Towards a Paradigm Shift in Education Practice: Developing Twenty-First Century Skills with Design Thinking

Christine Noweski, Andrea Scheer, Nadja Büttner, Julia von Thienen, Johannes Erdmann, and Christoph Meinel

1 What Is the Intention of This Article?

Science, business and social organizations alike describe a strong need for a set of skills and competencies, often referred to as twenty-first century skills and competencies (e.g. Pink, Wagner, Gardner). For many young people, schools are the only place where such competencies and skills can be learned. Therefore, educational systems are coming more and more under pressure to provide students with the social values and attitudes as well as with the constructive experiences they need, to benefit from the opportunities and contribute actively to the new spaces of social life and work. Contrary to this demand, the American as well as the German school system has a strong focus on cognitive skills, acknowledging the new need, but not supporting it in practice. Why is this so? True, we are talking about a complex challenge, but when one makes the effort to take a closer look, it quickly becomes apparent that most states have not even bothered to properly identify and conceptualize the set of skills and competencies they require. Neither have they incorporated them into their educational standards.

No wonder, teachers stand helpless in the face of new challenges and have – more or less – only their personal experience and good will to fall back on. An approach which is naturally not successful on a broad scale.

Developments in society and economy require that educational systems equip young people with new skills and competencies, which allow them to benefit from the emerging new forms of socialization and to contribute actively to economic development under a system where the main asset is knowledge (Ananiadou and Claro 2009, p. 5).

C. Noweski • A. Scheer • N. Büttner • J. von Thienen • J. Erdmann
Hasso-Plattner-Institute, Potsdam, Germany

C. Meinel (✉)
Hasso-Plattner-Institut (HPI), für Softwaresystemtechnik GmbH, Prof.-Dr.-Helmert-Str. 2-3, Potsdam 14482, Germany
e-mail: meinel@hpi.uni-potsdam.de

H. Plattner et al. (eds.), *Design Thinking Research*, Understanding Innovation,
DOI 10.1007/978-3-642-31991-4_5,

The research team e.valuate has worked on this challenge for 1 year now and wants to share some of its findings.

We will start by introducing skills and competencies behind the term twenty-first century skills, as well as the concept of constructivist teaching and learning – a methodology most promising to cope with the new demands. We will then explain, why Design Thinking, understood as constructivist methodology, is especially appropriate to enable teachers to prepare our students to cope with the challenges of the twenty-first century. In the fourth part, we will introduce an empirical study undertaken to prove the hypotheses derived from part three.

2 What Are Twenty-First Century Skills and Why Is Everybody Talking About Them?

Initiatives on the teaching and assessment of twenty-first century skills originate in the widely-held belief shared by several interest groups – teachers, educationalists, policy makers, politicians and employers – that the current century will demand a very different set of skills and competencies from people in order for them to cope with the challenges of life as citizens, at work and in their leisure time (e.g. Pink 2006; Wagner 2010; Gardner 2007). Initiatives such as the Partnership for twenty-first century skills and the Cisco/Intel/Microsoft assessment and teaching of twenty-first century skills project also point to the importance currently attached to this area not only by researchers, practitioners and policy makers but also the private sector. Supporters and advocates of the twenty-first century skills movement argue for the need for reforms in schools and education to respond to the social and economic needs of students and societies in the twenty-first century. Most of them are related to knowledge management, which includes processes related to information selection, acquisition, integration, analysis and sharing in socially networked environments.

Before presenting which skills and competencies are broadly understood in this context, we would like to define the terms “skills” and “competence” and make clear, how they relate to each other.[1]

[1] One useful distinction between the two is provided by the OECD’s DeSeCo project: A competence is more than just knowledge or skills. It involves the ability to meet complex demands, by drawing on and mobilizing psychosocial resources (including skills and attitudes) in a particular context. For example, the ability to communicate effectively is a competence that may draw on an individual’s knowledge of language, practical IT skills and attitudes towards those with whom he or she is communicating (Rychen and Salganik 2003). The European Commission’s Cedefop glossary defines the two terms as follows: A skill is the ability to perform tasks and solve problems, while a competence is the ability to apply learning outcomes adequately in a defined context (education, work, personal or professional development). A competence is not limited to cognitive elements (involving the use of theory, concepts or tacit knowledge); it also encompasses functional aspects (involving technical skills) as well as interpersonal attributes (e.g. social or organizational skills) and ethical values (Cedefop 2008).

A competence is thereby a broader concept that may actually comprise skills (as well as attitudes, knowledge, etc.). However, the terms are sometimes used interchangeably or with slightly different definitions in different countries and languages. This should always be kept in mind.

Based on the above, we will stick to the OECD working definition of twenty-first century skills and competencies: *Those skills and competencies young people will be required to have in order to be effective workers and citizens in the knowledge society of the twenty-first century.*[2]

A multitude of authors have laid down their concepts of twenty-first century skills. Giving a broad view of society, we want to present three. Researcher, author and internationally acclaimed speaker Tony Wagner (former teacher and principal) calls twenty-first century skills the *seven survival skills for careers, college and citizenship* (Wagner 2011) and distinguishes in his book *The global achievement gap*:

- Critical thinking and problem solving
- Collaboration across networks and leading by influence
- Agility and adaptability
- Initiative and entrepreneurialism
- Effective oral and written communication
- Accessing and analyzing information
- Curiosity and imagination.

Successful author and connoisseur of American politics Daniel Pink describes in his book *A Whole New Mind* six essential aptitudes: *on which professional success and personal fulfillment nowadays depend.* He distinguishes:

- Design: to detect patterns and opportunities
- Story: to create artistic and emotional beauty and to craft a satisfying narrative
- Synthesis: to combine seemingly unrelated ideas into something new
- Empathy: ability to empathize with others and to understand the subtleties of human interaction
- Meaning: to find joy in one's self and to elicit it in others and to stretch beyond the quotidian in the pursuit of purpose and meaning.

Harvard professor Howard Gardner builds on decades of cognitive research and rich examples from history, politics, business, science, and the arts when he describes: *the specific cognitive abilities that will be sought and cultivated by leaders in the years ahead* in his book *Five Minds for the Future*. The five Minds are:

- The Disciplinary Mind: the mastery of major schools of thought, including science, mathematics, and history, and of at least one professional craft.
- The Synthesizing Mind: the ability to integrate ideas from different disciplines or spheres into a coherent whole and to communicate that integration to others.

[2] Ananiadou and Claro (2009).

