How to Foster Creativity in Technology Enhanced Learning?

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Abstract Creativity-fostered learning in higher education enhanced by social media is described. The fostering of creativity in teaching and learning is illustrated by three examples; a) a European project about experimental online learning in production engineering (PeTEX), b) a longitudinal study about informal learning supported by online forums in a computer science faculty (InPUD), and c) a mind mapping scenario supported by a Web 2.0 tool. Aspects and conceptions towards a framework about fostering creativity in higher education regarding Media-enhanced education are illustrated.

1   Introduction

Teaching and learning in higher education institutions are becoming enhanced by the use of Internet-based technologies (Jahnke & Koch, 2009). According to Collins and Halverson (2009), the net generation asks particularly for online social networks with 'anytime, anywhere' access. Modern day learning systems are more flexible, adaptable to different existing levels of learning strategies, but are usually controlled by the teacher. They often do not implement concepts that embed the whole learning process into the given curriculum neither do they empower the students to manage their own learning nor do they foster creative thinking and creative actions. An approach to design technical, social and educational elements is delivered by the framework of socio-technical systems and networks (Whitworth & de Moor; 2009, Bolisani, 2008) and computer-supported collaborative learning. Reshaping blended and co-located learning requires the analysis and design of social processes, technical systems, and educational methods. One essential result is that new learning approaches should be situated in a specific context, and embedded within social interactions (Lave & Wenger, 1990). However, they do not often focus on such educational concepts which promote creativity in learning arrangements.

Universities play a particular role in this context since they are intended to educate people who support the development of creative ideas (generating new ideas) and innovation (enforcement and acceptance of new ideas). In addition to transmitting specialized knowledge to students, institutions of higher education are

challenged to develop or even enhance the students' creative potential. Therefore, it is not enough to restrict learning to how expertise, skills, and competencies can be acquired, reproduced, and applied. Students must also be encouraged to learn to think in multiple ways and reach beyond the spectrum of available options to form new relationships between established elements as well as to discover entirely new concepts or previously unconsidered connections.

This chapter describes creativity in higher education by way of three examples. First, an online learning arrangement called PeTEX in the field of engineering is illustrated, where the three dimensions – technical, social and educational principles – are designed. In the field of mechanical engineering remote laboratories are harnessed where creative learning is connected with Internet-supported distance-controlled live experimentation. Second, the socio-technical community called In-PUD (a large group with more than 1,500 members at a German university) will be described. The third example concerns a mind mapping tool.

2 Theoretical framework

It is well-known from computer-supported cooperative research (Suchman 1987, 2007) and computer-supported collaborative learning (Wasson, 2007), that a successful socio-technical system requires the integration of technical, social and educational elements (Collins & Halverson, 2009; Jahnke & Koch, 2009). But what does "successful" mean? This chapter describes a three dimensional framework that addresses that question.

2.1 Three design dimensions

Designing a socio-technical system must include the design of a technical and of a social system (Herrmann, Loser and Jahnke 2007). In addition, when designing computer-supported learning processes, the educational dimension must also be considered. So, there are three essential elements. These are: technical elements (learning management systems; social media, community platforms, Web 2.0 tools), social/organizational structures (forms of communication and participation, roles of instructors, students), and educational concepts (formal and informal learning, problem-based learning, creativity-supportive concepts).

The following questions are illuminate the critical design issues (Jahnke et al., 2010).

- The degree of structural coupling (degree of interdependency) of the three elements and their complex interconnections must be considered: Are the elements strongly connected and formalized, or flexibly usable? How closely or loosely are the elements connected?

- The degree of quality must be considered. This demonstrates how well the elements interact. The greater the unity among these three elements, the more likely that knowledge will be shared and co-construction of knowledge will occur. The better the participants can learn, the more satisfied they become (at least at the end of the learning process).
- "A successful design" depends on a careful description of each user's role. Different target groups, and people in different roles, have different cognitive conceptions of success in mind. Instructors, students, university managers, pedagogical experts, e-learning experts, each define success in different ways. A good design includes different views, or at least, supports a common understanding (Herrmann et al. 2007). In addition, a new target group consisting of the "digital natives" (Prensky 2001; Palfrey and Gasser 2008) are arriving at university. Younger people, who are growing up with social media, are developing different ideas about learning and knowledge. They are networking in many different online communities by using Social Media.

