COMPETENCIES FOR COLLABORATIVE INNOVATION: THE CASE FOR EDUCATION IN SUSTAINABLE DEVELOPMENT

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ABSTRACT

Increasing complexity at all levels of society calls for competencies that enable various stakeholders such as researchers, policy makers, managers, citizens and others to collaboratively and creatively generate innovations as paths for future development for the multifaceted real-world problems we face within families, organizations, and regions, as well as on national and meta-national levels. Usually, those complex problems cannot be solved by routine problem solving alone, but require additional nonroutine creative problem solving at the individual and collaborative level, as well. Although the necessity to innovate is widely accepted in both the academic and the practical worlds, the discussion about appropriate competencies for dealing innovatively with an increasingly complex world lacks far behind. In this paper we reflect on prevailing competence categorizations with regard to the specific competencies needed to deal with complex systems and, additionally, present the preliminary results from an empirical investigation of 450 students about their competence-related preferences.

INTRODUCTION

There seems to be a big difference between the problems we faced in the past compared with the problems we face today, and that difference is their complexity. Today's systems have more variable elements than ever before that show not only intense interaction among each other, but also with their environment, and are characterized by changing patterns of behavior in very short time intervals which implies that forecasting a single event actually becomes impossible and that changing patterns need to be considered as a set of potential paths of future development [10] [19] [22]. System patterns change increasingly faster at all levels of society and innovations occur not only on a technological level, but at various cultural and socio-economic levels, as well. As complexity increases, the collaborative effort within the problem-solving process becomes more important [21]. Furthermore, the more innovative the solution is for the complex problem, the corresponding degree of change will also be higher. The need for collaborative strategies for integrating various disciplines but also for joint collaborative processes among various stakeholders of organizations and of society becomes obvious in many theoretical approaches with practical relevance such as concepts like open innovation and transdisciplinary problem solving [3] [4] [19], social innovation [9] [8], open creativity [21] [22], society-, user-, customer-, or stakeholder-driven innovation [26] [27] [23] [25], and living labs [6]. Nevertheless, not much has been said about the specific competencies needed to accomplish these highly demanding challenges of collaborative problem solving and how educational policies, and related educational strategies, can be designed accordingly. Many previous educational strategies have been successful in providing the competencies needed to deal with routine problems, but they are not sufficient with regard to the specific requests of solving complex real-world problems. Instead, adequate educational policies and strategies are needed, based on competence concepts that address the peculiarities of complex problems. Routine problems can be solved by prescribed procedures, such as a calculation that requires the application of a certain algorithm; in other words, the present state (the routine problem) and the future state of the considered system (the solution), as well as the underlying procedure (the application of the algorithm), reveal deterministic characteristics. On the other hand, unique problems, such as the search for a

solution to a political conflict or the challenge of generating an outstanding product innovation in a specific field, cannot be solved solely by applying routine problem solving, but require additional nonroutine problem solving in conjunction with logic and objective-oriented creativity (based on an appropriate understanding of the underlying system and of the particular problem-solving process). Our objective with this paper is to reflect on the shortcomings of previous competences models with respect to their capability to solve complex problems as a basis for a more conceptual proposition of a general framework of competencies for dealing with complex problems

COMPETENCIES: DEFINITIONS AND META-FRAMWORKS

As shown in various competence concepts [12] [15] [16] [7], a meta-framework of competencies with a finite number of core-dimensions can help to make investigations more transparent, improve the orientation within comprehensive competence inventories, and build a powerful basis for the management of competencies. This can include the drafting of specific strategies for the development of a unique set of competencies. The Latin expression, *competentia*, is grounded in the verb *competere* and means "to coincide," but also "to be assigned to" or "to be due to" [14] [5]. The acquisition of competencies is different from the acquisition of knowledge, abilities, and skills. Generally speaking, knowledge can either be declarative or procedural and might be presented in explicit or tacit forms; abilities are related to the talent of an individual and present more stabile characteristics. Domain-specific, as well as domain-general skills, are the expertise gained by repeated exercises within cognitive or motoric processes. Whereas knowledge itself is not necessarily related to real-world action, the capability to apply this knowledge in diverse settings in an adaptive way is a core-characteristic of competencies. Competence can be a useful term, bridging the gap between educational and vocational requirements. Different than qualifications, competencies are more analogous to self-organized acting; In contrast, qualifications are independent of applied action and, instead, reflect current standardized skills and abilities [5]. Another definition, by UNIDO [24], considers competencies as "[..] 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."