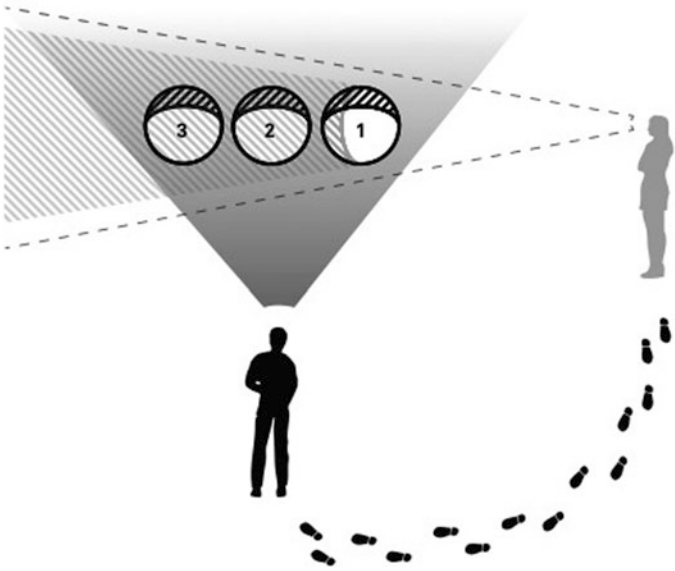

Fig. 1 Changing perspective (By Christine Noweski and Elias Barrasch 2011)

- The Creating Mind: the capacity to uncover and clarify new problems, questions and phenomena.
- The Respectful Mind: awareness of and appreciation for differences among human beings and human groups.
- The Ethical Mind: fulfillment of one's responsibilities as a worker and as a citizen.

We decided to offer these lists here to give you, our dear reader, a look at the broadness of the discussion. According to context, audience and goal, the descriptions vary a lot, but center around the same basic concepts.

After analyzing and comparing many more approaches, we decided to work with the rather abstract psychological three-tier categorization of competences offered by Himmelmann (2005). He classifies key competences into:

- Cognitive abilities (Fig. 1:1)
- Affective, moral attitudes (Fig. 1:2)
- Practical, instrumental skills (Fig. 1:3).

Figure 1 shows how dangerous it becomes when one is focusing too much on only one, as is today the case with cognitive abilities. It may overshadow the other competencies completely. What is happening in schools right now (and this includes both the very different American and German school systems) is a strong emphasis on measuring and comparing cognitive abilities. This is supported by multiple guidelines for teachers, as well as students, on how to find one's way through this system.

The goal of the years to come has to be to find a way back to a perspective, where teachers envision all three categories to lay down the base for twenty-first century skilled students. It's a challenge to confront the personal desire to do things the way one has always done: it feels so safe and good, why should one put this at risk? To reach out into the unknown is uncomfortable for most people, so why should teachers feel any differently about this? The few who still seek to try the shift, are often hindered by bureaucratic structures and hierarchies that are built on old principles. More on this in chapter "The Faith-Factor in Design Thinking: Creative Confidence Through d.school Education?", when we will describe the ideal role of a teacher in constructivism and how it differs from reality.

3 Opportunity Constructivism: What? Why? and How?

In this chapter, we will introduce the theory of constructivism and its implications on learning and teaching, in order to gain an overall understanding before describing in more detail the problem solving approach of Dewey and the Project Method Kilpatrick that can be seen as a still used predecessor of Design Thinking. We will then describe Design Thinking as a teaching and learning methodology while focusing on its potential to mediate twenty-first century skills.

There are three main philosophical frameworks under which learning theories fall (see Fig. 2): behaviorism, cognitivism, and constructivism. Behaviorism focuses on objectively observable aspects of learning. Cognitive theories look beyond behavior to explain brain-based learning. Both can be considered as approaches of realism (more on realism see e.g. Miller 2010 and Zalta 2010).

Learning can also be understood from a constructivist perspective, in which *learning is a process of understanding, which leads to modifications in the behavior of the learner due to experiences*,[3] a process of individually self-organizing knowledge. Learning theories from Jean Piaget, Jerome Bruner, Lev Vygotsky and John Dewey serve as a basis for constructivist learning theory. Several authors need to be mentioned because constructivist theory is a broad approach towards learning. Shared convictions are that the process of learning is unpredictable and knowledge constantly altered through new insights, which are gained through individual experiences (Reich 2008; Kolb 1984). In realism the learner is regarded as an independent observer of objects. In contrast, constructivism integrates the learner within his own observations in a cycle of creation and observation. An interactive relation between the observer and the observed arises (for an easier understanding see Fig. 3).

The educationalist and philosopher John Dewey regarded the interaction between the subject and the world as essential for gaining knowledge. Dewey's understanding identified learning as a direct process of the structured interaction of

[3] Hasselhorn and Gold (2006, p. 35).

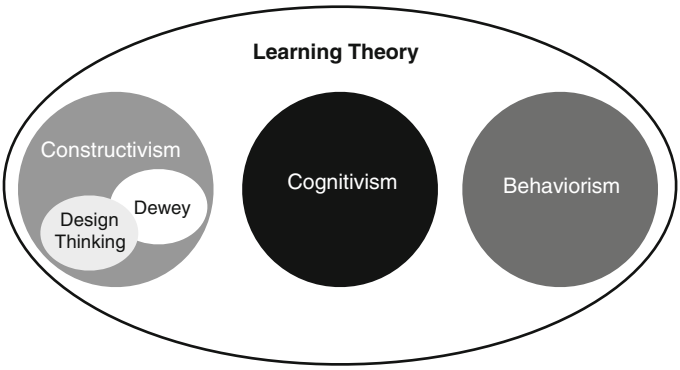

Fig. 2 Philosophical frameworks of learning theory (By Christine Noweski 2011)

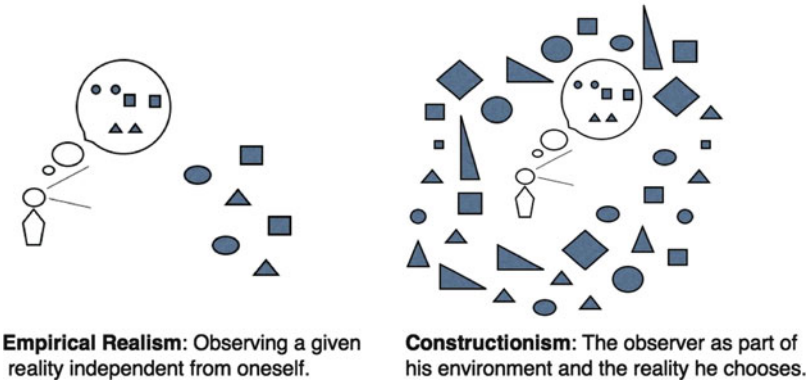

Fig. 3 The learner and his environment (By Andrea Scheer 2011)

humans and their natural and social environment. These interactions produce experiences which modify further interaction – then, learning takes place (see Hasselhorn and Gold in the beginning of this chapter).

There is no me without us.[4] Perception and knowledge is only developed in relation to and through interaction with the object and its context. Therefore, learning in the constructivist perspective is a process of constantly adapting to situations, which consist of ever-changing relations between subject, object and context. Navigating through this process and identifying relations creates knowledge. However, constructivism is neither a method nor a universal model, but it defines the perspectives on learning and knowledge.

[4] Dewey (1931, p. 91).