These three dimensions have driven the design process for fostering creativity in learning at higher education institutions. But what exactly is creativity? And what is an appropriate way to foster creativity in higher education?

2.2 Creative thinking and creative actions in higher education

Creativity has to do with something new, something valuable or *useful* for a particular group (Sternberg, 1999, p. 3). "Creativity is the ability to produce work that is both novel (original, unexpected) and appropriate (useful, adaptive concerning task constraints)". This useful novelty is found in an individual and social process of construction or generation: "You cannot be creative without creating something" (Quote by G. Fischer at International Conference CSCL2009, Greece). From this perspective, ideas and idea-generating people are only creative when an external authority assigns this value. But the question is for whom the creation is something new or valuable? Creativity therefore is relative with regard to the relationship of ideas to individuals and group who assign value to it. In these approaches, the concepts of creativity (generating ideas) and innovation (acceptance of new ideas by people, society, industry) are not sufficiently separated.

Historical Development of "Creativity"
In the early stages of creativity research (Guilford, 1956), the dominant approaches for explaining and investigating creativity came from psychology and were focused on individuals. According to the great mind approach (biographical creativity diagnostic or genius theory), creativity is ascribed to new ideas or products when exceptional inventors offer an ingenious solution to a problem at the right time. In contrast, the advocates of psychometric methods regard creativity as a cognitive ability expressed primarily through unorthodox thinking which is

available, in principle, to all people. Creativity is also regarded as an individual, cognitive ability and as a personality trait according to the experimental methods of psychology, but it is influenced by a number of parameters including: structures of work and space (Amabile et al. 1996), time available (Amabile, Hadley & Kramer 2002) and the behavior of leaders (Amabile et al. 2004). As such, a variety of factors affect the generation of ideas in a way that they open up certain possibilities and impose restrictions. According to the systemic understanding, not only the creative person but also the creative process, the creative product and its evaluation of creativity must be considered. The formative authors for this perspective are Csikszentmihalyi (1996) and Gardner (1993). They view creativity as the result of interaction between an individual (the generator of ideas), and a group who (embedded in a societal context) assess the creative achievement, and a domain containing symbolic rules (Sonnenburg 2007, p. 43).

The rise of the systemic view of creativity has sparked a debate regarding the focus of creativity research. Lenk criticizes the systemic view, maintaining that it describes two distinct concepts, creativity and acceptance of creativity (Lenk 2000, p. 8). Boden (1994) insists that the genesis of creative ideas rather than their evaluation is the appropriate focus of research into creativity. Dresler maintains that the "disagreement regarding the focus on psychological or social processes" is an "irreconcilable divide" (Dresler 2008, p. 9). The distinction between individual and (social) environment has become increasingly important in relation to the question of the source of creative ideas.

Elizabeth Watson (2007) provides an initial framework contrasting approaches focused on individuals with those studies which, in addition to individuals, also credit groups, teams and organizations with agency in creative achievement (Fischer et al. 2004). Watson identifies three levels of creative agents:

- The individuals in a group are the originators of creative new ideas.
- The product of an individual is socially influenced and therefore a socially constructed creative achievement. Creative production in a team differs from the creative achievement of a single individual. Hermann refers to this as "collaborative creativity" (2009).
- Organizations can also be the agents of creative accomplishment. They make a framework available to groups or teams, within which they can interact with other groups or teams.

Watson's efforts to draw fine distinctions in the tightly woven mesh of studies on creativity, demonstrate the complexity of the current state of the discussion (Greene, 2001).

Dresler (2008) attempts to differentiate the term creativity in another way. He lists, among others, every-day creativity, historical creativity, psychological creativity, group creativity, non-human creativity, technological creativity, artistic creativity and spontaneous creativity. He tries to assign them to the categories process, product and person. This enumeration could be expanded, but in the end, Dresler demonstrates how little help this differentiation: "Despite - or even because of - these manifold concepts of creativity, no precise definition of creativity is yet available" (translated by authors, ibid. p. 15).

