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Transforming Constructivist Learning into Action: Design thinking in education

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Abstract

The advantages of constructivist learning and criteria for its realization have been well-determined through theoretical findings in pedagogy (Reich, 2008; Dewey, 1916). Educational researchers and the Organization for Economic Cooperation and Development (OECD) promote a process oriented, so-called CSSC learning (constructed, self-regulated, situated, collaborative) to be effective in supporting 21st century competences (de Corte, 2010). However, the practical implementation itself leaves a lot to be desired (Gardner, 2010; Wagner, 2011). Lessons are not efficiently designed to help teachers execute CSSC learning. Common CSSC learning methods are abstractly describing what to do, while leaving the teacher uncertain about how to do it. We therefore conclude: there is a missing link between theoretical findings and demands by pedagogy science, and practical implementation of constructivist learning and teaching. Teachers have negative classroom experience with project methods. They would rather opt for the well structured, but abstract and instruction-only approach, than using an open structured, but more concrete and holistic mode of collaborative learning in projects. We claim that, Design Thinking as a methodology for project-oriented learning offers teachers the needed support towards a CSSC oriented teaching and learning design. Through a formalized process it may serve as a bridge between demand and reality of learning in the classroom. Thereby, Design Thinking would contribute to educational research. Our case study points out the improvement of the classroom experience for teacher and student alike, when using Design Thinking. This leads to a positive attitude towards constructivist learning and an increase of its implementation in education. The ultimate goal of this paper is to prove that Design Thinking gets teachers empowered to facilitate CSSC learning in order to foster 21st century skills.

Keywords: design thinking, education, learning process, constructivism

Introduction

Knowledge and content learning are important, but in order to effectively internalize them, metacognitive competences, attitudes, values and action skills are crucially necessary (Weinert, 2003). So-called CSSC learning, which enables learning processes that are constructed, self-regulated, situated in real-life context and collaborative are recommended by educational experts (de Corte, 2010). The question intrudes: what can a format look like that successfully implements CSSC learning in the school context? How to make complex phenomena understandable without too much breaking them down into isolated abstract parts of knowledge? We believe, the crucial point is to get teachers motivated and enabled to implement CSSC learning theory. It is necessary to give them the tools and methods at hand, which create a positive classroom experience while exercising project work. We furthermore claim that Design Thinking, understood as a meta-disciplinary methodology (Lindberg et al. 2009) can serve as such a format. Objectives are to synthesize research on issues related to constructivist learning theory and teaching design, to identify problems of realizing CSSC learning in the school context, and to offer a solution to meet those difficulties with the use of Design Thinking in order to facilitate and foster constructivist teaching and learning in the school context (e.g. high school). Research Questions are: Can the facilitation of CSSC learning be advanced through the use of Design Thinking? What is the classroom experience using Design Thinking? Is the use of Design Thinking valuable for the teacher?

The claim on education: Developing 21st century skills through a constructivist learning design

From educational researcher to business men and politicians, society is calling for so-called key competences in order to be able to deal with any sort of complex problems that dominate all facets of our society and business world (Pink, 2010; Gardner, 2010).

So called key competences involve knowledge, skills, attitudes and values (Weinert, 2003). Harvard professor Tony Wagner calls them the „seven survival skills for careers, college, and citizenship“ (Wagner, 2011):

- 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

Pedagogy science states that such accounts can be met especially well through a holistic constructivist approach (Weinert, 2003; Knoll, 1993; Reich, 2008). One method of which is project - learning (Dewey, 1913). In constructivism, learning is a process of individually self-organizing knowledge. The process of learning is unpredictable, and knowledge constantly altered through new insights, which are gained through individual experiences (Reich, 2008; Kolb, 1984). As opposed to realism, in which 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 figure 1). 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 humans and their natural and social environment. These interactions produce experiences which modify further interaction.