Westera defines competence as „[...] the ability to produce successful behaviors in non-standardized situations […] [28]." Similarly, Erpenbeck & von Rosenstiel [5] define competencies as manifestations of self-organized acting; competence becomes a form of appreciation of an intellectually self-organized agent based on the judgment of an observer. Hence, self-organization is related to actions that cannot be predicted at all (or only marginally), because of the complexity of the whole problem-solving system that depends on the agent(s), the current situation, and the underlying problem-solving process. With regard to corresponding concepts, Westera further stresses „[…] the need for a concept of competence that surpasses the levels of knowledge, skills and attitudes originates from the observation that something „extra" seems to be necessary to ensure effective and efficient performance" [28]. Simultaneously, he refers to the difficulty to draw a border between competencies, skills, and abilities.

According to Howell [13], the development of competencies can be considered a four-stage learning process starting with a stage of unconscious incompetence, followed by a stage of conscious incompetence (as a starting point for the acquisition of certain competencies), which leads to a stage of conscious competence that leads to unconscious competence as the highest level of development. There are conflicting details about the origin of this learning model (as stated by Adam [1], the model might either be referred to Howell [13] or to Gordon Training International; the question of the origin of this model is discussed in detail in Chapman [2]). To put it together, competencies consist of the agent's knowledge, skills, and abilities that are applied in a real-world setting and depend, themselves, on self-directed rules, attitudes, values, and norms. Hence, competencies allow for the development of target-specific behaviors suitable for dealing with complex, non-standardized problems.

CHARACTERIZATION OF COMPETENCE CONCEPTS

Most common classification schemes usually consist of three or four dimensions. Typically, a three-dimensional scheme is composed of professional, methodological, and social competencies [7], and a four-dimensional scheme may have personal competence as a fourth category [12] [15] [16]. Another example of an applied three-dimensional concept is the UNIDO competence typology that consists of managerial, generic, and technical/functional competencies [24]. For characterizing the different concepts, the following criteria were used: (i) author or source of origin; (ii) a distinction between general competence inventories versus domain specifity; (iii) the year of origin; (iv) the number of core-dimensions; (v) the number of further items (if available); and (vi) the specification of core-items. Specific shortcomings in the previous competence discussion are outlined below. Summarized, the main *shortcomings* of competence concepts and inventories, with respect to the requirements of complex problem solving, are confusing agglomeration of competence components with *missing classification according core-dimensions;* i*ncreased complexity* of real-world problems is not adequately taken into account; *imprecise, and/or improper, use* of the concepts of knowledge, abilities, skills, qualifications, and competencies; intense focus on *single domains of application* rather than connecting them to general competence frameworks and, therefore, making meta-disciplinary investigations impossible; *lack of differentiation between general and domain-specific competencies*; *incomplete, or one-sided, categories*; *overlapping categories* such as in the case of "methodological competencies,"; missing *process and systemic orientation*; and missing peculiarities with regard to *competencies for collaboration*.

A PROPOSED CONCEPTUAL MODEL

Complex problem solving processes in real-world settings, such as the fact that innovation increasingly depends on collaborative effort, which is more than just the agglomeration of individual performances. Hence, the question of how to deal with competencies within a complex system needs to focus

- primarily on the peculiarities of the collaborative system and
- secondarily on the development of the competencies of individuals in question of the improvement of the capabilities of the whole system.