Multiplicity of Sometimes Contradictory Definitions

Because of the multiplicity of (sometimes mutually exclusive) definitions, many questions remain open in the field of creativity research. In addition to the disagreement about the priority of person-centered or systemic methods, numerous other standpoints remain with regard to a quantitative or qualitative approach to the phenomenon of creativity, the localization of creativity as a general or context-specific phenomenon, as well as less pressing concerns such as the question whether animals or machines can also be creative. Dresler mentions a number of authors who rightly (at times even sarcastically) criticize the achievements of creativity research against this background, supporting Weitz (1972) in maintaining that creativity should be an open concept. The argument is that creativity is an umbrella concept, not to be exactly defined but offering a common frame of reference for the otherwise very different concepts. This makes it possible to approach the term "creativity" with different perspectives but without conflict. "Instead of looking for a universally valid criterion, a binding definition or a broadly accepted focus, creativity research should accept its inherent diversity" (Dresler 2008, p. 17). At the same time, scientific precision should not be sacrificed.

Brodbeck (2006), like Tosey (2006), advocates the notion that the development of creativity itself should not be the primary focus, rather the question under which conditions creativity can originate should be the focus: "On the other hand, we can say that when we are cramped, pig-headed, agitated, under stress, withdrawn, narrow-minded, then creativity cannot occur. We can limit creativity" (translated by authors, Brodbeck 2006).

Noise, distractions and disruptions inhibit creativity, and conversely, the absence of these factors *facilitates* the emergence of creativity. Routines and habits, for example, limit creativity, and certain techniques can help break down these barriers. Facilitating creativity always works on two levels: on external influences that inhibit the rise of creativity, and on internal factors in the form of self-imposed thinking barriers such as habits and predetermined opinions. In this context, Brodbeck and de Bono (1992) refer to the fact that according to current models of brain research, the human brain is trained to use patterns and routines. Creative thinking means suspending the use of these patterns.

The "Imaginative Curriculum Network" in Great Britain (Kleiman 2008; Jackson 2003, 2006) aims to change cultures of teaching and learning towards creativity-supported learning. Distancing itself from the scientific discussion in creativity research, the approach is oriented toward the requirements of its target group, the university and its members. The network does not give a universal definition. But while a few elements of creativity are specifically mentioned ("Creativity is..."), the fact that different concepts of creativity exist for each teacher and each student is emphasized.

For universities, the challenge becomes a matter to designing their cultures of teaching and learning in such a way that as many of these external barriers as possible are removed. At the same time, teaching and learning scenarios should be applied which encourage students to break down their thinking barriers and to

think 'differently' (away from traditional thinking). Strategies to promote creativity can, in this respect, only succeed as integrated approaches that focus on teaching and learning scenarios, individual factors, as well as institutional and media influences.

3 Definition, study design (methods), results

According to the multiplicity of (sometimes mutually exclusive) definitions (see section above), the authors accept creativity as an open concept. Creativity is subjective; every person has a unique perspective on what a creative effort means. What creative is, or is not, can be different. Majority opinions, about which efforts should be called creative or not creative, can be deceptive. But the open concept does not mean that creativity is 'everything'. Thus – in order to foster creativity – creativity must be contextualized. The challenge therefore is to define creativity in a specific context (here universities). Against this background, it seems appropriate to educate people involved in higher education with regard to the available, subjective conceptions of creativity. Instead of restricting strategies to promote creativity to specific elements, an effort should be made to do justice to as many different understandings of creativity as possible through a portfolio of different potential approaches.

3.1 Methods

To collect the target group's understanding about creativity (here teachers at universities) and what creativity is for them, the DaVinci sub-project "Didactics" included three phases of data collection and analysis.

The first phase of data collection consisted of 10 qualitative, expert interviews with exceptional teachers. These included excellent researchers (Leibniz Prize winners), award-winning teachers (ars legendi or "Professor of the Year" from unicum), as well as professors and research assistants who have been rated highly by students on the website "meinprof.de." In the second phase, 10 teachers from the University-Alliance-Metropolis-Ruhr (UAMR, consisting of the universities of Bochum, Dortmund and Duisburg-Essen, Germany) who are active in the discipline of pedagogy were interviewed. The purpose of the interviews was, among other things, to gain insight into different facets of creativity in teaching in higher education.

The interviews were conducted in the second half of 2009, at the interviewees' places of work and generally with two interviewers. The interviews were audio-recorded and later transcribed. In addition, notes were taken. The interviews were analyzed by means of "open codings" according to the "Grounded Theory" (Strauss & Corbin, 1990). Following the Grounded Theory, the empirical data

were used to formulate a theoretical model entitled 'Conceptual Framework for Fostering Creativity: 6 Ingredients'.

