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Competences for Complex Real-World Problems: Toward an Integrative Framework

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Toward an Integrative Framework

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ABSTRACT

Which competences enable problem solvers to successfully deal with complex real-world challenges such as the current economic and financial crises and in so doing, inspire innovation and sustainable development of society? Despite the importance of these questions, and although competences have become more center stage in management strategy, human resource development, and public policy / public administration research, a general theory of problem solving competence has remained elusive, largely because of insular single-disciplinary approaches. Embedded in a comprehensive review of management strategy, human resource development, and public policy / public administration theories, and by contrasting American and Central-European schools of thought, I discuss the theoretical formulations of previous competence frameworks, the empirical support for these frameworks, and their limitations in solving complex real-world problems. I outline how constituents of competence such as abilities, knowledge, and skills are entrenched within a multifaceted environment and influenced by the individual's mental model(s). Finally, I develop a five-dimensional framework of competences needed to solve complex real-world problems, which considers both individual and collaborative aspects. The five core dimensions of this new competence framework are (1) personal competence; (2) professional domain competence; (3) systemic competence; (4) creativity competence; and (5) sociocultural (collaborative) *competence. This paper is aimed at fostering further theory development and stimulating future research in the field of competence development.*

Keywords: *Competence, competency, complex real-world problems, mental models, environmental dimensions, abilities, knowledge, skills, competence frameworks, 2P2SC framework*, *personal competence, professional domain competence, systemic competence, creativity competence, sociocultural (collaborative) competence, education, crises, innovation.*

Competences are considered important determinants of individual and collaborative performance (e.g., McClelland, 1973, 1998; Boyatzis, 1982, 2001, 2007; Raven & Stephenson, 2001; Erpenbeck & von Rosenstiel, 2003, 2007; Wiek , Withycombe, & Redman, 2011); however, a coherent *competence theory* ascertaining competences that are needed for solving *complex real-world problems*, such as noticeable ongoing crises and the problem-based generation of innovations, is currently missing.

The Oxford Dictionaries provide a very *basic definition* of competence, explaining the attribute of being "competent", which is rooted in the Latin term *competere* and means to be fit or proper, as "having the necessary ability, knowledge, or skill to do something successfully," (Oxford Dictionaries, 2012). In contrast to more stable, performance-related characteristics such as a person's intelligence (e.g., Lubinski, 2004), a person's competences can be altered over time, either intentionally (e.g., by educational means) or unintentionally (e.g., as part of the interaction of a person with its environment). This dynamic feature, which allows to both newly develop competences as well as to improve existing ones, makes them an ideal target for interventions.

Scholars in competence research in the management field like Boyatzis (1982, 2008, 2009) and McClelland (1973, 1998) have contributed immensely to the development of contextual, *job performance related competences* in education and training; however, their focus is on general job profiles, not on problem-based competences. Given the tremendous difficulties of managers, decision-, and policy-makers, in dealing with, e.g., ongoing economic and financial crises, which, to various degrees, exemplify complex and therefore ill-defined, open-ended problems (for which standard procedures and standard solutions are not appropriate), it seems well

justified to focus on *problem-based competences* rather than simply considering them as subcomponents of a larger whole.

Furthermore, the linguistic difference between the terms competence and competency has not been clearly delineated (e.g., McClelland, 1973 versus McClelland, 1998; Snyder & Ebeling, 1992): different meanings of competence exist in public policy and public administration literature, management strategy literature, and human resource development literature (e.g., Delamare-Le Deist & Winterton, 2005, focus on the different use of competency versus competence especially in management strategy and human resource development literature); in addition, there is a lack of a commonly agreed upon theoretical foundation with respect to certain constituents of competence such as abilities, knowledge, and skills (e.g., Westera, 2001; Erpenbeck & Rosenstiel, 2003, 2007).

Existing frameworks tend to *focus on specific fields of application* (e.g., Man, Lau, & Chan, 2002; Inyang & Enuoh, 2009 on entrepreneurial competences or Wiek et al., 2011 on competences in sustainability), whereas the representation of key competences needed to solve complex real-world problems on a *meta-level* (i.e. what are the general patterns that are valid across various field of applications or disciplines?) remains incoherent. Consequences of this incomplete and incoherent picture might especially arise for higher education and training programs of public policy, public administration, management, and related fields: these programs, which should be designed to equip graduates with competences needed to succeed across a broad field of applications (see also overview given in Table 1and specific propositions in Table 2), may actually need to alter their training strategy.

The need to alter training strategies becomes evident when asking whether current educational programs – including primary, secondary, and tertiary education – and training programs

adequately prepare students, respectively problem solvers, to solve complex real-world problems? The handling of present global economic and financial crises might persuade us to believe that there is room for improvement. Complex real-world problems are usually open-ended problems, which are characterized not by only one obvious solution, but by several adequate solutions and a variety of procedures involved in attaining them. In the following I will discuss the specific aspects in which competences for solving open-ended, complex real-world problems fundamentally differ from competences for solving closed, respectively well-defined, problems.

At the enterprise-, societal-, and policy-level, a core research question of this paper is to outline essential competences in order for individuals and collaborative entities to meet the complex challenges faced by today's society. Popper and Soros have already posed the question "What competences are needed to develop a reflective and open society (Popper, 1971a, 1971b; Soros, 2000)?" By extension, one also ought to ask what competences the problem solver/s need/s in order to become driver/s for innovation and sustainable development of society. Such competences should enable individuals and collaborators to devise immediate, mid-term, and long-term solutions in both a consistent, creative, and rational manner, making them prerequisites for successful, sustainable outcomes.

As a basis for a forward-facing general framework for problem solving competencies, particularly as they relate to complex problems, this paper examines existing competence frameworks, their theoretical formulations, potential empirical support, and limitations. The aim of this review is to develop a new framework for solving complex real-world problems by determining which specific competences are needed. Specific propositions are deduced as basis for the framework developed in this paper. Lastly, constituents of competence such as abilities,

knowledge, and skills are discussed, in the context of a multifaceted environment and an individual's mental model(s). Ultimately, the newly developed framework summarizes competences needed to deal with complex problems by highlighting five core dimensions of competences: *personal competence, professional domain competence, systemic competence, creativity competence, and sociocultural (collaborative) competence*.

ESTABLISHED COMPETENCE FRAMEWORKS

Frameworks are intended to lay the groundwork for subsequently derived sound theories. Similarly, the primary aim of this here newly introduced framework for problem solving competence is to foster further theory development. Moreover, it provides a basis for the development of future, testable hypotheses. In the long run, this framework wants to (1) provide an outline of the *competence profile* (i.e., mix of various competences) a person needs in order to "be fit" for the challenges of dealing with (complex) real-world problems, and (2) help *design educational measures and the training* needed to attain those competences as part of the specific role requirements and characteristics of the problems to be dealt with (e.g., public administration, a company, or various forms of cross-border collaborations such as within open innovation).

Table 1 gives an overview of established competence frameworks based on a comprehensive literature review of articles, books, and databases in the field of competence/competency research. Columns in Table 1 summarize 3-, 4-, 5-, and more-dimensional competence/competency frameworks as follows: (1) Source; (2) Approach; (3) Applicability; (4) Number of core dimensions; (5) Core dimensions (i.e. meta-competences); (6) Number of items by core dimension; and (7) Methods & empirical evidence.