Education today is focused on breaking down complex phenomena into abstract parts (e.g. subjects, different topics within subjects). Aspects of knowledge are considered in their singularity, and distributed inductively[5] to the student. It is easier to only look at the parts and pieces of a clock than figuring out its complex correlations. Still, the clock only makes sense as whole, and the pieces need to be properly reassembled into the complexity of relations between its components. The process of reassembling pieces of knowledge into the complex phenomena is seldom realized in schools today. This makes it hard for student to see links between the subjects and topics to be learned in school and the real-life context. It is hard for the teacher to realize complex deductive[6] learning, as learning methods and theories are still very abstract. But, how do we make complex phenomena understandable without breaking them down into too many abstract parts?

3.1 What a Constructivist Learning Design and Teaching Should Look Like

Pedagogical science states that the competences claimed in chapter "Design Thinking Research" can be taught especially well through a deductive method from the perspective of constructivist learning (Weinert 2003; Knoll 1991; Reich 2008). Constructivism as described above looks at complex phenomena as a whole within its context and from the perspective of the observer.

Dewey stated the following three aspects as essential for a convenient learning design:

- Involvement of students
- Available space for experiencing
- Deductive instruction and
- Possibilities for construction.

Here, the teacher acts as a mediator between the different entities, and defines how the students go through their individual process of understanding. The teacher has a manipulative function laying down the framework for subject, object and context. The teacher as a facilitator of learning should consequently be able to design learning experiences. As participation and engagement of the students are crucial characteristics of constructivist learning (Reich 2008), the teacher should involve students in the learning design, e.g. by looking at students' interests when developing a problem statement or project challenge. Furthermore, teachers need to give space to the students to try out different mental models and methods. The

[5] Inductive as defined by the Oxford Dictionary: "inference of general laws from particular instances".

[6] Deductive as defined by the Oxford Dictionary: "inference of particular instances from a general law."

students would then have the opportunity to connect abstract knowledge with concrete applications and thereby be able to convert and apply abstract and general principles (instructions) in meaningful and responsible actions in life (construction). In a nutshell, a good lesson design needs to be a balanced composition of instruction and construction, or as Dewey would say construction through instruction (Dewey 1931; Knoll 1991). It should consist of a plan of how students can experience certain situations and how teachers can enable and support this experience. A good learning design is what schools have usually failed to provide up until today. The HOW, e.g. the instruction to execute constructivist learning, is either missing (free construction only) or too inductive (instructed construction only). It is an art to find the right balance between giving a frame through instruction and offering freedom for construction through paths within this frame – it is the art of teaching.

Teacher education should meet these implications by preparing the teacher not only in subject content, but also in meta-competencies like facilitation and design of learning experiences.

3.2 Abstract Concept: Project-Method Based on John Dewey

Dewey addressed the question of teaching complex phenomena as a whole by proposing recommendations for constructivist problem-solving, which was later transformed into the Project-Method by his student William Heard Kilpatrick in 1918. Dewey's approach was related to the natural sciences in that it started with an inquiry unfolding a problem or difficulty, which was then the motivation for further analyses and exploration. New insights are the basis for an explanation of that inquiry, and followed by a plan of action to solve the problem. Dewey recommended considering the following aspects:

- Problems situated in a real-life context
- Interaction of thinking and action
- Interaction and sharing of knowledge between learner and teacher
- Problem-solving and interpretation of insights
- Reflecting and understanding through application of ideas.

In conclusion, Dewey's perspective on learning and education is centered around a real-life inquiry, which has to be analyzed as a complex whole (deductive). The inquiry acts like *a magnet for further analysis of content and input of several disciplines in order to explain and solve that complex inquiry as a whole*.[7]

Dewey's recommendations have been around for more than a century, and although there is a common wish for their implementation, they are seldom practiced in schools. We believe this is because his theory is too abstract, and therefore hard for teachers to practically implement in the classroom. That is why

[7] Dewey (1931, p. 87).

we compared the realization of Deweys recommendations and its adaption in the Project-Method by Kilpatrick with the Design Thinking method.

We believe that Design Thinking builds on Dewey's argument of complex inquiry-based learning, and that it gives concrete recommendations for distributing a complex phenomenon without breaking it down and diluting the relations between subject, object and context, at the same time being digestible for the student and implementable for the teacher.

3.3 Concrete Framework: Design Thinking

In this paragraph, we will describe our understanding of the concept, and the methods employed in Design Thinking. As there is nothing such as an agreed theory in this field, we stick to our experience, observations and insights from expert interviews.

Design Thinking conveys a thinking and working style of its own uniqueness, while employing existing methods and theoretical concepts. The concept offers a frame to work on solving complex challenges, which Rittel (1973) described as *wicked problems* (1973). It also provides a pathway for innovations by creating and iterating inventions. Due to its innovation stimulating character, it has gained increasing attention and relevance over the last decades, especially in recent business practice (Amabile 2008; Runco 2004).

Building on the theoretical concepts of Dewey, Peirce and others, Design Thinking reproduces knowledge through action with the goal of changing existing situations into preferred ones. These challenges are tackled in interdisciplinary teams with a clear focus. The teams should ideally work together in a flexible working environment and in creative freedom, while at the same time being guided systematically through an iterative process. A coach mentors the team with methodological experience. There should be an emotional distance between the team member and coach, while at the same time sufficient closeness to always know when intervention is needed.

Throughout this process, all actions are aligned to a certain target, mostly the user for whom the project is designed. All of this together distinguishes the design thinking approach from usual business or technology driven concepts (see Fig. 4). Nonetheless, design thinking methodology acknowledges both of these concepts and tries to integrate these perspectives. It does this by transferring trends from science and practice, not forgetting that a holistic and fruitful innovation catalyzes human needs, technological feasibility and economic viability (Brown 2008).

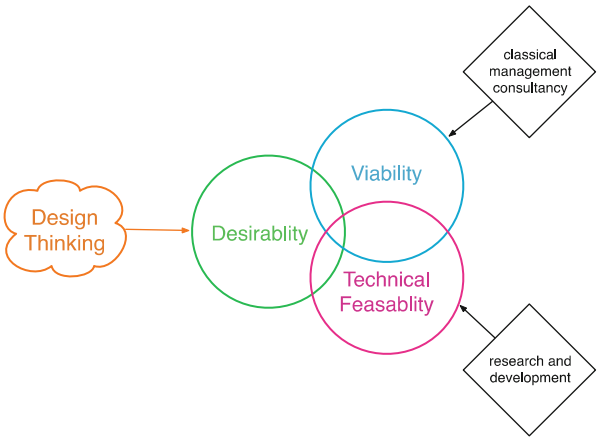

Fig. 4 Design Thinking approach (Based on Tim Brown 2006)

3.4 Excursus: Why Twenty-First Century Societies Need Innovation and Future Innovators Need Twenty-First Century Skills

With everyday complexity increasing, political concerns more intertwining, technologies changing faster, product cycles getting shorter and economic competition tightening, innovative capacities have become crucial to survive in a changing society and work life as a state, a company, and an individual (for further reading, see Freeman and Soete 1997). Without innovation there is no progress and without creative, skilled people who can meet these future demands there is no innovation. That's why future innovators, as social as well as a professional people, need to be equipped with twenty-first century skills (Carroll et al. 2010).