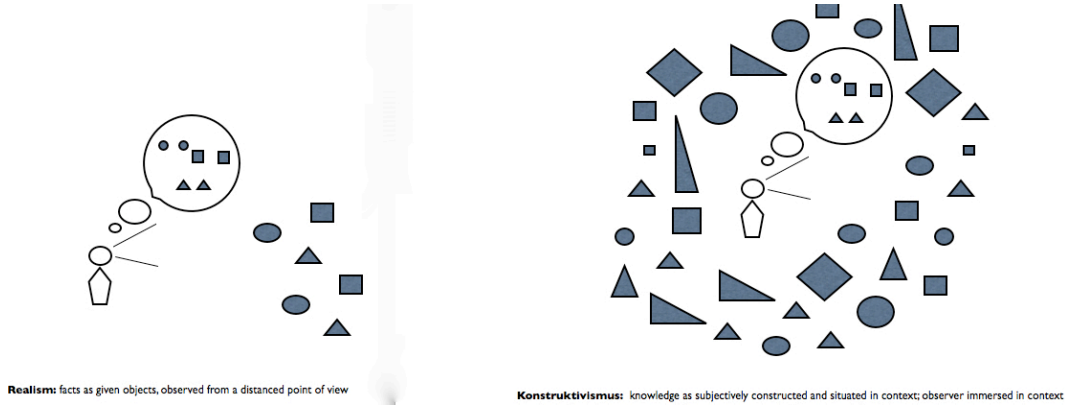

Figure 1: The learner and his environment, by Andrea Scheer 2011

„There is no me without us" (Dewey, 1931:91). 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. However, constructivism is neither a method nor a universal model, and it does not provide concrete didactic indications for the teacher. In contrast, education today is centered around specific disciplines and isolated strategies, which is the result of breaking down a complex real-life phenomena into little parts. Small information parts are thought to be easier to absorb for the student. Concentrating on one aspect of phenomena and distributing knowledge rather isolated from its complexity is better manageable for the teacher. Splitting up a complex phenomena into parts and only examining

isolated facts makes it hard for the student to recognize links between facts and phenomena. A connection to the real-life context is missing. Theoretical findings about the advantages of constructivist learning (the holistic approach, real-world challenges, motivation i.e.) and criteria for its realization are distinct (Reich, 2008; Dewey, 1916). The practical implementation itself does not yet take place effectively (Gardner, 2010; Wagner, 2011). We believe that teachers are demotivated and helpless in making use of constructivist learning theory and realizing holistic project work in the classroom, due to negative classroom experiences with project methods. This is partly because of difficulties in assessing performance in project work, as well as missing recommendations of designing constructivist learning and project-work. The latter shall be the focus in this paper. There is a missing link of transferring theoretical findings of pedagogy science into practical implementation, which leads the teacher to focus on approved and easily conductible content learning methods, denying constructivist learning projects. Harvard Professor Tony Wagner is referring to it 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 21st century“ (Wagner, 2011). We want to fill that gap by proposing Design Thinking as a meta-disciplinary methodology which offers teachers the needed support through a formalized process. Teachers, as facilitators of learning need to be equipped with up-to-date skills and tools to actually practice on the needed key competence learning. Otherwise, there is a risk that such competences will even more decline. There are high stakes in teacher education.

Criteria for a constructivist learning and teaching design

Learning is a process of understanding, which leads to modifications in the behavior of the learner (Hasselhorn and Gold, 2006). According to constructivist theory, this is achieved through experience. The teacher as a facilitator of learning should consequently be able to design learning experiences. What is needed for constructivist learning design? Erik de Corte points out four main criteria for competence oriented learning: to be constructed, situated in context, self-regulated by the learner and collaborative (de Corte, 2010). As participation and engagement of the student is a crucial characteristic of constructivist learning (Reich, 2008), the teacher needs to involve the student in the learning design, f.ex. to look at the students interests in order to propose a problem statement or project challenge. Even more so, they need space to try out different mental models and methods to connect abstract knowledge with concrete applications and thereby, being able to convert and apply abstract and

general principles (acquired through instruction) in meaningful and responsible acting in life (acquired through construction).