TABLE 1

An Overview of Established Competences/Competencies Frameworks (in chronological order)

Source	Approach (behavioral, functional, or a mix of both)	Applicability (general or specific)	Number of core dimensions	Core dimensions* (Meta-competences)					Number of items by core dimensions	Methods & empirical evidence
				Dimension 1	Dimension 2	Dimension 3	Dimension 4	Others		
McClelland (1973, 1975, 1976, 1998); Boyatzis (1982); Spencer & Spencer (1993)	Behavioral	General (Management performance) (Behavioral-Event Interview (BEI) Competencies)	12	Achievement orientation	Analytical thinking	Conceptual (inductive) thinking	Developing others	Flexibility; Impact and influence; Information seeking; Initiative; Interpersonal understanding; Organizational awareness; Self-confidence; Team leadership	4-6 each	Interview-based; quantitatively validated
Boyatzis (1982, 2001)	Behavioral	General (Management performance)	3(+2)	Goal and action management abilities	People management abilities	Analytic reasoning abilities	(Knowledge areas)	(Value themes)	6*8*8* (11*4)	Interview based; quantitatively validated
Epstein (1991); Epstein, Schmidt, & Warfel (2008)	Behavioral	Creativity (Epstein Creativity Competencies Inventory for Individuals)	4	Capturing	Challenging	Broadening	Surrounding		7*7*7*7	Questionnaire-based; quantitatively validated
Faix & Laier (1996)	Functional	General ('Handlungs-kompetenz')	3	Domain competence ('Fach-kompetenz')	Method competence ('Methoden-kompetenz')	Social competence ('Sozial-kompetenz')				Conceptual
Kauffeld, Grote, & Frieling (2000)	Functional	General ('Kasseler-Kompetenz-Raster')	4	Domain competence ('Fach-kompetenz')	Method competence ('Methoden-kompetenz')	Social competence ('Sozial-kompetenz')	Personal Competence ('Selbst-kompetenz')		11*12* 13*9	Video-analysis & quantitative descriptive
Virtanen (2000)	Mix	Public management	5	Task competence	Professional competence in substantive policy field	Professional competence in administration	Political competence	Ethical competence		Conceptual
Man, Lau, & Chan (2002); Man (2006)	Behavioral	Entrepreneur-ship	6	Opportunity competencies	Relationship competencies	Conceptual competencies	Organizing competencies	Strategic competencies; Commitment competencies		Conceptual & empirical exploration
Industrial Development Organization (UNIDO) (2002)	Mix	General (UNIDO Competency model)	3	Managerial competencies	Generic competencies	Technical & functional competencies			14*14*14	Conceptual & qualitative descriptive
Erpenbeck & von Rosenstiel (2003, 2007); Heyse & Erpenbeck (2004)	Mix	General ('Kompetenz Kompass')	4	Domain and method competence ('Fach- und Methoden-kompetenz')	Social-communicative competence ('Sozial-kommunikative Kompetenz')	Action competence ('Aktivitäts- und Handlungs-kompetenz')	Personal competence ('Personaler Kompetenz')		16*16* 16*16	Questionnaire-based; quantitative measurement
Dixon, Meier, Brown, & Custer (2005)	Behavioral	Entrepreneur-ship	8	Team leadership	Communication skills	Perception of trustworthiness	Planning and organizational skills	Basic business skills; Problem solving skills; Communication skills; Personal traits; Creativity	10*7*7*8* 7*7*12*8	Conceptual & empirical exploration
Boyatzis (2008, 2009)	Behavioral	General (Management performance)	3	Emotional intelligence competencies	Social intelligence competencies	Cognitive intelligence competencies			5*7*2	Conceptual
Getha-Taylor (2008)	Behavioral	Public administration (Competency Model of Effective Executive Collaborators)	7	Interpersonal understanding: Demonstrates empathy	Interpersonal understanding: Understands motivation	Teamwork and cooperation: Inclusive perspective on achievements	Teamwork and cooperation: Altruistic perspective on resource sharing	Teamwork and cooperation: Collaborative conflict resolution; Team leadership: Bridges diversity; Team leadership: Creates line of sight	4*4*4*5* 5*5*4	Conceptual & empirical exploration
Sipos, Battisti, & Grimm (2008)	Mix	Sustainability (Learning objectives for transformative sustainability learning (TSL))	3	Head	Hands	Heart			6*6*6	Conceptual
Inyang & Enuoh (2009)	Functional	Entrepreneur-ship	9	Time management	Communication	Human Resource Management	Marketing management	Business ethics; Social responsibility; Leadership; Decision-making; Financial management		Conceptual
Wiek, Withycombe, & Redman (2011)	Mix	Sustainability	5	Systems thinking competence	Anticipatory competence	Normative competence	Strategic competence	Interpersonal competence		Conceptual

* In case of originally German terminology, the German terminology is added in ('_').

As shown by various other competence frameworks (e.g., Boyatzis, 1982, 2001; Faix & Laier, 1996; Kauffeld & Grote, 2000; Kauffeld, Grote, & Frieling, 2000; Heyse & Erpenbeck, 2004; Epstein, Schmidt, & Warfel, 2008; Wiek et al., 2011), it can be useful to keep the number of *core dimensions* small; this helps refine and simplify competence analyses and management, since the condensation of a multitude of single competence dimensions into few core competences sharpens the focus and makes them more easily manageable.

Most existing classification schemes consist of three or four, and in some cases, five dimensions. Three-dimensional schemes usually include *professional*, *method*, and *social competences* (e.g., Faix & Laier, 1996 consider personal competence to be included within social competence); others, such as the three-dimensional scheme of the United National Industrial Development Organization's (UNIDO) consist of *managerial, generic, and technical/functional competencies* (UNIDO, 2002). Some four-dimensional schemes add *personal competence* and/or *action and activity competence* as own dimensions to *professional*, *method*, and *social competences* (Kauffeld & Grote, 2000: 30-37; Kauffeld et al., 2000: 213, 217; Heyse & Erpenbeck, 2004). An example for a five-dimensional framework is a recently developed framework by Wiek et al, which is primarily used in the sustainability field and includes *systems thinking*, *interpersonal*, *anticipatory*, *strategic*, and *normative competence* (Wiek et al., 2011).

Some frameworks show *overlap* of categories: *Method competences*, for example, might play a crucial role in other competence dimensions (e.g., Faix & Laier, 1996; Kauffeld & Grote, 2000; Kauffeld et al.; CEDEFOP, 2011); consequently such categorization only provides limited orientation since an item could be part of several dimensions, such as in professional and social competences.

In *applications*, competence frameworks often focus on *single domains* (e.g., the innovation- or entrepreneurship field, as done by Man et al., 2002; Dixon, Meier, Brown, & Custer, 2005; Inyang & Enuoh, 2009) rather than broadening their applicability to enable meta-disciplinary investigations. However, exceptions where competence frameworks have been applied across multiple domains exist (e.g., Raven, 2001: 18 f.; Boyatzis, 2001, 2009).

Table 1 shows that many frameworks are either conceptual and/or descriptive or conceptual and explorative in nature (Faix & Laier, 1996; Kauffeld, Grote, & Frieling, 2000; Virtanen, 2000; Man, Lau, & Chan, 2002; Man, 2006; UNIDO, 2002; Dixon, Meier, Brown, & Custer, 2005; Boyatzis, 2008, 2009; Sipos, Battisti, & Grimm, 2008; Inyang & Enuoh, 2009; Wiek, Withycombe, & Redman, 2011). Only few approaches provide empirical evidence including its quantitative validation; these include the interview-based approaches of McClelland (1973, 1975, 1976, 1998), Boyatzis (1982, 2001), and Spencer & Spencer (1993); or the questionnaire-based approach on "creativity competencies" of Epstein (1991) and Epstein, Schmidt, & Warfel (2008). Getha-Taylor (2008) utilized the protocols presented by Spencer & Spencer (1993), which are based on McClelland (1973, 1975, 1976), in her application in the field of public management. Others used video-analysis (Kauffeld, Grote, & Frieling, 2000), and Heyse & Erpenbeck (2004) and Erpenbeck & von Rosenstiel (2003, 2007) provide sophisticated competence measurements for the management and the development of competences in practice (see also Faix & Mergenthaler, 2010).

A comprehensive review of management strategy, human resource development, and public policy and public administration literature and, particularly, of 15 competence/competency frameworks as summarized in Table 1, generated four propositions, which form the underpinnings of the "2P2SC Framework of Problem Solving Competence" (i.e. **p**ersonal

competence, **p**rofessional domain competence, **s**ystemic competence, **c**reativity competence, **s**ociocultural competence). Each proposition is discussed in the following.

Proposition 1: *There is a need for a Lingua Franca, a clarification in terminology with respect to competence and competency (especially between U.S. and European scholars) and the recognition and avoidance of "jingle-jangle fallacies" within competence research.*

Proposition 2: *There is a need for a Lingua Franca, and a clarification in public policy and public administration, management strategy, and human resource development literature as it concerns (a) definitions and the use of constituents of competence such as abilities, knowledge, and skills; (c) the influence of individual's mental model(s); and (d) their integration in a multifaceted environment.*

Proposition 3: *Established frameworks only marginally focus on open-ended, complex (real-world) problems for which standard solutions and standard procedures are not sufficient (in difference to closed problems for which such solutions and procedures are available).*

Proposition 4: *Open ended, complex (real-world) systems, and associated real-world problems (a) call for systems thinking and reflection as underlying paradigms, in order to be adequately understood; (b) call for creativity, in order to develop" fitting" solutions; and (c) increasingly depend on "heterogeneous" collaborations, either between different disciplines, between science and practice, between*

collaborators with different cultural background, or between internal (e.g., within an organization) and external (e.g., from other organizations) agents.