An innovation, in contrast to an invention, is not merely the addition of something new or the creation of an idea but a newness that provokes and instigates a economic, social and technical change through its realization and application. This is exemplified in the transformation from sketch into implementation (Fagerberg 2003; Schumpeter 1961). Though Design Thinking not (yet) solely regards the implementation part itself, it contributes to the innovation progress through its conceptual setting and by employing people with an innovative thinking and acting style. On the one hand, inventions are created by deploying an elaborate process with a user-centered approach and by merging people and knowledge from different expertise fields and disciplinary perspectives, knowing that most surprising innovations are often combinations and transformations from other already existing areas. On the other hand, Design Thinking encourages and develops a certain mindset in which we believe can accomplish the demand of the twenty-first century. A design thinker, for example, goes out into the field, holds dialogues with different stakeholders, observes (perhaps using cases and needs that are expressed indirectly) and immerses him or herself into another person's world. In this way, design thinkers also use all their analytical as well as their creative senses and abilities.

In the 1980s Drucker (1985, p. 72) described successful innovators as being *conceptual and perceptual* and using *both the right and left sides of their brains*. This is an individual who has expert knowledge in a special field and an inventive talent, a person who is conscious and assiduous, devoted and engaged, untiring and driven by learning from failures. Interestingly, these innovative qualities perfectly capture the personality and mindset of a design thinker. They are applied throughout Design Thinking, as we were able to prove in the empirical survey described in the next chapter.

3.5 How Does Design Thinking Work?

In this passage, we will briefly describe the above-mentioned systematic. The method of Design Thinking merges successful models from psychology, economics and pedagogy. Designers have intuitively applied them over a long period of time and, since the 1960s, reflectively and systematically put them together into an educational concept that also allows novices to work with a process that provides them with orientation and stability. Every step in the process thereby mirrors a particular attitude of the designerly way of thinking. Moreover, design thinkers are provided with experience about difficulties and obstacles of team dynamics in the corresponding phase.

3.5.1 Board the Journey

In literature and practice, various process models exist, with process phases differing and their naming varying. Leaning on Erdmann's circular model (see Fig. 5), we comprehend the design thinking process featuring the phases Understand, Observe, Synthesis, Ideate, Prototype and TEST.

Basically, the process follows these six steps that build on each other while preserving a cyclical and iterative nature. The star's outer lines and imagined arrows illustrate that it is possible and desired to move from one phase to any other at any point of time, as well as to repeat the whole process or just certain stages. In conclusion, there are multiple itemizations of each phase that derive from free iterations of itself.

In each phase, the most important results are the insights about users or ideas deriving from these that have the goal of solving inconveniences. These are then cumulated and documented in the star's inner centre. Thanks to the iterative approach, they can be looked up and modified again at any time in the ongoing process. This is very useful to integrate crucial insights into earlier findings and to generate new insights out of earlier ones. Each step in the process is limited in time and interim presentations of the status quo are utilized as demanding landmarks along the process.

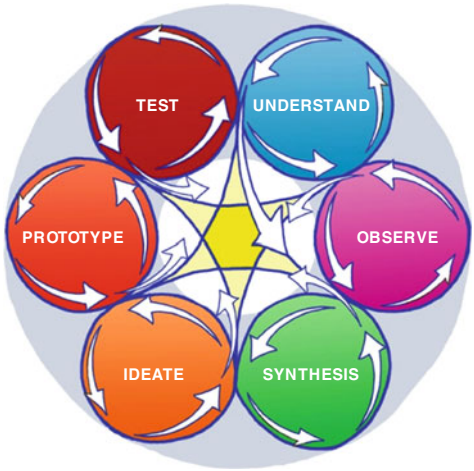

Fig. 5 Design Thinking process (After Johannes Erdmann 2010)

3.5.2 Where to Start

In the first step of the process "Understand" the initial task means to discuss in a team and work on a shared understanding of the challenge regarding its context, and dependencies. Successful design thinking teams often spend most of their project time exploring and understanding. First come the challenge and the user, later the possible solution spaces. Only by spending lots of time in this early phase, can a user-focused solution be ensured later on.

Furthermore, an agreed-on challenge helps the individuals to grow together as a team and make sure, everybody's knowledge, perspectives and skills can be utilized in the process. For more information, see the excellent article by Paulus (2000).

3.5.3 Be an Explorer

The aim of the next phase "Observe" is to get a 360°-overview about possible solution spaces. Besides interviews and observations it is often helpful for one to conduct the activities of the user him or herself, meaning to step into the role of the user and thereby to build up a special sense of empathy. For more information on methods in particular phases, we recommend checking out IDEO (2011).

In this phase, the team should take the time to look at as many different contexts as possible, because it often shows that interesting solutions in one particular challenge already exist in other contexts and can be successfully transferred.

3.5.4 Enter the Molten Bath

Experiences from the observe phase are exchanged in the "Synthesis" stage, where the most fruitful insights are compiled and distilled, eventually reframing the initial

questions according to the findings. This is the first *moment of truth* where the team that enjoyed diverging over a broad mass of information, exploration and solution spaces has to now converge to a point of view that has the power to give them the necessary drive for the next diverging session (necessary energy for the next loop in Fig. 4). This is often the hardest milestone in the process and proceeds with a lot of discussion and an abrupt loss of motivation. Teams that manage to get out of this abstract bottleneck still united as a team, with a shared and clear understanding of the challenge to work on, are usually the ones that will succeed.

3.5.5 Embark on the Idea RoundAbout

In the IDEATE phase, solutions are generated individually and in the team by applying multiple forms of bodystorming,[8] including brainstorming, sketching, acting out use cases and rough prototypes. A set of rules helps to preserve a positive team dynamic and encourages building on the ideas of others as well as to encourage uncommon ideas. There are different definitions but you may want to check IDEO's collection at Open IDEO, which has a nice description of each single one. Thereafter, the most suspicious, promising ideas are chosen in the team (another point of converging).

3.5.6 Become a Master-Builder and Actor

In the next step of "Prototyping," selected ideas are made tangible. This can mean to build a model or to prepare a role play that lets an audience experience what the situation the team is working on feels like. There are two categories of prototypes: lookalikes and feelalikes. Prototypes don't have to be detailed nor perfect but should primarily deliver the main concept of the idea to outside people and answers to predefined questions to the team in order to prove and improve ideas and concepts. It is proven that the more crude a prototype is, the easier it is to gain conceptual feedback. Vice versa, the more refined the prototype is, the more detailed and focused on the appearance the feedback will be. For more information on this, see the excellent dissertation by Edelman (2011).

