outside the university buildings (in our case, a setting in nature), each student enters individually into an "empty space" of listening and opening up to what wants to emerge. In this process of presencing (Scharmer 2007; Senge et al. 2004), both radically new and at the same time "organically grown" knowledge emerges out of a "left-behind" profound understanding of the thematic field (Peschl & Fundneider 2008a).

6 Crystallizing and cultivating – emergent design

51. The students are asked to (re-)consider their emerging ideas and concepts in a process of crystallizing and cultivating them individually and collectively. Most of these ideas are hard to articulate in the beginning as they are still vague. The resulting (still fragile) project ideas brought from the individuals are shared and collectively concretized and negotiated in a dialogical setting based on mutual trust and respect. A coaching session with the instructors supports this process. By cultivating and sharpening the project idea, the students create a new common ground of understanding in the form of a joint concrete innovation project.

7 Prototyping – fast cycle learning through immediate realization

52. The innovation teams are asked to prototype (Moggridge, Suri & Bray 2007; Kelley 2004) by creating artifacts. Prototyping as a knowledge creation technique allows for fast cycle learning through immediate realization and learning. This is a phase of high energy and enthusiasm within the innovation teams. The students can use a variety of creative techniques and playfully explore the potentials and possibilities of their projects. A coaching session with the instructors supports this process. The goal of this phase is to concretize the innovation project towards a final prototype.

8 Putting things into practice in an organizational setting

53. The final prototypes are consolidated and presented in class to the other teams. Final prototypes can vary from theoretical concepts, social formats, or business models, to touchable objects or physical models. An example of a prototype is a card game for dealing with different perspectives and upcoming conflicts in group-settings. For the instructors, one indication for the self-generated reinforcement described by von Glasersfeld (1983) is the ongoing interest students kept beyond the course. We know of at least one group that successfully continued their project, even after the end of the course.[4]

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[3] This is a special form of communication based on a high level of appreciation aiming at profound mutual understanding.

[4] The project "Numeris" is still ongoing at http://www.numeris.at.

54. The described course design was observed from March to June in the Summer Term 2013. In this term, six teams were formed, consisting of four to six students each. Data was collected throughout the whole course. Our research interest was to investigate how innovation processes develop in the designed setting. For the present paper, we focused on the factors of teaching and learning that turned out to be relevant for the process of innovation. The most relevant results regarding the teaching aspects and the influence of the course design and instructors are presented in the following section.

Analysis and Results

55. Von Glasersfeld (1991a) distinguishes between training and teaching. Our course clearly aims at generating understanding (i.e., teaching sensu von Glasersfeld) since competent performance (i.e., training sensu von Glasersfeld) is considered absolutely inadequate for creating new knowledge.

56. The presented results are derived from qualitative online journal entries made by the students seven times throughout the process. The entries were led by guiding questions. The students also filled in online questionnaires, and in addition to that, observation notes were taken by one instructor. Furthermore, reflection loops were continuously carried out among the instructors. However, only the journal entries were used to show the main advantage of this course setting compared to traditional university teaching settings.

57. The analysis was conducted with the qualitative data analysis software atlas.ti. The diary entries were coded based on Kathy Charmaz's (2006) grounded theory approach, as her methodology was developed for elicited texts (the individual learning journals). On the one hand, this method allows a very detailed and specific view deep into the material. On the other hand, the method also allows for an abstraction on a more general level. First, approximately 20% of the material was coded inductively line-by-line. This resulted in 20 focused codes. Second, the whole material was (re-)coded based on those codes on a more abstract level. This change of viewpoint helps to get a deeper understanding of the material and also provides the framework for emergence of theories out of the collected material.

58. In the context of this paper, we focused on the influence of instructors and the course setting on the processes of innovation. Therefore the codes that addressed the teaching and learning aspects (i.e., "influence of course design and/or instructors" and "knowledge creation/outcome") are discussed.

Influence of course design and/or instructors

59. The journal entries regarding the course design (i.e., specific sessions or the course as a whole), as well as regarding one or more instructors, are illustrated below. There are positive as well as negative comments. Those comments that might be interpreted positively as well as negatively were coded for both categories.