The third phase of data gathering existed of an online survey of all teachers at UAMR to find out to what extent they would confirm the conceptual framework described in the next section. In the third phase, the framework of 6 different ingredients has been empirically tested. The first question to the teachers at the universities was: "What is a creative effort (thinking, action) of your students?" And in a second question, the teachers were asked to match their given answers with the framework of the six ingredients. In addition, the answer "nothing matches" and "don't know" were also possible. The main result was that less than 1.5 percent of all given answers (out a total of n=591 given answers) did not fit to the six levels.

3.2 Results: framework about creativity in higher education

As a result of the interviews it can be concluded that the concept of creativity in the landscape of higher education is understood in a multitude of ways. The understanding of what creativity is ranges from viewing it:

- As a commonplace phenomenon which can be influenced by a change in one's "attentiveness,"
- Through seeing it as the development of one's own ideas (which generally could have already existed but are developed by the individual instead of simply being adopted) and
- As the creative linking of previously unconnected ideas or thoughts, up to considering creativity to be the ability to see objects and relationships from different perspectives, to abandon habitual patterns of thinking and finally to create and implement entirely new ideas.

This pluralistic character of the conception of creativity in higher education leads back to the question of whether creativity can actually be learned, whether people "create" ideas or whether they "receive" them. The view that creativity can be fostered – or blocked – was also widely represented. But the best way in which creativity could be fostered remained thoroughly subjective; in one case, restrictions were a challenge and motivation, while other experts found restrictions hinder their creative work. Independent of their understanding of creativity, the teachers in the first phase of the interviews thought it important to give students sufficient possibilities to develop ideas, thoughts and products, to allow them to "create" something themselves, in order to promote the unfolding of their creativity.

In order to do justice to the variety of ways that creativity is conceptualized (pluralistic view) the project team has developed a number of approaches for fostering creativity. Together they form a conceptual framework which allows academic teachers in higher education institutions to develop individual strategies. In reference to the different facets of creativity identified by the interviewed experts,

efforts to foster creativity target the following goals. The six facets for fostering creative thinking and creative actions are demonstrated in Table 1.

Table 1. Fostering creativity in higher education (HE) – a conceptual framework of 6 ingredients

Richness of creativity in HE	Description (Enabling students to do…)
6. Original, entirely new ideas	The production of many ideas can be encouraged through creativity techniques and an appropriate environment: 'enable the possibility of arrival'; Allowing and encouraging mistakes.
5. Fostering a new culture of thinking	Change of perspective, break through routines and patterns of habit, take a different attitude, reduce prejudice, integrate provocations, dealing with ambiguities, reflection on one's own creativity and thought-structure, knowledge about the inner-workings of the brain, perpetually scrutinizing.
4. Fostering constructive learning	Where students create something; creation of, for example, interconnections in theses, research-mode learning projects, aid and outreach projects; e.g., planning a congress.
3. Fostering fascination, increasing motivation to learn	Fostering of 'research curiosity', learn to ask right questions; enabling situated learning, use experiences of students, developing interesting ways to pose questions or problems; variety; establish a link to practice; use of metaphors, humor; individualization in larger courses.
2. Fostering the ability to work autonomously	Enabling the individual student to set the acquisition of knowledge in motion; Enabling students to learn that they are responsible for steering the processes of learning; enabling to make one's own decisions.
1. Fostering independent, self-reflective learning	Critical thinking, learner 'constructs' knowledge oneself rather than adopting it; enabling students to hold an internal dialog, breaking out of a receptive posture, supporting lateral and critical thinking.

The strengthening of independent, self-reflective learning or forcing students to work autonomously can be a fundamental improvement in encouraging creativity, even under inconvenient conditions (lecture courses with hundreds of students and predetermined content and exams), whereas these goals will essentially fulfill themselves in contexts such as project seminars or workshops. In these cases, higher levels of fostering creativity are appropriate. The decision regarding which level to strive for (and the related questions of how to design the teaching and learning scenarios) depends on the teachers and instructors. In order to make support easier, strategies for fostering creativity can, for example, be integrated into B.A. and M.A. Courses of study.