3.5.7 Proof of Concept

The team then presents the developed prototypes to designated users to let them try out and play with the idea. This TESTING aims to let crucial advantages and disadvantages become apparent through user feedback. In accordance to the

[8] Concept building on the common term brainstorming.

iterative principle, the team now is encouraged to go back to a previous phase and enhance or modify the idea or to start again from scratch.

3.6 How Does Design Thinking Contribute in Developing Twenty-First Century Skills?

In this passage, we outline which learnings and personality traits are fostered by Design Thinking and to what extent they contribute to Himmelmann's (2005) three-tier categorization of twenty-first century competences. Please be aware that these categories are overlapping and are categorized sequentially only for ease of understanding.

To operationalize Himmelmanns's abstract categories in our experiment, we used the ISK (ISK 2009). The ISK is a questionnaire that measures social competencies, subsumed under the four categories as shown in Fig. 6.

We will point out these competencies in design thinking process phases, where they are especially fostered, but as mentioned above, please be aware, that things go hand in hand at this level.

3.6.1 Cognitive Abilities

Learnings in this category comprise abilities regarding knowledge, cognizance, and comprehension.

In the OBSERVING phase design thinkers neutrally monitor people's actions in regard to what they say, how they act and what they actually mean. Information is generated and evaluated and divergent thinking is trained. While SYNTHESIZING, actions are mostly dedicated to cognitive skills: Information is selected and synthesized according to its relevance and degree of surprise. Convergent and abductive[9] procedures are also utilized.

Finding brainstorming questions requires different perspectives and phrasings. While IDEATING, divergent thinking and associative creativity come into play. Clustering ideas activates learning how to detect patterns and coherence by convergent thinking.

PROTOTYPING causes one to think about the details of the idea. Whereby, TESTING supports the ability to reflect upon one's own ideas, to cope with critical feedback and the comparison of expected and de facto performance. Convergent thinking is enhanced overall. Presenting findings at different milestones in front of a plenum, within strict time limitations, enhances the ability to put content in a nutshell while likewise conveying the message precisely to an audience.

[9] Described by Peirce as "guessing". The term refers to the process of arriving at an explanatory hypothesis (Peirce 1901, paragraph 219).

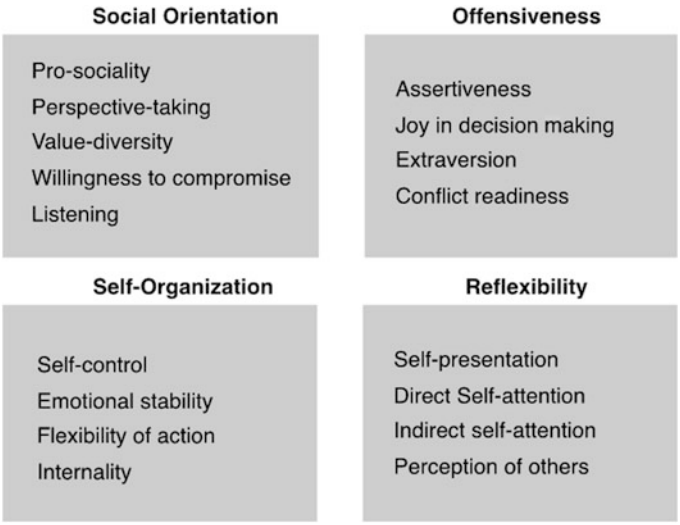

Fig. 6 Scales of the social competencies inventory (Based on Kanning 2009)

Communication throughout the process and set time frames serve to reflect in teams about content and non-content. Additionally, this helps to train the perception concerning oneself and others (direct self mindfulness, Indirect self mindfulness, perception of people).

3.6.2 Affective and Moral Attitudes

This rubric gathers all learnings concerning motivation, commitment, willing, attitudes, and habits.

In the first two phases UNDERSTAND and OBSERVE, prejudices and clichés are consciously avoided and dismantled by gaining a deep and broad understanding of the topic, people and context and also by exchanging different viewpoints within the team and with the outside, thereby learning to accept mindsets different than one's own (value pluralism and good listening). Further, the approach of getting involved in another person's thoughts and actions contributes well to the ability of one to empathize with others, and also the ability and willingness to socialize with and present oneself to unknown people (adoption of perspectives, extraversion, self-presentation).

In general, team communication and social skills regarding misunderstandings, opponent opinions, inner emotionality and rivalry between one's own and other preferences as well as actively finding a solution are challenged throughout all phases as interaction is demanded all the time in all directions. This category is operationalized by the ISK items: willingness to comprise, pro-sociality, willingness to deal with conflicts as well as emotional stability.

3.6.3 Practical and Instrumental Skills

In this category, learnings enfold abilities, proficiencies, and strategies.

Besides silent studying of situations, OBSERVING naturally requires talking to different stakeholders, whereby one is enabled to learn and apply various interviewing techniques and to listen actively.

BODYSTORMING rules stimulate the acceptance of rules in order to have a constructive, fair and creative working atmosphere. Even more so, graphical abilities are fostered by drawing ideas in accordance with the principle of visualization since images transport a meaning more precisely and faster. Clustering and selecting ideas unfold individual and team decision-making processes.

Prototyping an idea trains putting thoughts into action and learning how to communicate ideas. Using different forms of prototypes benefits haptic logic while building it, and opens the horizon to deliver an idea in distinct ways. This approach of several trials allows failures and deals with them playfully Further, it enables integrating and implementing user feedback from the TESTING to ITERATION in general.

Miscellaneous presentation tools are discovered and tried out as well as presentation skills being developed by the self-experience of presenting, but also by seeing the presentation of others. These team interactions in general thus activate how to cope with pushing forward one's own ideas and how to generally behave under certain social circumstances as well as under pressure (assertiveness, ability to decide on a behavior, ability to behave flexibly, self control).

During the whole design thinking process the ability to organize oneself as a person and in a team is practiced and improved through the freedom of guided self-regulation.

4 Do Our Theories Prove to be Resilient in Reality?

Having collected these theoretical frameworks and having gained many insights from interviews held at schools, ministries and with students, we made up numerous hypotheses we wanted to check in a real-life environment. In the following, we want to give you a short introduction into our experimental setup and then present five of our insights. For further information please consult the dissertation by Christine Noweski (Noweski 2012).

In order to observe realistic school settings, we decided to bring typical design thinking work style into regular schools.

The experiment therefore took place at a public *Gymnasium* in Potsdam with the full support of the principle and teachers of level 10. Level 10 is the last level, all students in Germany take together, before deciding to go on with Abitur, in preparation for a university admission, or to continue with a professional training.

Fig. 7 Design Thinking workspaces in the classroom (Photographer: Fabian Schülbe 2011)

It was comprised of students who were 15 or 16 (though we had one student aged 14 at the beginning of the experiment).