The following three aspects are essential for a convenient constructive learning design:

- involvement of students
- experience space
- balance of instruction and construction

In sum, a good lesson design needs to be a balanced composition of instruction and construction, or as Dewey would say „construction through instruction“ (Dewey, 1913; Knoll, 1993). A lesson design should answer, HOW students can experience certain situations, and how teacher can enable this experience. A good learning design is in what schools mostly fail until today. The HOW, e.g. the instruction to execute constructivist learning is either too open (free construction only) or too detailed (instruction only).

Teaching complex phenomena - Approaches for implementation

Abstract approach: Dewey’s Problem-Solving method

Dewey’s understanding of learning was a direct process of a structured interaction of humans and their natural and social environment. These interactions produce experiences which modify further interaction (Dewey, 1913) - learning took place (see definition of learning above, Hasselhorn and Gold, 2006).

Thinking and doing are very much intertwined as the one defines the other and vice versa. This reflects a holistic process of thinking and doing as education. Dewey suggested a method of constructive problem-solving. Dewey’s method is centered around an inquiry in context unfolding a problem or difficulty, which then motivates for further analyses and exploration. New insights are the foundation for an explanation of that inquiry, and are followed by a plan of action to solve the problem according to the explanation.

The following criteria are needed to realize this method:

- challenges situated in real-life environment of the learner
- action - interaction of thinking and action plus interaction and sharing of knowledge between learner and teacher
- application - solving the problem and applying the insights, reflecting and understanding through applying 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. The inquiry acts like „a magnet for content", it motivates further analysis of content and input of several disciplines in order to explain and solve that complex inquiry as a whole" (Dewey, 1931). In that, the Dewey approach meets the main aspects of constructivist learning. It involves the student throughout the learning process, suggests to balance instruction and construction, and more or less allows experience in real-life situations. Although, Dewey described his method theoretically, the complexity and abstractness of these recommendations is the crux of the matter for teachers to actually implement them into schools. His recommendations are not enough to get over the difficulties of teaching complex phenomena in a holistic constructivist manner. That might be why education today still is focused on breaking down complex phenomena into smaller parts, because they are easier to implement and to distribute to students in the first place. This is why we compared Dewey's method to Design Thinking, as we believe that Design Thinking can give concrete recommendations for distributing a complex phenomena/challenge without abstracting too much, but still being digestible for the student and implementable for the teacher.

Concrete approach: Design Thinking in Education

Design thinking understood as a meta-disciplinary methodology loosens the link to design as a profession. Even though design thinking was explored and developed in connection with professional designers at first, strategies have been identified that are relevant to all disciplines and professions (Lindberg et al., 2009:4, emphasis as per original)

Thinking like a designer involves different kinds of abilities and competence in different fields of knowledge: conceiving, planning and making products (Buchanan, 1999). Those are cognitive processes manifested in design action. Designers are used to deal with complex problems, and by generating diverse high-scoring solutions, analyzing and evaluating them in order to gradually improve them (Dorst, 2006). This is what students should be enabled for too and what the key competences are all about - dealing with complex real-life problems by analyzing and evaluating them in order to act solution-oriented and responsible. Design Thinking realizes what is recommended theoretically in constructivist pedagogy. Especially learning through experience and complex problem solving among other aspects are met in Design Thinking. Design Thinking is a constructivist learning design, because of its qualities in training certain skills, which are predispositions for a constructive way of learning: motivation for exploration, openness for new ideas, creative thinking and other metacognitive competences (Noweski, 2012). In a school learning context such predispositions need to be met to ensure 21st century skills

development. Students need to be motivated for exploration, trust needs to build up between student and teacher to give confidence for self-exploration, and team competences need to be fostered to express ones opinion and share knowledge. Such metacognitive competences cannot be developed in content oriented learning only, which is focused on information rather than on experience. A formalized process is needed, which facilitates constructive learning.