In Table 2, I apply each of the above four propositions to established frameworks (summarized in Table 1), meant to orient the reader to the current state.

Theoretical foundation for Proposition 1

The terms *competence* and *competency* are often confused and have been used inconsistently, creating *terminological* misinterpretation. Some authors have used these terms inter-exchangeable even within a single publication (e.g., Snyder & Ebeling, 1992; Horton, 2000; OECD, 2005; Draganidis & Mentzas, 2006; Inyang & Enuoh, 2009; Chin-Cheh, Pei-Wen, Chia-Chi, & Chin-Shin, 2011: 1123). Others, such as McClelland, initially used the expression *competence* (1973) and then later switched to *competency* (1998), using both terms to reflect the exact same concept. However, as several scholars of educational development have pointed out, based on typology analyses (Delamare-Le Deist & Winterton, 2005; Winterton, Delamare-LeDeist, & Stringfellow, 2006) *competence* and *competency* are indeed two distinct terms and are not interchangeable: specifically, *competency* refers to a behavioral approach (based on the U.S. educational development and training tradition) and *competence* refers to a functional approach (based on the European tradition in educational development and training). Related questions one might want to ask in the context of *competency* would then be (1) Which abilities, knowledge, and skills or personality characteristics *do successful people possess? (= behavioral approach)*; whereas in the context of *competence* one might ask (2) Which abilities, knowledge, and skills do people have to possess to *successfully accomplish a certain job, project, or problem*? *(= functional approach)*.

TABLE 2

Propositions Applied to Established Competences/Competencies Frameworks (in chronological order)

Source	Terminology: competence versus competency (Proposition 1)	Definition of competence & constituents of competence (Proposition 2)	Explicit determination of the interdependency between competence and mental model (Proposition 2)	Focus on competences for complex (real-world) problems (Proposition 3)	Systems thinking (Proposition 4)	Creativity (Proposition 4)	Collaboration (sociocultural competence) (Proposition 4)
McClelland (1973, 1975, 1976, 1998); Boyatzis (1982); Spencer & Spencer (1993)	Competency (McClelland originally used both)	Defined as capability or ability	Only implicit	Only marginally considered; focus is on outstanding management performance	Marginally considered, but not as 'core competency'	Marginally considered, but not as 'core competency'	Marginally considered, but not as 'core competency'
Boyatzis (1982, 2001)	Competency	Defined as capability or ability	Only implicit	Only marginally considered as part of value themes	As part of 'Analytic Reasoning Abilities'	Not considered explicitly	As part of 'People Management Abilities'
Epstein (1991); Epstein, Schmidt, & Warfel (2008)	Competency	No explicit differentiation - focus is on knowledge and skills	Only implicit	Limited to creativity	Not considered explicitly	Yes	Not considered explicitly
Faix & Laier (1996)	Competence ('Kompetenz')	Defined as knowledge, skills, and qualifications, including rules, values, and norms	No	Partly	Not considered explicitly	Not considered explicitly	Partly considered in social competence
Kauffeld, Grote, & Frieling (2000)	Competence ('Kompetenz')	Defined as abilities, skills, thinking methods, and knowledge	No	Partly	Not considered explicitly	Not considered explicitly	Partly considered in social competence
Virtanen (2000)	Competence	No explicit differentiation - competence as human capital	No	Limited to public administration	Not considered explicitly	Not considered explicitly	Not considered explicitly
Man, Lau, & Chan (2002); Man (2006)	Competency	Encompasses personality traits, skills, and knowledge	No	Limted to entrepreneurial competences	Not considered	Not considered	Partly considered in relationsship competencies
United Nations Industrial Development Organization (2002)	Competency	Defined as skills, knowledge, and attribute	No	Limted to public administration (at UNIDO)	Not considered	Partly considered	Partly considered
Erpenbeck & von Rosenstiel (2003, 2007); Heyse & Erpenbeck (2004)	Competence ('Kompetenz')	Defined as knowledge, skills, and qualifications, including rules, values, and norms	No	Marginally considered (as subcategory of social-communicative & action competences)	Marginally considered (as subcategory 'holistic thinking')	Marginally considered (as subcategories of action & personal competence)	Marginally considered (as subcategories of social-communicative comeptences)
Dixon, Meier, Brown, & Custer (2005)	Competency	Defined as knowledge, skills, and attitudes	No	Limted to entrepreneurial competences	Not considered	Yes	Partly considered
Boyatzis (2008, 2009)	Competency	Defined as capability or ability	No	Not considered - focus on outstanding management performance	Subdimension of cognitive intelligence	Not explicitly considered	Subdimension of social intelligence
Getha-Taylor (2008)	Competency	Defined as knowledge, skills, and abilities (KSAs), including job-related motives, traits, and self-concepts	No	Limited to collaboration	Not considered	Not considered	Yes
Sipos, Battisti, & Grimm (2008)	Learning objectives	Defined as knowledge, skills, and attitudes	No	Limited focus on problem-based learning for sustainability	Subdimension of "Head"	Subdimension of "Heart"	Subdimension of "Hands"
Inyang & Enuoh (2009)	Competence and Competency	Defined as knowledge, skills, and attitudes	No	Limted to entrepreneurial competences	Not considered	Not considered	Marginally considered as communication
Wiek, Withycombe, & Redman (2011)	Competence	Defined as knowledge, skills, and attitudes	No	Problem solving for sustainability	Yes	Marginally considered	As interpersonal competence

* In case of originally German terminology, the German terminology is added in ('_').

And yet, even though today's frameworks now frequently integrate both behavioral and functional aspects, the terminological distinction between competency and competence is still not always made, albeit sometimes simply due to *linguistic restraints*: In the German language, for example, only one term, - the term "*Kompetenz"* - exists (e.g., Erpenbeck & von Rosenstiel, 2003, 2007), which combines both functional and behavioral aspects thereby synthesizing competence and competency.

Theoretical foundation for Proposition 2

Definitions of competence are broad and differ with respect to related concepts of constituents such as *abilities, knowledge, and skills*. Various different interpretations of competence are provided in the *public policy and public administration, management strategy, and human resource development literature*. *Public policy and public administration*, for example, have very heavily drawn on management approaches (e.g., Hood & Lodge, 2004: 313, 314, 316), as "the practical ability of organizations to carry out particular operations" and "the ability of individuals to perform specific tasks", with some scholars arguing for a stronger focus on *value competences* (e.g., Kavathatzopoulos & Rigas, 1998; Virtanen, 2000) and on *cultural competences* (e.g., Rice, 2007). In another definition, (UNIDO, 2002: 8), competencies are considered "a set of skills, related knowledge and attributes that allow an individual to perform a task or an activity within a specific function or job." *Management strategy* refers to unique and industry-specific competences with *core competences* as a specific example (e.g., Prahalad & Hamel, 1990). The vast majority of literature, finally, stems from *human resource development.* It primarily strives for transferable generic competences for learners (e.g., Stasz, 1997). Raven (2001: 18f.) distinguishes between "*basic* and *high-level competencies"* and calls for a stronger focus on the latter to build a *more effective learning society*. Similarly, Westera relates competence to the

capability to solve complex problems characterized by ill-defined causes and thus defines competence as „the ability to produce successful behaviors in non-standardized situations" (2001: 82). Erpenbeck and von Rosenstiel (2007: XIX f.) refer to competences as manifestations of self-organized acting; competence is then the attribution of certain characteristics of an intellectually self-organized agent (problem solver) by the assessment of an observer. Hence, *self-organization* is related to actions that cannot be predicted (or can only be marginally forecast) because of the individuality of the agent's mental model and of the particular design of the problem solving process, the individuality of choice regarding the methods to be applied, and the emerging dynamic patterns of interaction in the case of collaborative processes. Westera further stresses „the need for a distinct concept of competence that surpasses the levels of knowledge, skills, and attitudes, originating from the observation that something 'extra' seems to be necessary to ensure effective and efficient performance" (2001: 81). Simultaneously, he refers to the difficulty of drawing boundaries between competences, skills, and abilities.

As Boon and van der Klink (2002) note, competence can be a useful term, bridging the gap between educational and vocational requirements. Erpenbeck & von Rosenstiel (2007: XII) similarly point out that, although competence includes skills, knowledge, and qualifications, the meaning cannot be reduced simply to those elements; in other words, the whole is greater than the sum of its parts. Interestingly, abilities are not included in their definition; they also state that the capability to act within open, uncertain, and complex situations needs to be based on self-governing rules, values, and norms. Boyatzis defines *"competency"* as *"an underlying characteristic that leads to, or causes effective performance"* (Boyatzis, 1982: 14, 2007; Yeung, 1996), and according to McClelland (1973, 1998: 331), a *competency assessment* measures successful performance. For McClelland (1973: 4) such an assessment is different from

intelligence- and aptitude tests which have very little or no predictive value regarding how people actually perform in life and, since they only account for a very limited segment of performance, their implications for the criteria of job proficiency are also only very limited.