60. In general, results show that theoretical constructivist principles and concepts of intersubjectivity, viability, and knowing as understanding (by making; Glasersfeld 1995 1991a, 1989a, 1989b) manifested in the course design affect and influence students by being a source of irritation and uncertainty. The instructors, as representation of the

course design, additionally provide an atmosphere of trust and safety as well as freedom and openness by serving as a role model for students.

61. In more detail, results suggest that heterogeneity and interdisciplinarity of the teams fosters perturbation. In this sense, the course design stresses the issue of intersubjectivity, as students need to communicate ideas and thoughts throughout the whole process of innovation. The course setting establishes a need for perturbation through "the other" in order to gain viable knowledge, as can be seen in the following quotes from the journal entries

> "Interestingly, none of the assumptions and core beliefs I figured out myself during yesterday's class would have brought up the issue of power of numbers. Rather questions of colleagues, their reflections on core beliefs and assumptions, discussions and crosslinking of a different group led to this topic." 5:18[5]

> "I learned in this seminar that unorthodox approaches when several people are working on the same but not clearly defined subject can help a lot to get some productive output." 1:98

> "I gained new insights about possibilities and ways to work and facilitate work in a group. And I learned about myself acting in the group." 17:138

62. Furthermore, results show that the course design triggers *irritation* and *uncertainty* – feelings students, as well as instructors, have to cope with. Within the teams, such irritation and uncertainty seem to be dealt with by an interplay of coherence and perturbation through others as a mean of "overcoming" the experienced uncertainty.

63. This need for intersubjectivity, as well as the concept of accommodation and knowing as understanding, are considered in the course design. Results show that students undergo a subjective process of change, triggered by perturbation and irritation by colleagues, course design, and instructors. E.g.,

> "I learned that knowledge creation is not a random process… I have learned that it is okay not to have everything under control all the time. In addition, questioning the assumptions helped me to realize why I was thinking in a certain way." 20:76

64. Most teams reported feelings of clarity while crystallizing and prototyping, as they gained a deep level of understanding by making prototypes of their novel knowledge and insights. The last coaching sessions and the presencing phase also seem to be points in time where coherence and perturbation are crucial.

65. It is the interplay between processes of accommodation and generation of new and viable conceptual knowledge on an individual and the group level that leads teams to sustainable innovation in terms of re-establishing a relative equilibrium. From the instructors' perspective, the "success" of the teams and their prototypes is particularly dependent on the attendance rate of team members. This thus makes sense, as each individual team member is a subjective creator of knowledge and potential source of perturbation for others.

66. Students noticed the recursive and reflective nature of the process and acknowledged the presencing phase as important experience:

> "Overall, the day was governed by reflection. Each of us spent his time in the wilderness reflecting and thinking about the observations that we made in the prior stages of the course. 16:45

> "Well, to our surprise it came different and when we discussed our topic right after the presencing phase, it suddenly became clear where to go" 4:72

> "Then we had the outdoor session in Lobau and we took some time to just clear our minds in the nature. And – I do not remember exactly at which point in this session – it suddenly became clear that in fact there was one characteristic common to all our observations" 4:104

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[5] Numbers refer to case:quote.

67. Throughout the innovation process, students become "experts" in their chosen field and topic. Instructors are no longer in possession of the one and only truth (like educators in classical contexts), they rather act as *coaches* and *co-creators*. They no longer have an expert status or any hierarchical advantage regarding the innovation and learning outcomes of the students. Their teaching activity lies only in guiding through the process, as they become coaches in terms of yet another source of coherence and perturbation. Students themselves decide which ideas, or "knowledge," are valuable or worthwhile following, and which ones are not:

> "During our last meeting our ideas crystallized to one bigger idea. We wanted to do a lot of different things but nothing was really useful by itself. So we decided to connect all those ideas into one purpose. It was fascinating how suddenly all of us agreed on what to do, but I was even more surprised when our supervisors accepted the idea and motivated us to follow this approach. I thought that our idea might seem strange to someone not involved in our group and that we won't be taken serious." 6:51

> "The couching session was quite a boost for us. At least for me the whole idea seemed too vague to have any real value, but you guys give us a push out of the vagueness." 24:18

68. Instructors furthermore establish an open and safe space in terms of an Enabling Space, thereby eliciting feelings of trust and freedom within students.