Within this conceptual framework it is stated that complex problem solving, such as the generation of innovation or innovation-based entrepreneurial processes requires the dynamic interplay of process, system, personal, social c, and domain-specific competences. It needs to be stressed that one competence usually cannot be substituted with one of the others; substitution might only be a marginally successful strategy. Therefore, the development of successful action-competence depends on the synergetic consideration of all four dimensions cited. This categorization differs from other classification schemes on competencies since it stresses the necessity of having process- and system competencies as a kind of meta-competence within every complex problem-solving process as its own competence category. Furthermore, this classification is distinguished from others since it has two more types of meta-competencies that are: 1) Personal competence (as individual reflection capability), and 2) Social competence (as a prerequisite to collaborate within groups or networks). Different than most other categorizations as there is no single category about methodological competencies, since it is argued that these cannot be separated as a single class, but instead methodological competencies are needed for process, system, personal, and social competences, as well.

The four competence dimensions should be considered as an interactive holistic system that depends on the problem-related requirements that characterize the competence profile of the collaborative entity:

1. *Process- and system-competence:* To be an „expert in the process" and in the „analysis and design of systems" (holistic system thinking) is a meta-competence that does not depend on specific contents, but is a prerequisite for understanding complex processes and systems. Hence, the design

of problem-solving processes and the decision about the choice of methods to be applied is crucial (e.g. project management, creative techniques, problem analysis, and scenario methods);

2. *Personal competence:* Collaborative, creative, problem-solving processes require that the involved individuals are capable to reflect on themselves and their value systems and to act in a self-responsible, goal- and future-oriented manner. Hence, personal competence enables the development of their own personality and is a prerequisite for social competence;
3. *Social competence:* The collaborative nature of most complex problem-solving processes becomes obvious not only in the various communication and interaction processes among disciplines, but also between organizations and stakeholder groups [22]. Here, team-, integration-, reflection-, and conflict-specific abilities are required (similar to Heyse & Erpenbeck [12]) in order to enable appreciative collaborative processes, like those involved with collaborative creative problem solving. Therefore, the establishment of a joint system of objectives is essential; \
4. *Domain-specific competence:* The initial problem is related to certain domain-specific knowledge, skills, and methods (e.g. the domain of transport systems when working on mobility innovations).

Rather than competence concepts, we do not assign creativity its own competence category, since it cannot be understood as a separate category because it requires the interplay of domain-specific, process, system, social, and personal competences.

THE CASE FOR EDUCATION IN SUSTAINABLE DEVELOPMENT

After making a case for a conceptual competence model as the basis for collaboratively dealing with complex real-world challenges, we further focus on the case for education in sustainable development as a specific example of application. First, we briefly describe some core characteristics for education in sustainable development; secondly, we outline some preliminary results from an empirical investigation of students' assessment of competencies needed for acting in a sustainable manner. Previous crises not only concerned economic, but also social and ecological issues as well. This inevitably leads to the concept of sustainable development as potential counteraction. At its core, sustainable development can be understood as development that "[…] meets the needs of the present without compromising the ability of future generations to meet their own needs." [29]. Furthermore, it is currently understood that this type of development encompasses economic prosperity, social equality, and ecological quality simultaneously, also known as the triple bottom line concept [11]. Sustainable development is neither stable, nor does it merely entail passively responding to changes in the environment. Instead, it has to be stressed that sustainable development is, itself, dynamic (with pattern change as a core characteristic). Achieving sustainable development involves a great dynamic in itself. It is by no means a fixed objective, and has, therefore, been considered a ”form of ongoing enquiry” [17]. The system peculiarities of sustainable development are characteristic of any complex system due to the high number of elements constituting the system, the high degree of interdependency among these elements and their interaction with the environment in a dynamically changing system pattern over time.