Across the definitions of competency, the significance of *superiority* varies strongly. For Boyatzis (1982), for example, competency is not just a behavior, but also an inherent characteristic that yields *superior or effective performance.* By contrast, Wagner, Kegan, Lahey, Lemons, Garnier, Helsing, Howell, & Rasmussen (2006) define competencies in the context of school transformation as "the repertoire of skills and knowledge that influence student learning" and they stress that "competencies are most effectively built when professional development is focused, job-embedded, continuous, constructed, and collaborative" (Wagner et al., 2006: 99). The comparison of national qualification frameworks in Europe by The European Centre for the Development of Vocational Training (e.g., CEDEFOP, 2011), finally, is another example for an inconsistent use of the terms abilities, knowledge, and skills even within the same report.

Of relevance for proposition 1 and 2, all these "jingle-jangle fallacies" in competence research can be detrimental for future progress in this field. Thorndike (1904: 14) stated already in 1904, "The words are identical and we tend to accept all the different things to which they may refer as of identical amount." Block (2000: 156) stressed that this so-called "jingle fallacy can cause the scientifically uncareful to believe they are talking about the same phenomenon when indeed they are not." As in the case of competence research, a simple jingle fallacy can be further complicated by the jangle fallacy (Kelly, 1927; Block, 2000), a situation where "different terms are used for the same or almost the same underlying construct". This is confusing and may confound efforts of understanding, - "it limits discernment of important empirical and conceptual convergences" (Block, 2000: 156). By extension, what has been called for in personality

psychology (Block, 2000), is also valid for the field of competence research, namely, the need for a Lingua Franca (i.e. a common language).

Theoretical foundation for Proposition 3

The overview of established frameworks in Table 1 together with the propositions applied in Table 2 clearly illustrates that none of these approaches has its main focus either on problem solving or on solving complex real-world problems. For example, McClelland (1973, 1975, 1976, 1998), Boyatzis (1982, 2001), and Spencer & Spencer (1993) focus on job performance; Epstein (1991) and Epstein, Schmidt, & Warfel (2008) emphasis creativity; and Getha-Taylor (2008) concentrates on collaboration. Others have a general orientation not specific for a certain research area, but still do not explicitly center around (complex) problem solving (e.g., Faix & Laier, 1996; Kauffeld, Grote, & Frieling, 2000; Erpenbeck & von Rosenstiel, 2003, 2007; and Heyse & Erpenbeck , 2004). Other frameworks serve a specified purpose, for example, Virtanen (2000) and UNIDO (2002) on public administration; Man, Lau, & Chan (2002); Dixon, Meier, Brown, & Custer (2005), and Inyang & Enuoh (2009) on entrepreneurship. Sipos, Battisti, & Grimm (2008) and Wiek, Withycombe, & Redman (2011) focus on sustainability, where Sipos, Battisti, & Grimm (2008) includes problem-based learning as part of their approach and Wiek, Withycombe, & Redman (2011) incorporate problem solving for sustainability purposes.

The necessity of a new framework is largely related to some key differences between routine and non-routine problems. Routine problems (also considered as *tasks*, e.g., Scholz & Tietje, 2002) can be solved by prescribed, traditional procedures such as calculations that apply certain algorithms and that have been shown to be successful (e.g., well-established cost-accounting methods). In other words, the present and future state of the considered problem as well as the underlying trajectory and the problem solving process reveal deterministic characteristics.

By contrast, unique non-routine problems, such as the search for a solution to a political conflict or the challenge of generating an outstanding product innovation, cannot be solved solely by applying routine problem solving strategies, but they also require non-routine problem solving in the form of logic, creativity (based on an understanding of the underlying system, the particular problem solving process), a systemic endeavor, and collaboration.

A key problem associated with a system's increasing *complexity* is that such a system, and hence the problem associated with it, can no longer be exhaustively and perfectly understood (nor can their inherent structure be sufficiently determined), making predictions for the future practically impossible. Moreover, an increasing complexity of systems and problems, and consequently their ill-defined nature (e.g., have all relevant system parameters been taken into consideration and are all explicit and implicit interdependencies understood?) imply that these problems cannot be solved relying on routine problem solving approaches. These tended to work in situations with explicit solutions and a clearly definable process solving procedure in which the system pattern relied on a well-defined algorithm. By contrast, *complex and ill-defined systems and problems* require *non-routine problem solving* at the individual and collaborative level. However, although the necessity to innovate is widely accepted in the academic and business realms, capabilities to appropriately deal with an increasingly complex and interdependent world lag far behind (e.g., Scholz, 2011). This gap likely reflects an insufficient holistic understanding of dynamically changing interrelated systems and a lack of abilities, knowledge, and skills needed to successfully engage in heterogeneous collaborations across disciplines, between science, society, large organizations, and between citizens. More generally, this concerns the relations between societal expertise and professional expertise and among various cultures in an increasingly globalized world. Hence, a rethinking and reframing of

competence-requirements is necessary, including the reshaping of *society's collaborative competences*.

Complex problems are special also because of their unpredictable, massive, and often global effects, and the difficulty of pinpointing their evolution. That complex problems are *ill-defined* makes them particularly difficult to address, (1) because our knowledge of their present state is imperfect due to peculiarities of the various interrelationships and their intensities; (2) because their future state cannot fully be determined or might be ambivalent; (3) because the trajectory connecting the present with the future state(s) cannot be fully understood, e.g., related to imperfect knowledge of potential barriers occurring within the trajectory such as technological or societal disturbances; and (4) because underlying behavioral patterns of involved individuals and collaborators change, based on alternating mental models (Scholz & Tietje, 2002; Steiner, 2011: 126-127). Thus, today's systems tend to be characterized by an increasing amount of variables, which intensely interact with each other and with their environment. In addition, they also have quickly changing patterns of behavior, which need to be considered as sources of potential paths to future development (Gomez & Probst, 1999; Scholz & Tietje, 2002; Scholz, 2011; Steiner, 2011), making the forecasting of a single event practically impossible. Scholz (2011) describes as an example of such a complex path of development the interaction of human systems (e.g., industrial activities) with environmental systems (e.g., water, air, and soil) embedded within the larger human-environment system; this example demonstrates how human decisions (at the organizational as well as policy levels) can lead to actions that, as part of a circular learning process, can influence further decisions and simultaneously impact environmental systems, which, as a second-order reaction, interrelate with human decisions.

Crises, either of anthropogenic or of natural origin, have at all times accompanied mankind's history. Today's crises include the current global economic crisis, food crises, global warming, genocides, energy shortages, and carcinogens, all of which represent only the tip of the iceberg. But most current crises differ from previous crises in one key aspect: Because of globalization and our constantly increasing *interconnectedness*, today, we are affected both by near *and* remote crises (geographically and contextually) (e.g., Reimers, 2009; Chinn & Frieden, 2011; World Bank, 2012; Lim, 2012;). Furthermore, the inherent interdependencies within a globalized world prominently highlight the responsibilities of society, of its decision-makers, and of all its stakeholders for any decisions that are, or are not made, and for their consequences. Hence, in crises that we seemingly have not called upon us, such as the still resonating 2008 economic crisis, two crucial questions to ask are whether we, as individuals and collectives, are equipped with the competencies needed to be constructive, effective and successful problem solvers for the sustainable development of the world – particularly its ecological, social, and economic dimensions, and, secondly, whether current educational and training programs are adequate.

Globalization and our *increasing interconnectedness* are largely driven by technological innovation and, in particular, by modern information and communication technologies. Hence, although complex man-made problems (e.g., political, economic, technological, ecological, and social issues) have been present throughout mankind's development, they are increasingly arising as a result of a rapidly growing world population, globalization, and interconnectedness.

The following fourth proposition is especially related to the need to emphasize the role of systemic competence, creativity competence, and sociocultural competence for solving complex real-world problems. Personal competence and professional domain competence are important as

well, however, they are much more common in established European frameworks (e.g., Heyse & Erpenbeck, 2004; Kauffeld & Grote, 2000; Kauffeld et al., 2000; and Faix & Laier, 1996).

Theoretical foundation for Proposition 4

The analysis of established frameworks (see Table 1) reveals that most approaches seem to be insufficient in dealing with the *complexity* of real-world problems *holistically* (i.e. by using a *systems thinking* approach) and creatively (i.e. as basis for innovative solutions).