We split up the whole level (4 classes and 116 students) into teams of 4 and 5 students and had them work for 3 days on the challenge: *What and how can teachers profit from students knowledge as digital natives?* in a typical, flexible design thinking space, also used by the *School of Design Thinking* in Potsdam. The workspaces, consisting of two moveable whiteboards, a moveable high table and two highchairs (for up to five team member, so standing most of the time was inevitable) were brought into regular classrooms (Fig. 7).

Twelve of the 24 teams were supported by six teachers in training following Dewey's instructions, and 12 supported by six design thinking coaches. All coaches (Dewey and design thinking instructions) were chosen on the basis of having no particular knowledge in the subject of the workshop (digital media), being young (between 24 and 28) and motivated. The coaches were prepared in a training session. Here, they got information to intensify their already existing knowledge on their pedagogical approach.

We told the students when they arrived the morning to which teams they had randomly been assigned (giving attention that gender and classes were dispersed as equally dispersed as possible). There was a facilitator for each room (six teams), supporting the teacher and students with organizational and methodological difficulties, but the main challenge was left to the coaches and students themselves. They knew their challenge, the time frame and the method they ought to use and all of them were told to have as much fun as possible.

Everyday, students and teacher had to fill out several questionnaires, but spending no more than 20 min altogether per day on it, except for the "Social Competencies Inventory" (ISK 2009, see chapter "The Faith-Factor in Design Thinking: Creative Confidence Through d.school Education?" *How does Design*

Question answered by teachers: How did the students come across throughout the workshop?								
	-3	-2	-1	0	1	2	3	
	☐	☐	☐	☐	☐	☐	☐	
more interested than normally at school								less interested than normally at school
more receptive than normally at school								less receptive than normally at school
less independent than normally at school								more independent than normally at school
more friendly than normally at school								less friendly than normally at school
less engaged than normally at school								more engaged than normally at school
less emotionally involved than normally at school								more emotionally involved than normally at school

Fig. 8 Average teacher judgments regarding the question: "How did the students came across throughout the workshop?" rated on a scale ranging from − 3 to + 3; negative values indicate the *left* characterization applies more; positive values indicate the *right* characterization is more applicable

Thinking contribute in developing twenty-first century skills?), which was filled out by the students in their regular class settings before and after the workshop.

To see what impact the workshop had – if any – on the social skills of students, pre-post comparisons (that is: gain-scores) were calculated. In summary, students of the design thinking condition profit more than students of the Dewey-condition. Even though not all differences in gain-scores are large enough to reach statistical significance, the picture is pretty consistent: In an 18 out of 21 scale the gain-scores are more favorable for design thinkers. In particular, the gain-scores differ with statistical significance ($p < .05$) on the following scales, favoring design thinking: Self-Expression, Direct Self-Attention, Self-Monitoring and Reflexibility. Close to significant ($p < .1$) are differences of gain-scores on the following scales: Assertiveness, Flexibility of Action, Indirect Self Attention and Person Perception.

1. Teachers describe the students as more participatory than usual at school if a constructivist teaching method is applied (see Fig. 8).
2. Teachers consider Design Thinking a highly valuable teaching method– more valuable than the Dewey approach (see Fig. 9).
3. Teachers state they are very likely to pursue a Design Thinking project if possible. Whether they would carry out a Dewey project is much less certain (see Fig. 10).
4. The teacher-student relation is positive in Design Thinking and in Dewey projects. In Design Thinking projects it is even more positive than in Dewey projects, and this consistently so (see Fig. 11).

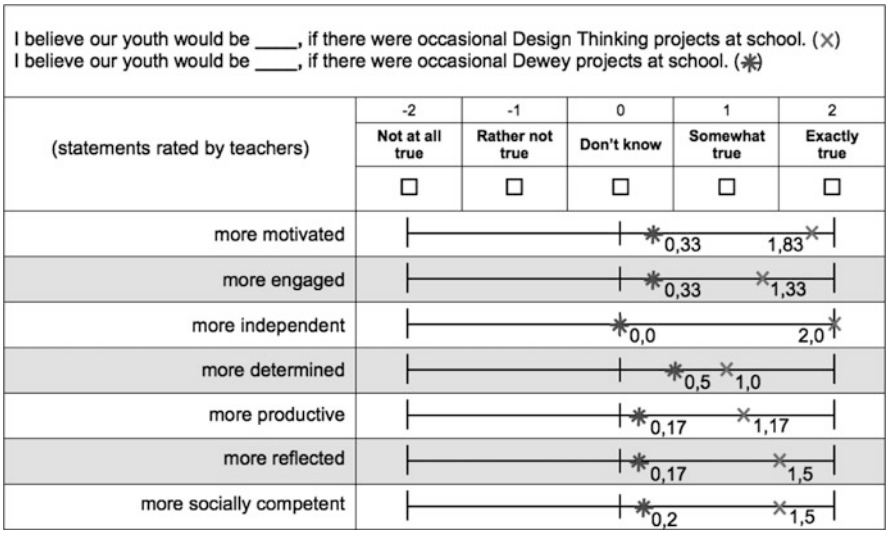

Fig. 9 Average teacher judgments regarding the expected impact of Design Thinking or Dewey's project work at school

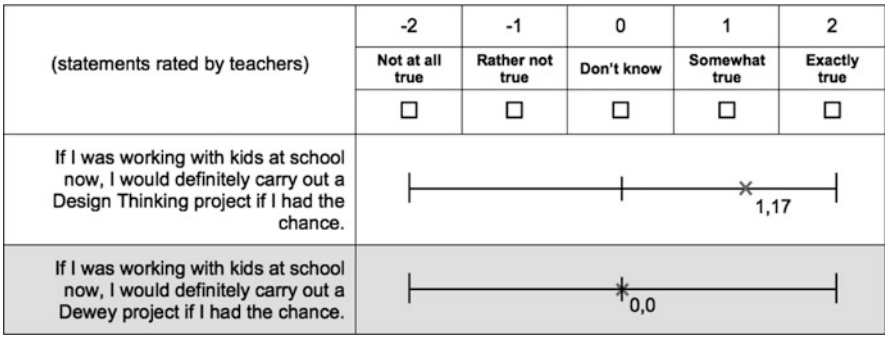

Fig. 10 Average teacher statements regarding whether or not they are likely to carry out a Design Thinking or Dewey project at school

5. Students appreciate the Design Thinking and the Dewey method. Consistently, they value the Design Thinking method even more than the Dewey method (see Fig. 12).
6. Mood assessment (see Fig. 13)
   On each workshop day, students and coaches specify their mood: in the morning, at midday and in the afternoon. The mood scale ranges from −10 (extremely negative) to +10 (extremely positive). There is one additional point of measurement for coaches due to their day of preparation ahead of the workshop.