These six ingredients of the framework require action on multiple levels. Essentially, they address a change in personal attitude and social activity. Students should, in the end, become more 'creative' than before (with regard to the six ingredients, students developed competences like reflective and critical thinking, self-autonomous learning, motivation to learn (including research curiosity), ability to do constructive actions and change of perspectives). This should be achieved through particular teaching and learning scenarios which inspire individuals in the

unfolding of their creativity (in the various categories described above) and support them therein. A fundamental distinction must be made between the level of students (level 1), and the level of teaching practice, teachers and others (level 2). Students need an appropriate teaching and learning scenario where creativity will be fostered. Instructors/teachers need to learn strategies to structure courses towards creativity-supportive learning cultures. This is possible, for example, through faculty development, or workshops in pedagogy. The teaching and learning scenarios (of both levels), personal attitudes and social actions are embedded in an institutional context (level 3). Through its influences, this context can affect the levels either positively or negatively, and for this reason, adequate measures to promote creativity must also take this level into account and make suitable suggestions to shape it.

Changeable elements at the level of teaching
There are many potential starting-points on the level of the teaching practice and learning cultures in higher education which can be implemented. Depending upon the given understanding of creativity and the respective goals, there are many methods of support. Teachers can decide on their goals based on the conceptual framework outlined here. Through working out their own plans, instructors can be inspired to implement appropriate measures. This plan should not be understood as normative; rather it should encourage teachers to become aware of their own understanding of creativity, to reflect on the meaning of creativity for teaching and to consider how creativity can be fostered in their own teaching and learning scenarios regarding the context (like existing curriculum or discipline cultures).

To design a course that fosters creativity requires the integration of short, mid, and long-term measures:
- Elements of a session of a course are changed.
- A complete session of a course is changed.
- Multiple sessions of a course are changed.
- An entire course is changed.
- The curriculum (and its structure) of an entire university is changed.

'Session' in this context means the individual meeting of a course during the semester. Short-term measures include the change of elements in a session of a course (use cognitive techniques, or creative thinking methods); and change of a single session of a course (integrate experts or practitioners). Middle-term measures focus on the change of multiple sessions of a course (alter structures) and change of the entire course (the course will be designed like a student's project 'Plan an International Congress'). And third, long-term measures consist of a change of the entire curricula or degree program (institutionalize a year of creativity).

Approaches for structuring and therefore the re-structuring of existing courses as well as the development of new courses so that they foster creativity can be broken down into four areas:
1. Educational elements:

1.1 Mode of the course (variable time configurations, physical/virtual, spaces, assessments and its mechanisms, pre-defined structure and student work)

1.2 Learning process (when in the learning process is creativity needed)

2. Social context (group size, ratio of individual to collaborative learning; group work, group size, learning atmosphere, behavior/role of the teacher)

3. Technical systems; tools (Social Media, Web 2.0, facilitation tools, but also cognitive techniques such as PMI)

These four elements can be used to change a course or a single session to foster creativity-supportive learning processes. They are partly dependent on one another and are not exhaustive. They have not yet been assigned to concrete ingredients (1-6); rather they can be variably applied depending upon the learning scenario.

Ad 1.1) In the area of the *mode* of the course, a number of different modes can be reflected. For example, the environment can be arranged to better promote creativity: the space can be formatted differently (discussion walls, circular seating arrangements), physical and online meetings can be changed or staggered (one longer meeting per month instead of weekly meetings). In order to shape cultures of learning to help foster creativity, assessment mechanisms must also be critically examined. One of the interviewees emphasized that it is necessary to change the content of assessments. It is not enough to simply test for specialized knowledge. If creative processes have been encouraged in the course, the assessment mechanism must be altered (several assessments instead of one exam; evaluation of progress throughout the course; testing competences and specialized knowledge). Finally, the format of the course can be changed with respect to fostering creativity, adjusting the ratio of formal, teacher-provided structures to individual work by the students.

Ad 1.2) A second area is *shaping the process of teaching and learning*. This can be the case in a wide variety of situations throughout the process:

- The solution to a problem is provided by the teacher and the process of getting there must be creatively developed. (creative process)
- The exercise is specified, but the solution and result must be achieved creatively. (creative process and creative product)
- Only the topic is defined: the problem, solution and the process of solving the problem must be creatively contested. (creative process of defining the problem and the way to solve it as well as a creative product)

Ad 2) In the area of *social context*, the classroom setting (group size, learning environment, course atmosphere), ratio of (creative) individual and group work as well as the behavior of the teacher must be considered, and depending on the strategy for promoting creativity (compare to the six levels in Table 1), perhaps altered.