Boyatzis includes systems thinking in his competence framework as part of the dimension "analytic reasoning abilities" (2001: 307), but not as an own category, and later as part of "cognitive competencies" (2009: 754 f.). In a most recent sustainability-related framework, Wiek et al. (2011) prominently consider systems thinking as one of five core dimensions.

As to creative thinking, most frameworks do not include creativity at all. The *Epstein Creativity Competencies Inventory for Individuals (ECCI-i)* centers on "measuring and training creativity competencies" (Epstein, Schmidt, & Warfel, 2008), whereas Dixon et al. (2005) consider creativity as one of eight core dimensions. Alternatively, Sipos, Battisti, & Grimm, 2008, incorporate systems thinking and creativity as learning objectives in their framework.

Sociocultural (collaborative respectively inter-personal) competences are only marginally considered within the analyzed frameworks (see Table 1 and 2, e.g., Getha-Taylor, 2008; Sipos et al., 2008; Wiek et al., 2011). Collaborative competences play a crucial role when organizations are supposed to work together, such as in public administration (National Academy of Public Administration, 2002; Getha-Taylor, 2008; and O'Leary & Vij, 2012), but generally speaking, in any form of collaboration across or within specific stakeholder groups.

Summary

Taking crises as examples for complex real-world problems, as stated by e.g., OECD (2009), an adequate policy response requires investing in innovation and education. This investment not only concerns the provision of financial resources, but, even more importantly, the development of educational and training programs which are suitable for delivering appropriate competences needed for dealing with complex real-world problems. Past educational strategies have been successful mainly in providing competences that are needed to address routine problems, but they often fell short of adequately addressing today's increasingly multilayered, complex real-world (i.e., non-routine) problems. Modern educational policies and strategies need to be based on competence concepts that address the peculiarities of such non-routine problems. However, to date, with few exceptions (e.g., Kegan, 1994; Kegan & Lahey, 2009; Scholz, 2011), scholars have mostly overlooked, especially, the specific *capabilities* needed to address the highly demanding challenges of *systems thinking* and *collaborative problem solving*; they have also largely ignored how educational policies and related educational strategies need to be designed accordingly.

In essence, since a common theoretical foundation, consistent terminology, and definitions of competence are missing, we currently lack clear, commonly agreed-upon competence frameworks. Based on this analysis and the propositions derived, the four core objectives of this paper, which is aimed at competences for complex real-world problems, are to: (1) provide a clear competence terminology based on the definitions and distinctions made throughout this paper; (2) outline the role of abilities, knowledge, and skills across all competences (see Figure 1); (3) consider the influence of mental models in conjunction with the environment (see Figure 1); and (4) delineate additional competences needed, apart from personal competence and

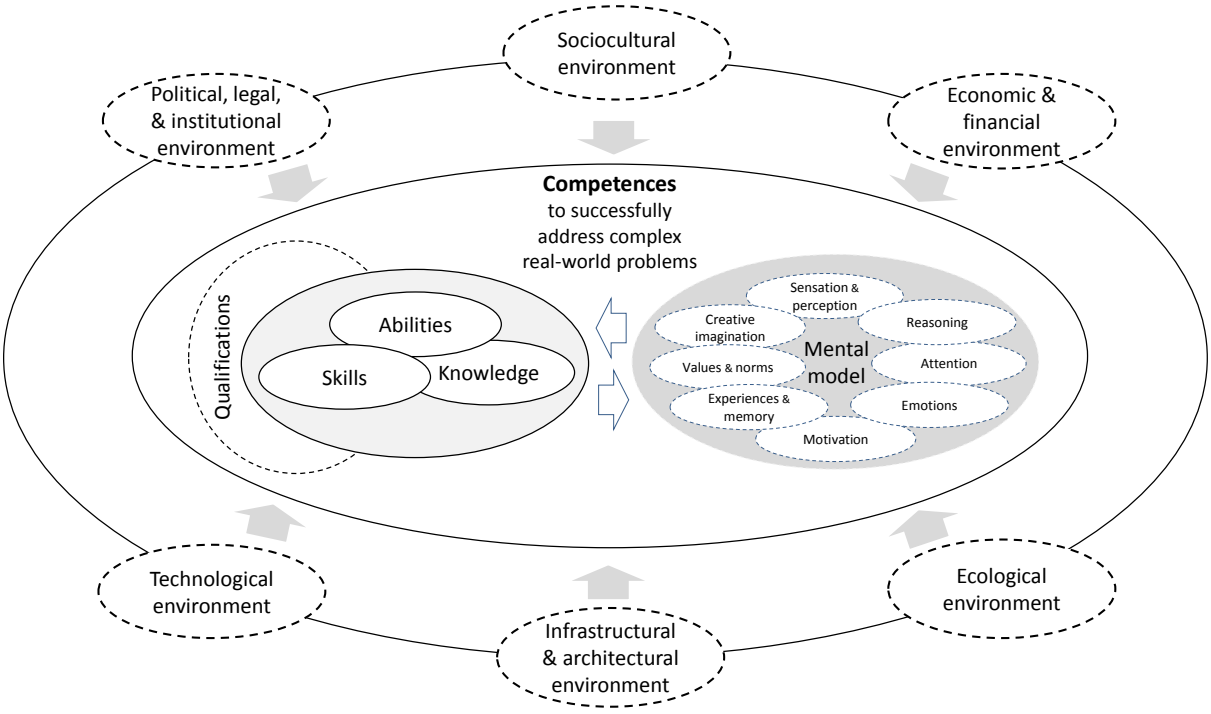
professional domain competence, to systemically, creatively, and collaboratively address complex real-world problems.

CLARIFICATION: COMPETENCES, CONSTITUENTS, MENTAL MODEL, AND ENVIRONMENT

I suggest that *competence can be defined as the problem solver's abilities, knowledge, and skills needed to adequately deal with a complex real-world problem; competence depends on specific underlying mental models, which themselves are not stable but change over time; and they also depend on the specific features of the environment. I consider environment as a six-dimensional interrelated entity which consists of (1) political, legal, & institutional; (2) sociocultural; (3) economic & financial; (4) technological; (5) infrastructural & architectural; and (6) ecological dimensions* (see Figure 1).

FIGURE 1

Competences: A clarification



Cognitive, affective (emotional), and motoric *abilities* strongly correlate with the individual's talents and are more stable than skills, since abilities cannot be altered as quickly as skills; in fact, certain abilities are prerequisites for specific skills (always depending on initial conditions) (e.g., Zimbardo, Johnson, & McCann, 2009). As an example, modeling and simulation of systems as part of the system dynamics approach is a specific skill that can be trained, based on basic intellectual abilities that allow to comprehend, analyze, and reflect the system adequately. Domain-specific and domain-general skills are the expertise gained by repeated exercises within cognitive or motoric processes.

Knowledge itself is not necessarily related to real-world action and can either be declarative respectively factual (i.e. knowledge about something), or procedural (i.e. knowledge of how to do something), and can be conveyed in explicit forms (i.e. universal knowledge that can be uttered and formally formulated in sentences) or tacit forms (i.e. "knowledge tied to the senses, tactile experiences, movement skills, intuition, unarticulated mental models" that is informal and can only marginally be communicated) (Nonaka & Krogh, 2009: 636; Nonaka, Konno, & Toyama, 2001). As Westera (2001: 75) states, declarative or factual knowledge alone no longer meets the requirements of a changing society since it is not sufficient for dealing with "ill-defined problems, contradictory information, informal collaboration, and abstract, dynamic and highly integrated processes."

Qualifications are independent of applied action and real-world experience and reflect current standardized abilities, knowledge, and skills (see also Erpenbeck & von Rosenstiel, 2007: XIX). Therefore they can only account for the formal aspects of abilities, knowledge, and skills.