Students and coaches report positive sentiments throughout the whole project. Indeed, at each single point of measurement all four groups (students Dewey,

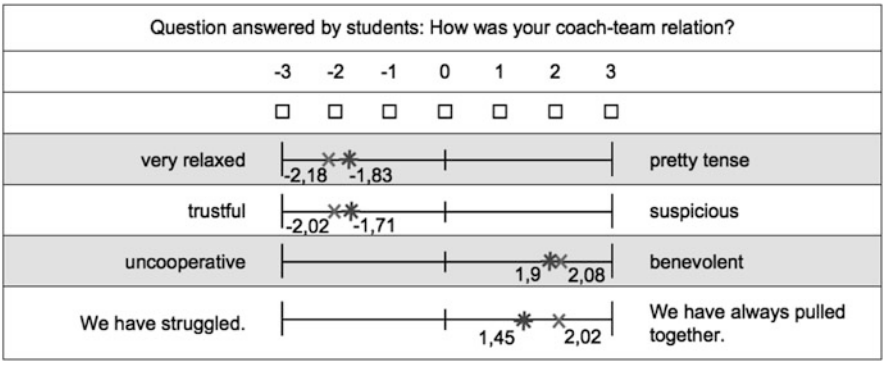

Fig. 11 Average student ratings of coach-team relation in Design Thinking (×) versus Dewey (∗) projects

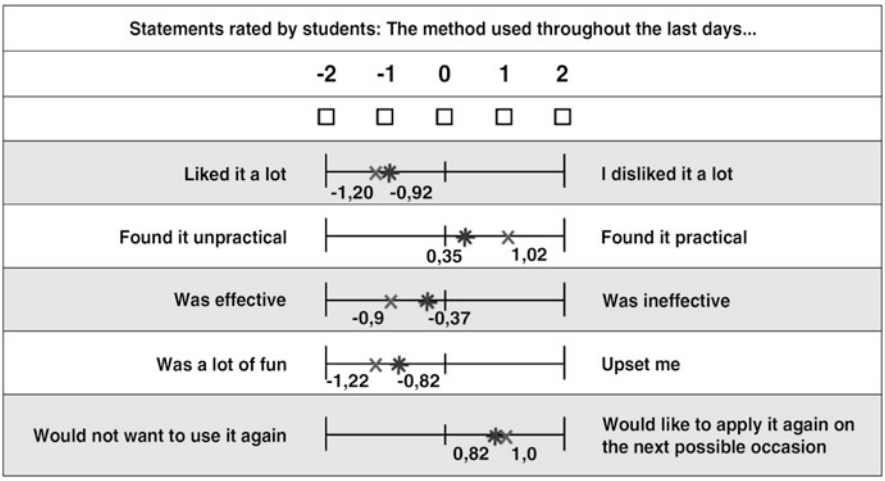

Fig. 12 Average student ratings regarding the Design Thinking (×) versus Dewey (∗) method

students Design Thinking, coaches Dewey, coaches Design Thinking) report an average mood in the positive realm (above zero).

Daily trends. On all three project days there is a trend that the mood improves from morning to afternoon.

Final sentiments. Students leave the workshop with a very good sentiment both in the Dewey and in the Design Thinking condition. For the coaches, an immense difference becomes apparent: The mood of Dewey coaches drops drastically while that of Design Thinking coaches takes off.

All in all, we can conclude our hypotheses confirmed that a teacher would be more likely to repeat a constructivist teaching method in a real school scenario

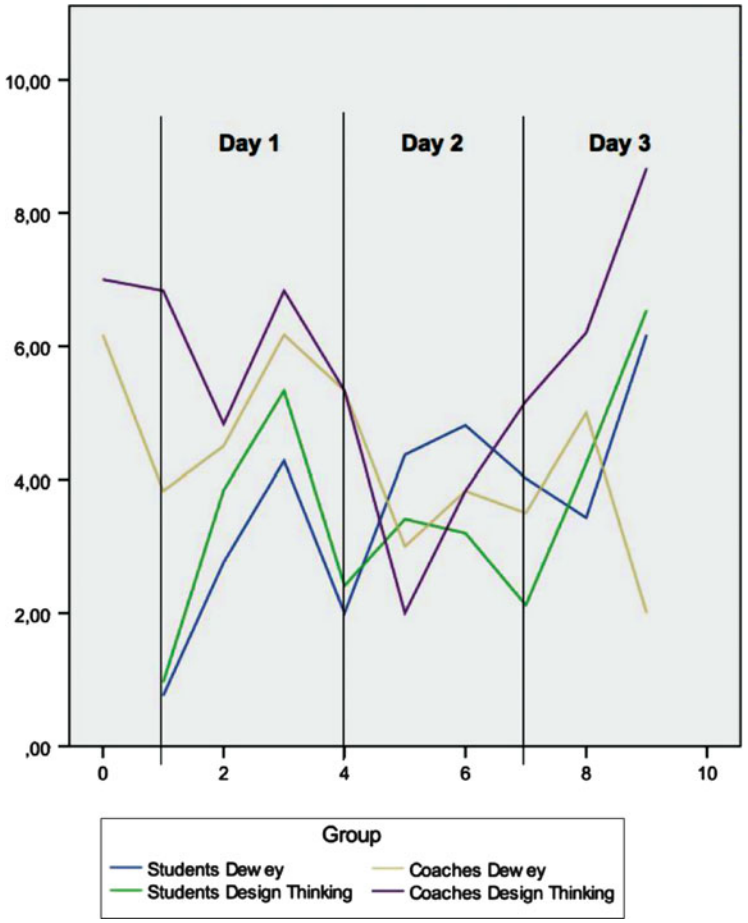

Fig. 13 Positive sentiments

when applying the design thinking process. And not only that, but surprisingly for us, the students of the design thinking condition profited more than the students of the Dewey-condition. So, the impact of Design Thinking in teaching in schools is even stronger than we expected. Students and teachers profit from it and the Department of Education's requirements (as demanded by society and economy) are being fulfilled.

5 Where Do We Go from Here?

Theoretical findings about the advantages and the use of constructivist learning and criteria for its realization are clear (Reich 2008; Dewey 1916). The practical implementation itself, however, is not yet being implemented effectively (Gardner

2010; Wagner 2011). Teachers seem to be demotivated and helpless in realizing holistic project work, and using constructivist methods, partly because of the absence of feedback, partly because of difficulties in assessing performance, as well as a lack of recommendations of designing constructive learning, according to the individual needs of their classes. We therefore conclude: there is a missing link between theoretical findings and demands and practical implementation of constructivist learning and teachings. This has led teachers to focus on approved and easily assessable content learning methods, and mostly deny affective, moral attitudes and practical, instrumental skills (Himmelmann 2005, also see Fig. 1) which however are a crucial fundament of the development of twenty-first century skills. Wagner refers to this as the *Global Achievement Gap*, the gap between *what even the best schools are teaching and testing versus the skills all students will need for careers, college, and citizenship in the twenty-first century* (Wagner 2011). We claim that, Design Thinking as constructivist methodology offers teachers the needed support towards a new way of teaching. Through a formalized process it may serve as a bridge between demand and reality.