69. The following quotes serve as examples that show that the need for perturbation through "the other," as well as engaging in a process aiming at conceptual understanding, was triggered and influenced by the course design and instructors.

> "The freedom that the lecturers gave us gave me so much. I know this should be a report, but I cannot not say one big 'Thank you!' to the team who organized this." 13:27

> "I feel that I had to open myself because without that I wouldn't be creative and working with my group would be much harder. That was also something new for me and I like it very much. I feel that course was kind of trigger for me." 25:23

> "A rather easy-going organization of a course can lead to more engaged and motivated students than a rather strict organization. Not thinking about marks and evaluation of students can create a very positive atmosphere in a course. It can be fun to think about alternative ways of presentation techniques…if someone had told me that I would do a role play during my PhD classes and will open a presentation with music of Carmina Burana I had not believed it. But it was really much fun…I am happy that the instructors of the course gave us the possibility to be as creative as possible." 15:84

70. Such a shift in the instructors' role, as well as the immense communication and interaction between students and their subjective processes of knowledge generation, have certain implications regarding both the instructors' and students' roles within an educational setting. These issues will be discussed in the following section.

Conclusion

71. Based on radical constructivist principles, we created a space of collaborative and individual knowledge creation within the whole course setting. Designing such an Enabling Space for innovation processes is a major challenge. There has to be established an (epistemological) understanding that the knowledge processes that the innovation teams are dealing with are highly fragile and require completely different mindsets and didactics than in classical educational settings. The design of the course has to reflect – on the one hand –vulnerability and fragility and – on the other hand – openness. It is necessary to create a safe and trustful atmosphere and a non-hierarchical layout enabling the free flow of knowledge. It is crucial that these design qualities not only exist on paper, but are practiced in every role, routine, and interaction.

72. Applying constructivist principles on a practical level implies the creation of new concepts and roles of both students and instructors. Students can no longer be seen as

starting as a white canvas but as individuals with their own history and as subjective constructors of their knowledge of the world. As innovation is about bringing forth novel knowledge and producing change, we draw heavily upon Ernst von Glasersfeld's understanding of learning and teaching (Glasersfeld 1991a, 1989a). Novel knowledge cannot be acquired passively, but has to be handled through assimilation, which needs to be perturbed in order to lead to a process of accommodation, and thus to novel conceptual structures that re-establish a relative equilibrium (Glasersfeld 1989a). We consider the concept of intersubjectivity (Glasersfeld 1991b, 1989a, 1995) crucial for such constructions of novel conceptual structures, as processes of coherence and perturbation through the interaction with "others" lead to the creation of not only novel but also viable (Glasersfeld 1974, 1989a, 1996) knowledge. These principles are considered in all phases of the course design. Constant negotiations and interactions between students – especially the ones in highly heterogeneous and interdisciplinary teams – as well as between students and instructors in the coaching sessions, are sources of perturbation.

73. Our research shows that students face feelings and experiences of uncertainty and irritation triggered by the course design and/or instructors. These experiences were mostly reported in the processes involved in the first five phases of the course. Our results support the theoretical assumption that intersubjectivity is a source of both perturbation and coherence. Negotiation with team members and instructors is needed to move forward in the innovation process. Students reported subjective processes of change, and new insights and perspectives gained after course, coaching, or team sessions of intense negotiation and interaction. Techniques such as the collaborative creation of semantic maps (cf. "Strukturlegetechnik"; Dann 1992), the world café (Brown & Isaacs 2005), or the dialogue (Bohm 1996) allow instructors to create a facilitating framework for such negotiations and interactions.

74. Furthermore, the course setting aims at teaching innovation by establishing a framework for guiding student's understanding. Students cannot be trained (Glasersfeld 1991a), but new knowledge can only derive from a profound understanding, based on von Glasersfeld's concept of "generating autonomous conceptual understanding" (Glasersfeld 1991a: xix). This concept is especially crucial in the phases of crystallizing and prototyping, as "understanding" means knowing how to make. Our research supports this theoretical concept, as most student's reported experiencing moments of sudden clarity and deep understanding during, and especially after, the phases of crystallizing and prototyping. Whereas earlier phases aim at students' understanding on a conceptual level, the prototyping is crucial as innovation also requires "realization" in the form of an externalized artifact that has to be successfully implemented in its environmental context.