There is no commonly agreed upon, objective manner in which our senses and related cognitive and affective processes reveal an underlying (complex) problem and its enclosing,

broader real-world situation to us. Similarly, there is no commonly agreed upon, objective approach to problem solving processes we are involved in, our perceived roles and competences, and interdependencies among us. Quite on the contrary, we actively construct (model) these problem solving processes by using our senses and our brain in an interplay between sensation (the stimulation of a sense organ) and perception (the mental representation of sensation) (e.g., Schacter, Gilbert, & Wegner, 2011: 125-174), reasoning (e.g., Johnson-Laird, 2010; Pinker, 2009: 299-362), attention (e.g., LaBerge, 1990), emotions (e.g., Schacter et al., 2011: 307-346; Zajonc, 1980: 151–175), motivation (Amabile, 1993; Mitchell, 1982; Robinson, Stevens, Threapleton, Vainiute, McAllister-Williams, & Gallagher, 2012), experiences and memory (e.g., Schacter et al., 2011: 219-262), values and norms (and other elements of evaluation) (Miller & Prentice, 1996; Maseland & van Hoorn, 2010; Scholz, 2011: 190-212), and creative imagination (e.g., Byrne, 1996; Steiner, 2011) (the mental model concept was originally introduced by Craik, 1943, see also e.g., Forrester, 1961, 2009; Gentner & Stevens, 1983; Porac & Thomas, 1990; Oakhill & Garnham 1996; Johnson-Laird, 1999, 2010; Sterman, 2000: 16–19). Johnson-Laird (1983, 1999, 2010) states that human reasoning depends on "envisaging the possibilities consistent with the starting point – a perception of the world, as set of assertions, a memory, or some mixture of them," as an alternative view for considering formal rules of inference as the underlying cognitive mechanism. By contrast, the mental model is an internal representation of the world or of its specific segments (such as a problem), for which language (either verbal or non-verbal) is needed (e.g., Chomsky, 1965; Pinker, 2007; Schacter et al., 2011: 347-388) in order to communicate or share them with others.

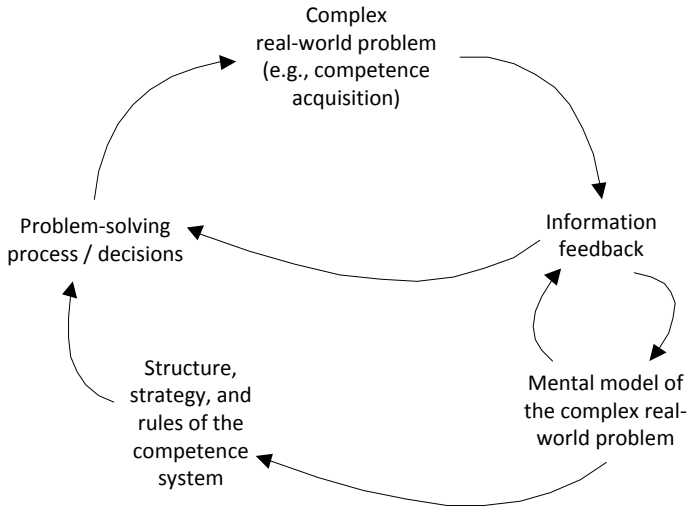
As shown in Figure 1, mental models not only influence the competences which are applied, but they themselves are influenced by the application of problem solver's/solvers' abilities,

knowledge, and skills within a particular complex, real-world setting. In this sense, mental models are theories about the real world, which are based on individuals' unique sensations, perceptions, reasoning, attention, emotions, motivation, experiences, memory, emotions, values, norms, and creative imagination. Those theories "are not true and accurate images of our surroundings, but are only sets of assumptions and observations gained from experience" (Forrester, 2009: 13), such as being engaged within a real-world problem solving process. Mental models differ from individual to individual, although they might be members of the same problem solving team; as Forrester (2009) points out, the model may also have serious shortcomings based on incomplete information and internal contradictions.

The consideration of mental models within a theory of competences is essential. As second-order cybernetics, this effort might also be considered as thinking of thinking (e.g., von Foerster, 2003; Bateson, 2002). As pointed out by system thinkers (e.g., Forrester, 1961; Sterman, 2000; Meadows, 2008; Gharajedaghi, 2006; Scholz, 2011: 429-443), all decisions (including learning) occur in the context of feedback loops. Consequently, not only the problem solving process, but also problem solving competences for dealing with the world (and with complex, real-world problems) are influenced by their underlying mental models and vice versa. That is, the relationship between competences and mental models is not based on a linear cause-effect relationship; on the contrary, *feedback* is the core characteristic of this relationship. This feedback mechanism also forms the basis for *reframing* complex real-world problems (e.g., as an inventory of existing competences related to the needs of the specific problem such as specific actions taken to enhance competences or to acquire new ones).

FIGURE 2

Competence acquisition as double-loop learning (based on Sterman, 2000: 19; Argyris, 1985)



Using *competence acquisition* as an example for a complex, real-world problem solving process, Figure 2 illustrates how information feedback regarding a complex, real-world problem affects the problem solving process, decisions, and the underlying mental model. As the mental model changes, the structure, strategy and rules of the competence system will change along with it, which in turn will change the problem solving process and decisions. Consequently, the same information transforms the problem solving process not only directly but also indirectly by changing the mental model and adapting the competence system.

For an extended perspective on competence acquisition, Howell's approach of *linking consciousness and unconsciousness* can be helpful: The *acquisition of competences* is different from the acquisition of knowledge, abilities, skills, and qualifications. According to Howell (1982), the *development of competences* is a four-stage learning process starting with unconscious incompetence (i.e. not being aware of missing competences), followed by conscious incompetence (i.e. being aware of missing competences; a necessary starting point for the

acquisition of competences), and then conscious competence (i.e. the application of acquired competences is strongly related to focused acting), which leads to unconscious competence (i.e. competences are applied in a natural sense based on experience; competences become part of one's personal approach) as the highest level of development (if practiced sufficiently within real-world scenarios over a certain period). Details about the origin of this learning model are not entirely clear; according to Adam (2010), the model might either be attributed to Howell (1982) or the Gordon Training International, but he does not provide a clear reference; the model's origin is discussed in greater detail in Chapman (2010).

Resistance to change within the learning process can differ widely depending on the (1) specific dimension of a competence (as summarized by various competence frameworks such as listed in Table 1, or using the dimension specification I propose in this paper - personal competence, professional domain competence, systemic competence, creativity competence, and sociocultural (collaborative) competence, (2) underlying mental model, (3) specific development patterns of abilities, knowledge, and skills of relevance, and (4) the influence of the political, legal, & institutional; sociocultural; economic & financial, technological; infrastructural & architectural; and ecological environment.

In the following, I will describe each of the specific constituents of the six-dimensional interrelated environmental entity (Figure 1) in greater detail. The *political, legal, & institutional environment (1)* centers around, e.g., governance, administrative policies, bureaucracy, government attitudes, transparency, laws and enforcement mechanisms, political stability, lobbyism, and corruption (related to public and private institutions as well); the *sociocultural environment (2)* comprises factors such as the gender and age structure of a certain group or population, their ethnical diversity, lifestyle, religion, migratory trends, value systems, social

regulations, social cohesion, education, human capital, health, standard of living, well-being, and human rights; *the economic & financial environment (3)* comprises economic development and trends of the gross domestic product, stability of the macroeconomic system, foreign direct investments, inflation, employment, taxation, transparency, regulations of the financial system, labor market, and entrepreneurial spirit; the *infrastructural & architectural environment (5)* refers to, e.g., transport and communication infrastructure, electricity supply, physical structures such as urban design and landscape architecture, but also the design of buildings and workplaces; and *ecological environment (6)* which encompasses all living organisms (i.e. biotic) within their natural milieus such as water, air, and soils (i.e. abiotic), potentially harmful effects such as pollution and degradation, and availability of natural resources. Especially the *technological environment (4)* is characterized by its strong correlations to the other dimensions of the environment, such as innovation policies as part of (1), private and government funding for research and development (1)(3), scientific education and training (2), intellectual property rights (3), creative innovation climate (2)(5), and resource availability & accessibility (6).

With respect to the environment in which the problem solving takes place, today, changes of system patterns are moving at increasingly faster rates at all levels of society, affecting it's e.g., political, legal, & institutional; sociocultural; economic & financial; technological; infrastructural & architectural; and ecological environment. *Innovations*, as one specific pattern of change for example, occur not only on a technological level, but at various cultural and socioeconomic levels as well. Especially radical innovations are usually related to changing behaviors as well; for example, the telephone or the www were related to a radical change of customers' behavior and cultural changes in addition to its implications on a technological and technical level.

Summary

To summarize, competences consist of the agent's abilities, knowledge, and skills applied in a real-world setting and they depend on specific underlying mental models as well as on the environment's distinct features. *Mental models are theories about the real world based on the agent's sensation, perception, reasoning, attention, emotions, motivation, experiences, memory, values, norms, and creative imagination.* Via double-loop learning, competences enable the development of problem-specific behaviors suitable for dealing with complex non-standardized problems (see Figure 2).