6 Thanks

We sincerely want to thank the Hasso Plattner Design Thinking Research Program, especially Hasso Plattner, who believes in the value of our research, the board for funding us for 3 years and our dear colleagues for the fruitful discussions and insights.

References

Amabile TM, Khaire M (2008) Creativity and the role of the leader. Harv Bus Rev 86(10):100–109

Ananiadou K, Claro M (2009) 21st century skills and competences for new millennium learners in OECD countries, OECD education working papers, No. 41, OECD publishing. Available at: http://dx.doi.org/10.1787/218525261154. Accessed 11 Nov 2011

Brown T (2006) Presentation on innovation through design thinking at MIT World Forum, 16 March 2006. Available at: http://mitworld.mit.edu/video/357/. Accessed 11 Nov 2011

Brown T (2008) Design thinking. Harv Bus Rev 86(6):84–92

Buchanan R (1992) Wicked problems in design thinking, design issues, The MIT Press, 8(2):5–21. Available at: http://www.thestudiony.com/ed/bfa/Rittel+Webber+Dilemmas.pdf. Accessed 11 Nov 2011

Carroll M, Goldman S, Britos L, Koh J, Royalty A, Hornstein M (2010) Destination, imagination and the fires within: design thinking in a middle school classroom. Int J Art Design Educ 29(1):37–53

Cedefop (2008) Terminology of European education and training policy. A selection of 100 key terms. Luxembourg: office for official publications of the European communities. Available at: http://partners.becta.org.uk/upload-dir/downloads/page_documents/research/ict_attainment04.pdf. Accessed 11 Nov 2011

Cisco/Intel/Microsoft assessment and teaching of 21st century skills project. www.atc21s.org. Accessed 11 Nov 2011

Dewey J (1916) Democracy and education: an introduction to the philosophy of education. MacMillan Company, New York

Dewey J (1931) Ausweg aus dem pädagogischen Wirrwarr. Inglis Vorlseung 1931. In: Petersen P (ed) (1935) Der Projekt-Plan. Grundlegung und Praxis von, John Dewey und William Heard Kilpatrick, Weimar, pp 85–101

Drucker PF (1985) The discipline of innovation. Harv Bus Rev 1985:67–72

Edelman J (2011) Understanding radical breaks: media and behavior in small teams engaged in redesign scenarios. Ph.D thesis, Stanford University (to appear in December 2011)

Erdmann J (2010) Design thinking und multisensuelles Lernen Praxisbeispiele zur Gewaltprävention und zum sozialen Lernen, Schriftliche Hausarbeit im Rahmen der Ersten Staatsprüfung für das Lehramt für die Bildungsgänge der Sekundarstufe I und der Primarstufe an allgemein bildenden Schulen, Landesinstitut für Lehrerbildung, Berlin

Fagerberg J (2003) Innovation – a guide to the literature. In: Working papers on innovation studies, Centre for Technology, Innovation and Culture, University of Oslo. Available at: http://ideas.repec.org/s/tik/inowpp.html. Accessed 11 Nov 2011

Freeman C, Soete L (1997) The economics of industrial innovation, 3rd edn. Routledge, London/New York

Gardner H (2007) Five minds for the future. McGraw-Hill Professional, New York

Hasselhorn M, Gold A (2009) Pädagogische Psychologie: Erfolgreiches Lernen und Lehren. Kohlhammer, Stuttgar

Himmelmann G (2005) Was ist Demokratiekompetenz? Ein Vergleich von Kompetenzmodellen unter Berücksichtigung internationaler Ansätze, in Edelstein, Wolfgang und Fauser, Peter: Beiträge zur Demokratiepädagogik, Schriftenreihe des BLK-Programms "Demokratie lernen & leben", Editor Himmelmann, Gerhard: Berlin. Available at: http://blk-demokratie.de/materialien/beitraege-zur-demokratiepaedagogik/himmelmann-gerhard-2005-was-ist-demokratiekompetenz.html. Accessed 11 Nov 2011

IDEO (2011) The design thinking toolkit for educators. Available at: http://designthinkingforeducators.com/#toolkit. Accessed 11 Nov 2011

Kanning UP (2009) ISK – Inventar sozialer Kompetenzen, Manual and test. Hogrefe, Göttingen

Kilpatrick WH (1918) The project method. Teach Coll Rec 19:319–323

Knoll M (1991) Lernen durch praktisches Problemlösen. Die Projektmethode in den U.S.A., 1860–1915. In: Zeitschrift für internationale erziehungs- und sozialwissenschaftliche Forschung 8:103–127

Kolb DA (1984) Experiential learning: experience as the source of learning and development. Prentice-Hall Inc., New Jersey

Miller A (2010) Realism. In: Edward Z N (ed) The Stanford Encyclopedia of Philosophy, Summer 2010 edn. Available at: http://plato.stanford.edu/archives/sum2010/entries/realism/. Accessed 11 Nov 2011

Noweski C (to appear in 2012): Mediation of democracy competencies through 21st century skill support at secondary schools (working title)

Open Ideo http://www.openideo.com (for the brainstorming rules: http://www.openideo.com/fieldnotes/openideo-team-notes/seven-tips-on-better-brainstorming). Accessed 23 Nov 2011

Partnership for 21st skills www.21stcenturyskills.org. Accessed 11 Nov 2011

Paulus PB (2000) Groups, teams, and creativity: the creative potential of idea-generating groups. Appl Psychol: Int Rev 49(2):237–263. Available at: http://web.ebscohost.com/ehost/detail?vid=1&hid=17&sid=21ba8342-ea0e-465a-b4b1-02190525481c@SRCSM2&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ==#db=pbh&AN=3263821. Accessed 11 Nov 2008

Peirce CS (1901) On the logic of drawing history from ancient documents especially from testimonies, collected papers, vol. 7

Pink DH (2006) A whole new mind: why right-brainers will rule the future. Penguin Group, New York

Reich K (2008) Konstruktivistische Didaktik: Lehr- und Studienbuch. Beltz, Weinheim

Rittel HWJ, Webber MM (1973) Dilemmas in a general theory of planning, vol 4, Policy sciences journal. Elsevier Scientific Publishing Company, Amsterdam, pp 155–169
Runco MA (2004) Creativity. Annu Rev Psychol 55:657–687
Rychen DS, Hersch SL (eds) (2003) Key competencies for a successful life and a well-functioning society. Hogrefe & Huber, Cambridge, MA
Schumpeter JA (1961) The fundamental phenomenon of economic development, in: the theory of economic development. Oxford University Press, New York, pp 57–94
Wagner T (2010) The global achievement gap: why even our best schools don't teach the new survival skills our children need–and what we can do about it. Basic Books, New York
Weinert FE (2003) Concept of competence, OECD 1999 (not citeable). Definition und Auswahl von Schlüsselkompetenzen, Zusammenfassung PISA Bericht, OECD 2003