The Design Thinking process fosters several competencies in different phases, which are as follows:

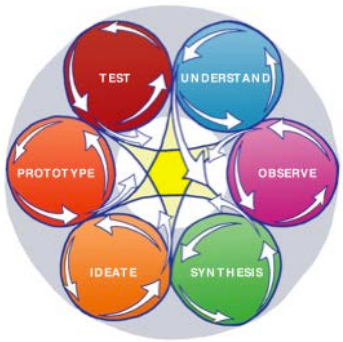

Figure 2: Design Thinking Process, after Johannes Erdmann 2010

Understand and Observe

The first step in the design process is to build up empathy and understanding of the people and the situation the problem or challenge is set in. The goal is to get a clue of relations between the problem and its context, and to find out hidden needs. Empathy is the competence of recognizing feelings, thoughts, intentions and characteristics of others.

Synthesis

In order to solve a problem and generate meaningful ideas, one has to define the problem and its context. As seen in the phase of understanding, there are different perspectives on one particular problem and a lot of information was generated to describe the problem. In the defining phase, all this information needs to be interpreted and condensed to meaningful insights, in order to be able to generate actionable solutions. It involves critical thinking and interpretation skills to condense a lot of information into a compelling point of view and clear direction for ideation.

Ideate

Ideation means opening up the mind, being imaginative and generating lots of ideas for solving the problem. Brainstorming in the team helps to build on the ideas of others and collaboratively transforming the knowledge about the problem and its origins into actionable problem

solving ideas. This is was pedagogy describes as the competence of applying knowledge.

Prototype

The prototype phase is all about experimentation to bring ideas alive, to make them tangible, actionable, testable. Learning more about the ideas, its possibilities in form and function through building them. The goal of prototyping is to be able to share ideas with others, to specify your abstract imaginations and to get the mental concept of an idea into the physical world.

Test

Testing means bringing the idea, the solution generated through the design process into action in order to get feedback on which to build on. Feedback from other persons, from experts, from novices, from users, everyone involved in the problem context. Through testing a lot of information is gathered, in that it is similar to the observe and understand phase. However, this information is focused on the solution, and shows how well the problem has been understood. It is important to be able to communicate the idea you want to get feedback on, and to capture and interpret that feedback in order to refine your idea.

Iteration

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 certain stages. The testing phase already implies a smooth transition to the observing and understand phase, as the problem context has changed with your idea. Its iterative nature unfolds the whole concept of constructivism - there is no such thing as a fixed and one dimensional reality, rather different situations apply different perspectives and new perspectives generate new situations. Knowledge is individually self-organized, and proofed in and adapted to the context.

In summary, Design Thinking, involvement of the participants is realized all the time, starting with reframing the initial challenge to the participants understanding, going individually and as a team through the process steps, and adjusting them to their needs, and last but not least presentations in which the team communicates its perspective on the challenge and shows the teams‘ solution to get feedback on it. Many characteristics of constructivist learning are combined in Design Thinking. It is collaborative as it requires conversation, sharing of knowledge and opens the mind for different perspectives. It is experiential as it creates a real space to try out new things and ideas, get feedback, iterate,

experience to fail and stand up again, and learning-by-doing. It is optimistic and gives you faith in your creative abilities by offering a process to take action through when faced with a difficult challenge. Most of all, Design Thinking does not deny the complexity of real-life phenomena and thus, manages for learning to keep its relevance in the world, and for the student. Design Thinking is constructive in that the student teams‘ self-organize their knowledge within the phases of the process. Different perspectives are taken into account and different approaches are converged to a consensus. There is a high degree of student involvement, the whole learning process is a situation for experiences, and a good balance between instruction and construction is accomplished through the iterative manner of the learning process.