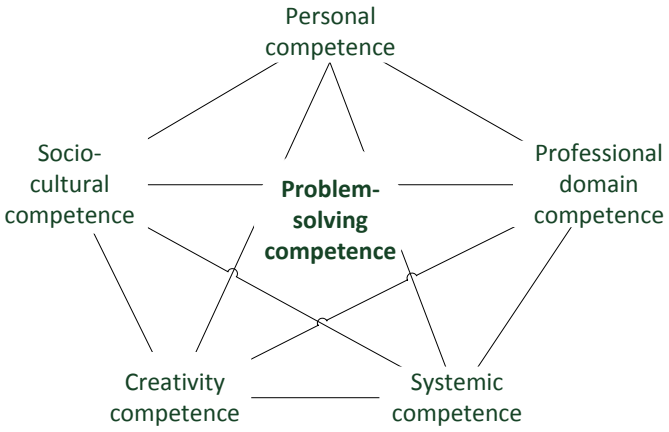
The 2P2SC FRAMEWORK OF PROBLEM SOLVING COMPETENCE

The following concept provides a new competence framework to address complex real-world problems. This *framework of problem-solving competence* focuses on the previously outlined peculiarities of complex real-world problems and the competences needed to solve them. It builds on peculiarities and shortcomings of established approaches (see Table 2 for propositions made), which, as one of their core limitations, do not center on problem solving competence as means for dealing with complex real-world challenges.

FIGURE 3

Problem solving competence:

The C2P2S framework of problem solving competence



Albert Einstein, when faced with the challenge of the atomic bomb, emphasized already in 1946 the need for a new way of thinking: "[…] a new type of thinking is essential if mankind is to survive and move to higher levels. […] Past thinking and methods did not prevent world wars. Future thinking must prevent wars." (Einstein, 1946). Sixty-six years later, his words still reverberate in the face of today's multi-faceted crises, given that most influential people or 'leaders' in business, politics, and academia are now narrow specialists with linear paths of logic, oftentimes leading to constrained, one-dimensional policies and similar problem solving strategies. Hence, complex phenomena, such as crises and the generation of innovation, call for a shift in education aimed at supporting students and citizens not only in achieving disciplinary excellence but also in their endeavor to holistically (i.e. systems thinking) understand systems and related problems and to creatively reframe and solve problems (sometimes related to reinventing oneself). Future successful education policies need firstly to point out those 'new' educational challenges and secondly, to provide strategies that help students and citizens to

acquire the competences needed to successfully deal with complex real-world problems. *Disciplinary excellence* is not to be replaced but extended by *holistic and creative thinking*. In exploring the roots of the phenomenon of crisis, Schwaninger and Groesser (2010) contend that all crises, large and small, are caused by errors flowing from wrong actions stemming from wrong thinking generated by agents' mediocre mental models, otherwise known as the Conant-Ashby theorem (Conant & Ashby, 1970). Consequently, a complex issue cannot be explained by applying a mono-causal linear thinking approach nor can it likely be solved with capabilities that might have been successful in the past, where simpler system characteristics tended to be in place. Likewise, the challenges society faces today and into the future, including crises in their extreme, call for a change of traditional conceptual paradigms and, more generally, for a change in our thinking patterns as well as an effective set of *cognitive* (e.g., logical reasoning and reflecting), *affective* (e.g., feeling), and *motoric* (e.g., as basis for rapid prototyping and design thinking) *capabilities* to address complex challenges; clearly, these paradigms and capabilities must also be wrapped into appropriate educational policies and practices.

I suggest that *problem solving competence* for complex real-world problems depends on the synergetic interaction of personal competence, professional domain competence, systemic competence, creativity competence, and sociocultural (collaborative) competence (see Figure 3): (1) *personal competence* – to be aware of, and manage oneself within, the problem solving process and to develop one's personality; (2) *professional domain competence* – needed to comprehend the peculiarities of the specific domain in which the problem is embedded (e.g., in order to develop a public health strategy for Haiti post the 2010 earthquake, political, medical, social, and cultural expertise is needed); (3) *systemic competence* – needed to understand and appropriately affect the entire system and all its intra- and interdependencies (e.g., Scholz, 2011;

Kegan, 1994; Kegan & Lahey, 2009; Wiek et al., 2011; Steiner, 2011); (4) *creativity competence* – to be capable of "stepping outside" of old habits and synthesize convergent and divergent thinking in order to create something new or find a new solution to complex real-world problems such as crises (e.g., Dixon, Meier, Brown, & Custer, 2005; Epstein et al., 2008; Sipos et al., 2008; Steiner, 2011); (5) *sociocultural (collaborative) competence* – needed for collaboration between various disciplines but also to enable joint problem solving in the interplay of science and society (e.g., Sipos et al., 2008; Getha-Taylor, 2008; Wiek et al., 2011). Every single competence dimension is composed of a specific repertoire of abilities, knowledge, and skills (e.g., 'professional domain competence' comprises the abilities, knowledge, and skills needed for the specific professional domain).

When dealing with complex challenges such as crises or sustainability on a *global scale*, the integration of cultural and global requirements becomes even more crucial (e.g., Rice, 2007; Mansilla & Jackson, 2011; Reimers, 2009). The need for an extended set of competences is highlighted by the fact that crises as well as innovation (and their interplay), due to their dynamic behavior, most probably cannot be addressed without them. For example, while a single problem solver might lack the required competences to successfully deal with a problem, other members of the collaborative entity might provide those missing capabilities – hence, the collaborative entity such as a group or a network might be successful even if the individual would have failed.

Consequently, to address a complex real-world problem such as a crisis, one needs to enhance competences within a complex system by focusing on (1) the development of an individual's competences and (2) on the proper constellation of a collaborative system, since they, together, provide the overall set of competences. Importantly, one competence can usually not be substituted by another; such a substitution might lead to suboptimal solutions or failure.

Many European frameworks consider method competence as an own dimension (e.g., Faix & Laier, 1996; Kauffeld & Grote, 2000; Kauffeld et al.; CEDEFOP, 2011); within their "competence compass", Heyse & Erpenbeck (2004), consider domain and method competence ('Fach- und Methodenkompetenz') as one of 'four basic competences'. As opposed to those frameworks, the here introduced competence framework does not consider *method competence* as an own dimension. It has historically been difficult to cluster method related capabilities (particularly related to skills and knowledge) into a single competence dimension; moreover, in my view, method competence is required across all five competence dimensions (i.e., personal, professional domain, systemic, creativity, and sociocultural competence; see Figure 3).

All five competence dimensions specified in this new conceptual framework for solving real-world problems interact synergistically as one joint holistic system, which can be referred to as *problem solving competence;* problem solving competence profiles of the individual and of the collaborative entity will vary, depending on the specific requirements each real-world problem poses. In the following, each of the five competence dimensions is described in greater detail.

Personal competence

The capability to be aware of and manage oneself within the problem solving process (and within collaborations), and self-reflection as part of personality development, to comprehend mental models that underlie one's own thinking (including e.g., values and norms – see Figure 1), to think in a goal- and future-oriented manner, to be self-motivated, to act self-dependent, and to be able to apply supportive methods. Hence, personal competence enables individuals (problem solvers) to develop their own personality as a prerequisite for sociocultural (collaborative) competence. Personal competence has previously been considered by European scholars in various constellations (e.g., Heyse & Erpenbeck, 2004; Kauffeld & Grote, 2000;

Kauffeld et al., 2000; and Faix & Laier, 1996), whereas U.S. scholars have mainly considered it within their behavioral dimension related to *competencies* (as opposed to competences) (e.g., Boyatzis, 1982, 2001, 2007; McClelland, 1973, 1998).

Professional domain competence

A specific problem is always related to certain domain-specific knowledge, methods, and skills (e.g., when working on mobility innovations, domain-specific competence related to transport systems is required), which are predominantly acquired through education (including vocational training). In contrast to the other four competence dimensions, this competence dimension focuses on *specific* disciplines or domains. Other terms which have been used in place of professional domain competence are domain competence, subject competence, or – in German – "Fachkompetenz" (e.g., Heyse & Erpenbeck, 2004; Kauffeld & Grote, 2000; Kauffeld et al., 2000; and Faix & Laier, 1996). Today, developing professional domain competence still represents the core objective of most educational programs despite the growing demand for systems thinking in our globalized world.