As previously stated, we propose that dealing with complex systems, like sustainable development, calls for process, system, personal, social, and domain-specific competences. In the spring of 2011, we conducted an empirical survey at The University of Graz in Austria to gain insight into the students' assessment of the importance of competences for dealing with sustainable development. This was the first stage of a multilevel investigation that is still in process and that encompasses the consideration of stakeholders at various levels of the education system. Based on a random sampling procedure, 271 undergraduates, 168 graduate students, and seven Doctoral candidates filled out questionnaires handed out at the beginning of various participating courses. The total sample represented 446 participants.

The competence-related questions included nine items altogether. Process-, and system-, competence was represented by items Q1: Understanding system interdependencies, Q2: Process design, and Q9: Divergent thinking. Personal competence was represented by items Q3: Reflective and self-reliant acting and Q6: Critical thinking and responsible acting; social competence was represented by items Q4: Domain-specific knowledge and methods and Q5: Interdisciplinary knowledge and methods Domain-specific competence was represented by Q7: Interdisciplinary collaboration and Q8: Transdisciplinary collaboration. A factor analysis (principal components analysis) was performed on the nine competence-related items of the questionnaire. Based on the high mean score of each item and their strong correlation all nine items were subsumed to single-factor "competences." Only the item Q6: Critical thinking and responsible acting showed a comparably higher mean score of 8.32 (SD=2.218). This is particularly interesting with respect to future societal challenges like those related to crises, since critical thinking and responsible action might become most critical for a society that not only tries to react to a crisis, but also proactively takes precautionary measures to avoid said crisis.

CONCLUDING REMARKS

In this paper we state that creativity and collaboration are core ingredients for being able to handle the complexity of today's real-world challenges. Furthermore, complexity is not so much a burden to be dealt with in the problem-solving process, but one that provides a broad range of opportunities to create innovative solutions. The analyses of the competence models and concepts showed a specific need for a broadened set of competences that includes process- and system-competence. Interestingly, the four competence dimensions were considered equally important for students. For further research, it will be necessary to extend the survey to additional relevant stakeholder groups such as industry, public companies, and nonprofit organizations.

REFERENCES

[1] Adams, L. 2010. *Learning a new skll is easier said than done*. Gordon Training International. URL: http://www.gordontraining.com/Learning_a_New_Skill_is_Easier_Said_Than_Done.html (20.7.2010).

[2] Chapman, A. 2010. *Conscious competence learning model.* Businessballs. URL: http://www.businessballs.com/consciouscompetencelearningmodel.htm (20.7.2010).

[3] Chesbrough, H.W. 2003. The era of open innovation. *MIT Sloan Management Review*, 44/3: 35-41.

[4] Chesbrough, H.W. 2006. *Open innovation: The new imperative for creating and profiting from technology.* Boston: Harvard Business School Press.

[5] Erpenbeck, J. & von Rosenstiel, L. (eds.) 2007. *Handbuch Kompetenzmessung. Erkennen, verstehen und bewerten von Kompetenzen in der betrieblichen und psychologischen Praxis.* 2., überarb. und erw. Aufl. Stuttgart: Schäffer-Poeschel Verlag.

[6] European Commission 2010. *Living labs for user-driven open innovation.* URL: http://ec.europa.eu/information_society/activities/livinglabs/index_en.htm (27.12.2010).

[7] Faix, W.G. & Laier, A. 1996: Soziale Kompetenz: Wettbewerbsfaktor der Zukunft. Wiesbaden: Gabler.

[8] Goldsmith, S. & Eggers, B. 2004. *Governing by network: The new shape of the public sector.* Washington, D.C.: Brookings Institution Press.

[9] Goldsmith, S. 2010. *The power of social innovation. How civic entrepreneurs ignite community networks for good.* San Francisco: Jossey-Bass.