As theoretically proofed, Design Thinking as a formalization of constructivist learning would foster 21st century skills. In this paper the success of realization of Design Thinking in a school context, and its usability for teachers was tested.

- Do students like to work with Design Thinking and do they actively participate?
- Do teacher like working with Design Thinking and are they likely to use this method again?
- Does Design Thinking built up a positive learning atmosphere between teacher and student?

Case study

Design Thinking was tested with high school students in order to analyze and evaluate Design Thinking as a teaching method in comparison to Dewey’s recommendations. The students and teachers motivation, the learning atmosphere and the development of cognitive and social competencies were the main criteria for analysis. An empirical study was set up to prove the above stated hypotheses with the use of quantitative questionnaires and the Inventory of Social Competence - ISK (Kanning, 2009). A three-day case study took place in a secondary school in Potsdam, Germany, involving 125 students and a team of 12 teachers and coaches. The students were divided into 22 teams of 5 to 6 students each, to face the real-world challenge „New Media in the classroom - How can we help teacher to use new media efficiently in the classroom?“ . The Design Thinking process, as described above was used by 11 teams. One Design Thinking coach was facilitator for two teams. These 11 Design Thinking teams were compared to 11 teams using the project-based method (Kilpatrick, 1918). One teacher was facilitator for two teams in this experimental category. 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 (6 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. All teams were set in an ordinary classroom of the high-school (six teams per room) and equipped with whiteboards, bar tables and stools, working-, research- and prototyping material, as well as one laptop and a beamer for presentations.

Figure 3: Design Thinking Workspaces in the classroom, photographer: Fabian Schülbe 2011

Everyday, students and teacher had to fill out several questionnaires, but spending no more than 20 minutes altogether per day on it, except for the Inventar Sozialer Kompetenzen - ISK (Kanning, 2009, see chapter III How does Design Thinking contribute in developing 21st 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 sum, 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.

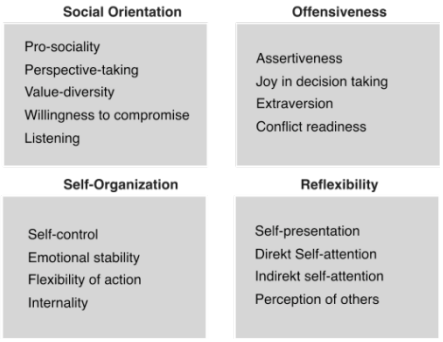

Figure 4: Scales of the Inventar Sozialer Kompetenzen, based on Kanning 2009

Results

Design Thinking understood as a meta-disciplinary methodology (Lindberg et al., 2009) fosters metacognitive skills and competences explicitly by using a formalized (design) process. The formalization of the Design Thinking process offers the teacher support in realizing constructivist learning and gives recommendations for methods (f.ex. method for effective reflection, brainstorming rules). As described in the theoretical part above, Design Thinking projects focus on constructivist learning and integrate content. What is crucial in Design Thinking are the process phases which need to be run through. The teacher can put different emphasis on different phases, according to the learning goal and individual needs. But only the process as a whole, with all its steps sets the frame for constructivist learning. Phenomena like encountering content and indirect connections to the challenge, solving team crises and getting feedback for intermediate results in between those steps are crucial for developing metacognitive competences and are only encountered through the Design Thinking process as a whole or as Dewey would point out the whole act of thinking. With the process on hand, the teacher is prepared for these phenomena, being confident in solving them and thus more motivated in using the process and actually realizing constructivist learning. Once succeeded in the process (solving of challenge, mastering the process),the teacher gets positive feedback and the development of students social competences can be assessed (Noweski, 2012). This success leads to motivation of both students and teacher in realizing more constructivist learning.

1.) Teachers describe the students as more participatory than usual at school if a constructivist teaching method is applied.

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

Figure 5: 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

2.) Teachers consider Design Thinking a highly valuable teaching method – more valuable than the Dewey approach.