Systemic competence

Systems thinking denotes the capability to understand core characteristics and general patterns of a complex system (i.e., its borders, the interrelatedness of its elements, its interaction with its environment, and its dynamic behavior over time, based on the peculiarities of the underlying mental models that are being employed) and the capability to choose and apply appropriate methods for modeling a current complex system and its potential future paths of development. Methods that are being used can be either qualitative, such as graphical causal-loops diagrams, or quantitative, such as stock and flow diagrams, as applied within or in conjunction with system dynamics. Furthermore, systemic competence aims to develop and analyze future scenarios in

the context of historical development. For example, systemic competence can help illuminate the transition of a socioeconomic system over time. The term *systemic* is not used synonymously with *systems thinking*, but rather as a meta-concept that includes systems thinking. Forrester (2009: 21), for example, points out that systems thinking refers to "thinking about systems, talking about the characteristics of systems, acknowledging that systems are important, discussing some of the insights from system archetypes, and relating the experiences people have with systems" yet, he also points out that "systems thinking is not more than five percent of a systems education," and he calls for participative activities such as active learning which can produce changes in mental models. Other scholars (e.g., Meadows, 2008) consider systems thinking as a comprehensive concept that may range from 'natural systems thinking' (i.e., holistic thinking without the need for sophisticated methods) to computer-based simulations. No other competence framework, thus far, has fully incorporated systemic competence, and only few have considered systems thinking, for example frameworks within the sustainability field (see overview in Wiek et al., 2011; Sipos et al., 2008). General management and human resource development do not include systems thinking as core dimensions in their frameworks. For example, the five meta-dimensions within Boyatzis' (1982, 2001) model of management are goal and action management abilities, people management abilities, analytic reasoning abilities, knowledge areas, and value themes. In their model, systems thinking is only one of eight analytic reasoning abilities.

Creativity competence

In the here proposed new competence framework, creativity is not considered an ability or personality trait, but rather a competence that can be developed and, for example, trained through creativity techniques applied in real-world settings (Steiner, 2011). Such techniques include

individual and group-specific methods for creative problem solving and team analysis, amongst others. Therefore, creativity is a competence needed to generate original outcomes (e.g., solutions for a specific problem or process related improvements) that go beyond routine problem solving and already known solutions (Steiner, 2011: 17; Epstein et al., 2008). As Simonton (2003: 320) points out, creativity must be viewed as a complex phenomenon "that occurs at multiple levels, from individuals, interpersonal interactions and problem solving groups to cultures, nations, and civilizations." Similar to systemic competence, only few competence frameworks have previously considered (or even mentioned) creativity, with few exceptions (e.g., Halbesleben, Novicevic, Harvey, & Buckley, 2003; Sipos et al., 2008).

Sociocultural (collaborative) competence

As discussed earlier, - complex problems tend to have ill-defined properties and cannot easily be solved by routine, straight-line problem solving for which one explicit solution is available and for which a system pattern relies on a well-defined algorithm. This imposes additional and new requirements on the problem solver; collaborations are a possibility to possess the competences as an entity, instead of individually acquiring these competences in a time-consuming manner. As complexity increases, the collaborative effort (e.g., inter- and transdisciplinary approaches), the interplay of logic and creative problem solving capabilities, and approaches to understanding and acting within the problem solving process also take on greater significance (Steiner, 2009: 5; regarding knowledge integration see, e.g., Scholz & Tietje, 2002; Scholz, 2011). Consequently, a *collaborative team* must include not only diverse experts, but stakeholders at various levels of the problem solving system, including decision-makers and citizens as well. Furthermore, the more innovative the solution, the greater the corresponding degree of change will be. Heightened innovativeness requires increased creativity, something

that can more readily be provided by a collaborative entity. The need for collaborative strategies which integrate various disciplines and for joint collaborative processes among various organizational and societal stakeholders is underlined by several theoretical approaches with great practical relevance such as "open innovation" and "transdisciplinary problem solving" (Scholz & Tietje, 2002; Chesbrough, 2003, 2006; Scholz, 2011), "social innovation" (e.g., Goldsmith & Eggers, 2004; Goldsmith, 2010), "open creativity" (Steiner, 2009, 2011), "society-, user-, customer- or stakeholder-driven innovation" (e.g., Tuomi, 2002; von Hippel, 2002, 2005; Vigier, 2007), and "living labs" (European Commission, 2010). However, collaboration, especially if it is interdisciplinary and if it encompasses various stakeholders and cultures, requires specific capabilities. Educational policies and educational strategies need to be designed accordingly.

Recent global crises highlight a *lack of competence for collaborative problem solving* in our highly interrelated and complex world (e.g., Gabellone, 2011; PWC & Atlantic Council, 2011). Complex real-world problems call for innovation in general, and citizen-driven innovation in particular. They increasingly depend on *collaborative effort*, which is more than just the aggregate of individual performances. The collaborative nature of most complex problem solving processes becomes obvious not only in the various communication and interaction processes among academic disciplines (i.e. interdisciplinarity), but also between academics and society respectively, between experts and various stakeholder groups (transdisciplinarity) (Scholz, 2012; Steiner, 2011; Scholz & Tietje, 2002). There is also a need to teach inter- and transdisciplinarity in higher and professional education (the latter also known as VTE, vocational training and education) as well as in the larger context of national and international innovation systems (e.g., Lundvall, 2010: 329 f.; Lundvall, Johnson, Andersen, & Dalum, 2002). Sociocultural

(collaborative) competence builds on team-, integration-, reflection-, and conflict-specific capabilities, and the willingness and capability for appreciative interaction among the involved problem solvers as the basis for any collaborative *inter- and transdisciplinary* problem solving process. In any problem solving process, it is therefore essential for individual and teams of problem solvers as well as other stakeholders to establish a joint system of objectives (Steiner, 2008, 2009). Key questions to ask are: What are the required competences in order to succeed, and how can each individual involved improve their competences to maximize their contribution?

Cultural competence is the capability to deal with various cultural settings (Hampden-Turner & Trompenaars, 2000; Dana & Allen, 2009), and represents a subcategory of *social competence* (e.g., Boyatzis, 2008, 2009; Kauffeld & Grote, 2000; Kauffeld et al., 2000; Faix & Laier, 1996). *Social competence* is the capability and willingness to communicate and collaborate with others, based on an (approximate) understanding of the preference profiles and emotional effects as well as of potential benefits and burdens for all other stakeholders. Together, the two constitute sociocultural competence. Further, *competences of a collaborative entity* (e.g., an interdisciplinary working group, transdisciplinary collaborations between science and society, a border-crossing collaboration between companies) are not just the sum of the individuals' competences. Instead, to comprehensively assess a group's competences and/or its dynamic behavior, several additional phenomena need to be considered. These include "groupthink" (according to Janis, 1982: 7 f., the desire for harmony within a group can interfere with realistic and logical reasoning), "group productivity" (according to Steiner, 1972, process losses can reduce the overall productivity of the group), "principle of non-summativity" (according to

Rathunde, 1999, the whole system is greater than the sum of its parts); and "equifinality" (according to Bertalanffy, 1998, various paths can lead to the same goal).

CONCLUDING REMARKS

The analysis of competence/competency literature and competence frameworks in particular revealed a number of differences and inconsistencies between U.S. and European scholars, imprecise use of the concepts of knowledge, abilities, skills, and qualifications in the context of competence/competency, and an under-appreciation for systemic, creativity, and sociocultural (collaborative) competences as prerequisites to innovatively deal with complex real-world challenges.

In the proposed framework, systemic, creativity, and sociocultural (collaborative) competences are considered crucial in complementing personal and professional domain competences to tackle today's complex real-world challenges. Furthermore, here, complexity is not considered simply a burden to be dealt with in the problem solving process, but rather a tremendous opportunity to create innovative solutions based on the provision of appropriate competences of the problem solvers.

Future research, from a systemic point of view, should focus on factors that influence the capability to develop comprehensive competences, beyond an individual's cognitive, emotional, and motoric capabilities. As outlined in Figure 1, such factors could be the political, legal, & institutional; sociocultural; economic & financial; technological; infrastructural & architectural; and the ecological environment. Consequently, the identification and analysis of exceptional educational and training programs, which can act as role models for future policies, is of extraordinary importance. Furthermore, the peculiarities of collaborative competences of groups,

organizations, regions, nations, and beyond should be studied. This especially includes the specification of competences required for inter- and transdisciplinary collaborations. Models of comprehensive problem-solving systems, such as provided by the *Planetary Model for Collaborative Creative Problem Solving* (Steiner, 2009, 2011), could aid in studying competences systemically. Finally, to further operationalize the here proposed five core competence dimensions – personal competence, professional domain competence, systemic competence, creativity competence, and sociocultural (collaborative) competence – they need to be measured within comprehensive subcategories of each competence, using sophisticated assessment methods. Only then will it be possible to conduct a scientifically sound evaluation of the success of future educational and training measures aimed at providing competences to deal with complex real-world issues.

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