[10] Gomez, P. & Probst, G.J.B. 1999. *Die Praxis des ganzheitlichen Problemlösens. Vernetzt denken, unternehmerisch handeln, persönlich überzeugen.* 3. Aufl. Bern, Stuttgart/Wien: Haupt.

[11] Hasna, A. M. (2007). Dimensions of sustainability. *Journal of Engineering for Sustainable Development: Energy, Environment, and Health*, 2/1: 47–57.
[12] Heyse, V. & Erpenbeck, J. 2004. *Kompetenztraining: 64 Informations- und Trainingsprogramme.* Stuttgart: Schäffer-Poeschel.
[13] Howell, W.C. 1982. An overview of models, methods, and problems. In: Howell, W.C./Fleishman, E.A. (eds.): *Human performance and productivity. Information processing and decision making.* Bd. 2: 1-30. Hillsdale, NJ: Erlbaum.
[14] Huber, H.D. 2001. Interkontextualität und künstlerische Kompetenz. Plamen Dejanow und Swetlana Heger. In: Bühler, M./Koch, A. (eds.): *Kunst und Interkontextualität. Materialien zum Symposium schau-vogel-schau*: 29-47. Köln: Salon Verlag.
[15] Kauffeld, S. & Grote, S. 2000. Kompetenzdiagnose mit dem Kasseler-Kompetenz-Raster. *Personalführung*, 1: 30-37.
[16] Kauffeld, S./Grote, S./Frieling, E. 2000. Diagnose der beruflichen Handlungskompetenz bei der Bewältigung von Optimierungsaufgaben in Gruppen. *Zeitschrift für Arbeitswissenschaft*, 2: 211-219.
[17] Laws, D./Scholz, R./Shiroyama, H./Susskind, L./Suzuki, T./Weber, O. 2002. *Expert Views on Sustainability and Technology Implementation.* Working Paper 30. Zurich: ETH-UNS.
[18] Pink, D.H. 2005. *A whole new mind: Moving from the information age to the conceptual age.* New York: Riverhead Books.
[19] Scholz, R./Tietje, O. 2002. *Embedded case study methods: Integrating quantitative and qualitative knowledge.* Thousand Oaks/London/New Delhi: Sage Publications.
[20] Simonton, D.K. 2003. Creative cultures, nations, and civilizations: Strategies and results. In Paulus, P.B. & Nijstad, B.A. (eds.), *Group creativity: Innovation through collaboration.* Oxford: Oxford University Press.
[21] Steiner, G. 2009. The concept of open creativity: Collaborative creative problem solving for innovation generation - a systems approach. *Journal of Business and Management*, 15/1: 5-34.
[22] Steiner, G. 2011. *Das Planetenmodell der kollaborativen Kreativität. Systemisch-kreatives Problemlösen für komplexe Herausforderungen.* Wiesbaden: Gabler Research.
[23] Tuomi, I. 2002. *Networks of innovation: Change and meaning in the age of the internet.* Oxford: Oxford University Press
[24] UNIDO 2002. *UNIDO Competences.* Part 1. Vienna: United Nations Industrial Development Organization, Human Resource Management Branch.
[25] Vigier, P. 2007. Towards a citizen-driven innovation system in Europe: A governance approach for a European innovation agenda. *Innovation: The European Journal of Social Science Research*, 20/3: 191 – 202.
[26] von Hippel, E. 2002. *Horizontal innovation networks - by and for users.* MIT Sloan School of Management Working Paper No. 4366-02.
[27] von Hippel, E. 2005. *Democratizing innovation.* Cambridge, Massachusetts: The MIT Press.
[28] Westera, W. 2001. Competencies in education: A confusion of tongues. *Journal of Curriculum Studies*, 33: 75-88.
[29] World Commission on Environment and Development. 1987. *Report of the World Commission on Environment and Development: Our Common Future.* Annex to document A/42/427 - Development and International Co-operation: Environment. http://www.un-documents.net/wced-ocf.htm. Retrieved: Oct. 1, 2011.