I believe our youth would be ____, if there were occasional Design Thinking projects at school. (×)
I believe our youth would be ____, if there were occasional Dewey projects at school. (✱)

(statements rated by teachers)	-2 Not at all true	-1 Rather not true	0 Don't know	1 Somewhat true	2 Exactly true
	☐	☐	☐	☐	☐
more motivated			✱ 0,33		× 1,83
more engaged			✱ 0,33		× 1,33
more independent			✱ 0,0		2,0 × ✱
more determined			✱ 0,5	× 1,0	
more productive			✱ 0,17		× 1,17
more reflected			✱ 0,17		× 1,5
more socially competent			✱ 0,2		× 1,5

Figure 6: Average teacher judgments regarding the expected impact of Design Thinking or Dewey's project work at school

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.

(statements rated by teachers)	-2 Not at all true	-1 Rather not true	0 Don't know	1 Somewhat true	2 Exactly true
	☐	☐	☐	☐	☐
If I was working with kids at school now, I would definitely carry out a Design Thinking project if I had the chance.					× 1,17
If I was working with kids at school now, I would definitely carry out a Dewey project if I had the chance.			✱ 0,0		

Figure 7: Average teacher statements regarding whether or not they are likely to carry out a Design Thinking or Dewey project at school

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.

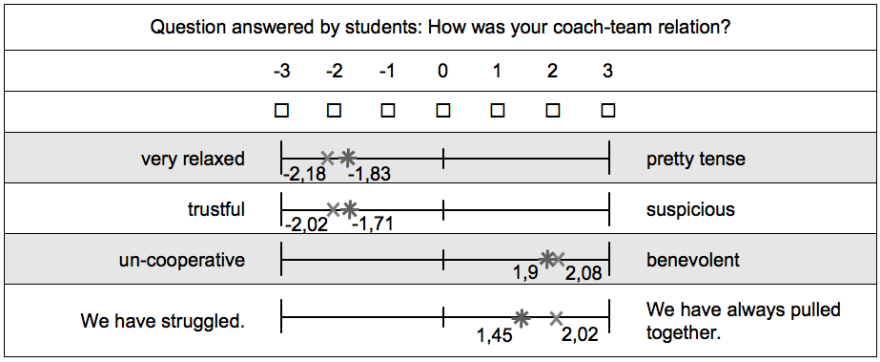

Figure 8: Average student ratings of coach-team relation in Design Thinking (✕) versus Dewey (✱) projects

5.) Students appreciate the Design Thinking and the Dewey method. Consistently, they value the Design Thinking method even more than the Dewey method.

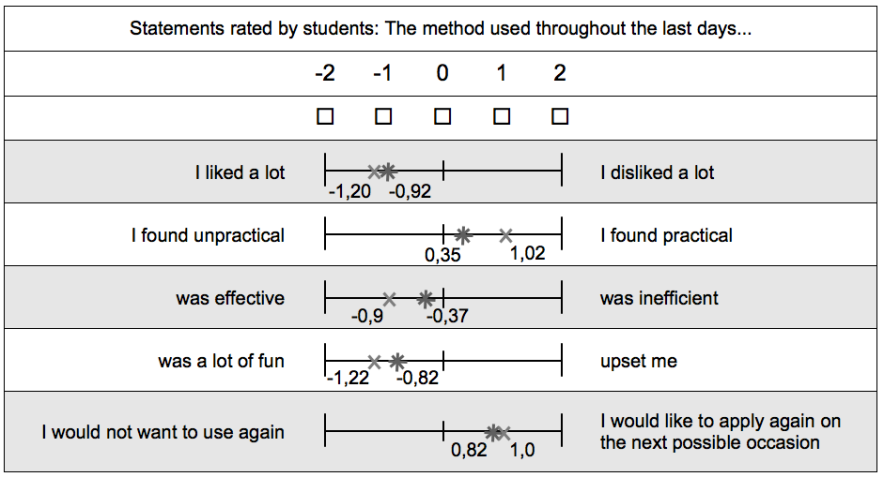

Figure 9: Average student ratings regarding the Design Thinking (✕) versus Dewey (✱) method

6.) Mood assessment

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.