75. The final process of prototyping and co-creation furthermore leads to the implementation of the generated "new" in the form of an innovation artifact. This "new" can be perceived as such only in relation to already existing structures, and it can only be implemented as a sustainable innovation when students manage to establish a dynamic equilibrium.

76. Socio-epistemological processes of innovation – the generation of autonomous conceptual understanding and creation of innovation artifacts – are therefore understood as processes of change – processes driven by ongoing reciprocal relations between assimilation and accommodation that tend towards dynamic equilibration in which the

interplay of coherence and perturbation through "others" leads to novel, viable, and sustainable knowledge implemented in an innovation artifact.

77. Such a setting for teaching and learning clearly implies a redefinition of the "classic" teacher's role. As the students are the creators of novel and viable knowledge, the instructors can no longer determine the learning outcomes and must serve as coaches and co-creators, guiding students through the process of innovation by fostering processes of coherence and perturbation. It is the instructors' task to provide constrains framing a "safe space," to let go of their hierarchical position, and take the role of a coach for the students throughout that process. It has to be noted that further research is required to highlight what the instructors are actually doing on a practical level to provide such a safe space. It has turned out that it is essential for such a course design to provide a nurturing learning environment (Enabling Spaces) that helps students as well as instructors to cope with the challenges of such an innovation process. Although these aspects are considered in the course design and respected by the instructors intuitively, actual effects need to be studied in more detail.

78. We consider it very important and helpful for instructors to work in a team. This way, they can not only provide students with different perspectives from their diverse backgrounds, but also help each other to face the challenges of such a course design. Furthermore, the openness of the course design and the individual needs and developments of the students within the process make it necessary for instructors to reflect on the process and adapt the design continuously.

79. In the present paper, we have shown that a constructivist approach is not only appropriate as an epistemological foundation for innovation processes, but may also act as a framework providing guiding principles for educational settings in the field of teaching innovation. It turned out that von Glasersfeld provided a suitable framework for dealing with these fragile and open-ended processes we are confronted with in the field of (teaching) innovation.

80. To close with a student's quote:

> "The development of it was very fun, and let me reevaluate my opinion on teachers and the amount of responsibility they are carrying. I think it was a good combination of something new, as well as something that has a use outside this course" 21:52

Appendix: questions asked in the diaries as well as for the group reports

QUESTION(S)	TIME
What do you expect to happen in part B (Knowledge Creation Process) and how does it relate to you and your field of interest? (write about 150 words)	T1: Previous to Phase 1
Write about 500 words regarding the following questions: What do I consider to be the objectives of my KCT and what do I consider to be the topic of the emergent thematic field? How clear are they for me? How do they relate to my personal goals? How do I feel about my KCT?	T2: Previous to Phase 2
Write about 500 words regarding the following questions: What are the most important points and issues in our observation strategy? How do I think about it? How do we work together in the KCT (e.g., working modes, communication modes, meeting frequency, processes of decision making, trust, rules, etc.)? How do I feel about my KCT?	T3: Previous to Phase 3
Write about 500 words regarding the following questions: How was the deep observation? In what way did I gain a deeper understanding of our topic? How do I feel about the collective sense making in my KCT? How do I identify with the KCT and its goals? How do I feel about the outdoor day in the Lobau?	T4: Previous to Phase 4
Write about 500 words regarding the following questions: We spent the outdoor day in Lobau. How did the KCT's goals and my/our understanding develop? How did I/we experience the day?	T5: After finishing Phase 5
Write about 500 words regarding the following questions: How do the sparks of my/our ideas crystallize? How clear is the prototype? What are our group values? How do I and my KCT deal with ideas that come up?	T6: After finishing Phase 6
Write about 500 words regarding the following questions: What do I think about our prototype? When I think about the whole knowledge-creation process (during the whole semester), what worked best? What new insights or new knowledge did I gain in that course? How engaged was I with the process? How was the group dynamics in my KCT?	T7: After finishing Phase 8

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