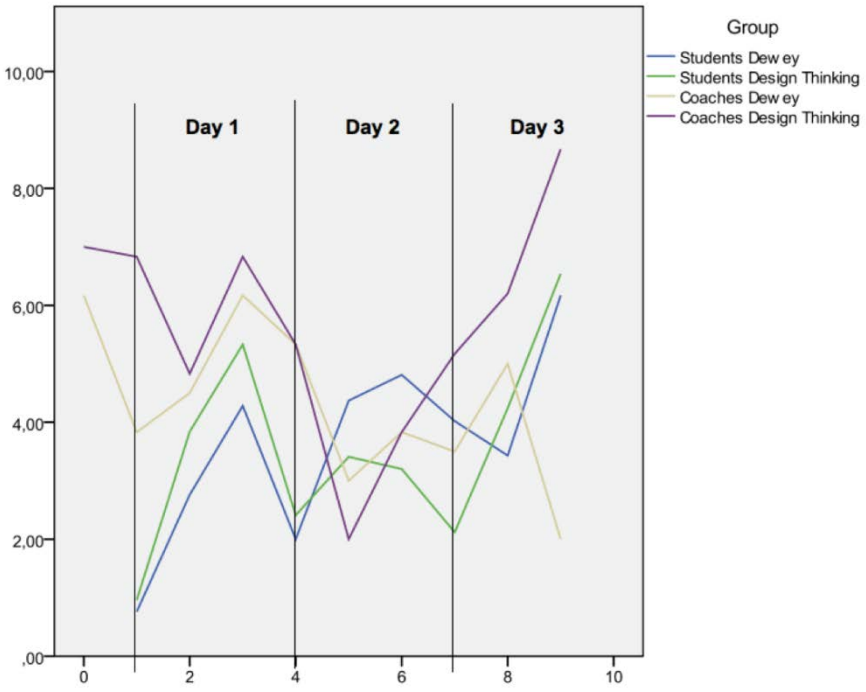

Figure 10: Positive sentiments.

Students and coaches report positive sentiments throughout the whole project. Indeed, at each single point of measurement all four groups (students Dewey, students Design Thinking, coaches Dewey, coaches Design Thinking) report an average mood in the positive realm (above zero).

Daily trends. At 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.

Conclusion

The impact of Design Thinking in teaching and learning at schools is promising. The experiment has resulted in a positive experience for the participants. Design Thinking gives teachers faith in his/her creative abilities, plus a process to hold on to when facing difficulties in the project work. It is the missing link between theoretical findings in pedagogy science and the actual practical realization in schools. It meets the crucial criteria for effective 21st century learning, by facilitating constructed, situated in a real-world context, self-regulated and collaborative (CSSC) learning. It motivates the teacher and fosters a positive relationship between him and his students. It enhances the implementation of

collaborative project work by giving teachers more confidence in creating and exercising such methods. In addition to this, the corresponding paper by Noweski (2012) confirms the fostering of student's social and metacognitive competences through Design Thinking. In sum, we can conclude our hypothesis confirmed that a teacher would be more likely to repeat constructivist teaching method in a real school scenario when applying the Design Thinking process. There is a need for Design Thinking in schools, and also in teacher education, which could be analyzed in further research. It is a difference to possess the knowledge of project methods and to be able to actually apply them. Teachers do need confidence and the expertise in facilitating constructivist CSSC learning. Design Thinking can help the teacher to facilitate constructivist learning and add the missing link to effectively complement content oriented lessons. Another important aspect for further consideration is the assessment of such 21st century competences in such a learning process.

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