Ad 3) *Technical systems* are social media, learning management systems or combinations. *Tools* for fostering creativity range from cognitive techniques such as the synectic technique, 'headstand method', and thinking-hats', to general dis-

cussion techniques, facilitation methods including brainstorming tools and methods that promote reflection. These tools can be helpful, particularly in achieving the goals in steps 4, 5 and 6 (table 1):

- Facilitating a shift in perspective: The challenge "Think the impossible," and assistance in changing one's perspective help to bring about scrutiny of established patterns of thinking and the abandonment of ingrained lines of thought. This allows one to see things from a new, unfamiliar angle in order to encourage creative thinking and arrive at the solutions to problems.
- Encouragement in being able to establish distance between oneself and the situation (and thereby being able to see it from another perspective.)
- Breaking down barriers to creativity: Sometimes expressed through resignation or stagnation, these blockages usually stem from environmental/systemic conditions: economic dependence, and cannot be overcome by logic or rationality, rather by constructive problem-solving strategies (lateral thinking).

Methods for fostering creative thinking are available in many publications (de Bono, 1992). Efforts to foster creativity itself can also benefit from the integration of technology (such as the integration of Web 2.0, existing learning management systems at universities, or using modern discussion labs with an interactive wall).

4   Technology-enhanced creative learning cultures – examples

When designing and implementing creativity concepts in higher education, special courses or classes, the design-based research is one appropriate methodology. It is grounded in empirical data analysis with the aim to improve and change practice including researching the effects of implementation.

The design-based research approach (DBR) fosters collaboration among researchers and teachers (Reeves, Herrington, & Oliver, 2005). Researchers working together with educators and teachers seek to refine theories of teaching and learning by designing, studying, and refining rich, theory-based innovations, in realistic learning environments. DBR is a "systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (Wang and Hannafin, 2005, p. 6). DBR consists of several phases of analysis (reflection) and design (interventions for improving learning) which are alternate and interwoven (cycle of activities). The iterative process enables researchers to understand the sociotechnical-pedagogical phenomenon required to improve practice. It is similar to "action research" where researchers and practitioners acting together on a cycle of activities, including action intervention and in this way "*gain feedback from this experience, modify the theory as a result of this feedback, and try it again*" (Avison, Lau, Neilsen and Myers 1999, p. 94-95).

The first two studies into fostering creativity in media-enhanced learning were conducted with this methodology. The design-based research procedures regarding these two case studies are illustrated in more detail in Jahnke, 2010 (example 2) and Jahnke, Terkowsky, Pleul and Tekkaya, 2010 (example 1).

4.1 PeTEX – experimental online learning

The PeTEX (Platform for eLearning and Telemetric Experimentation) project (2008-2010) aimed to develop online learning within remote laboratories. Interactive live experiments in the fields of forming (tensile tests for characterizing the material behavior), cutting (milling processes), and joining (friction stir welding) were realized. The physical-real laboratories exist in the three European countries Germany (TU Dortmund University, IUL), Italy (University of Palermo, DTMPIG), and Sweden (KTH, Stockholm). As a result of the project´s interdisciplinary nature, researchers, educational experts, online learning experts, modeling moderators, and in particular the target groups – teachers and students from engineering – have been involved. Table 2 shows the educational design in particular the creativity concept of PeTEX.

Table 2. PeTEX scenarios

Elements	Description	PeTEX
Fostering of creativity…	Reflective learning *(focused on No 1 from 6 ingredients)*	Students get the task to create hypotheses, parameters, and reflect results by observing an online, telemetric experiment in Mechanical Engineering (cutting)
	Constructive learning *(focused on No 4 from 6 ingredients)*	Planning and conducting a remote experiment; writing a learning diary about learning progress
Session	Elements of a session of a course are changed	a) Integrating PeTEX into an existing course
	An entire course is changed	b) Using PeTEX like a standalone course
Educational elements: Mode of the course	Both physical and online (format which regulates the ratio of formal, pre-defined structure and student work)	a) Integrating PeTEX into an existing course: from one week to next week, give the students homework, a specific questions to guide them through module 1 (later module 2,3 and so forth) b) PeTEX as standalone course online
	Online Assessments	a) PeTEX as part of existing assessments (40% of the grade) b) PeTEX as online course: writing a report about results and a learning diary
Learning processes	When in the process is creativity needed	For beginners: learning walkthrough is guided, some tasks support creative thinking. For intermediate level: scenario-based, case-based learning (problem solving process), creative thinking and creative actions.

		For advanced level: Only the topic is defined: the problem, solution and the process of solving the problem must be creatively contested (creative process of defining the problem and the way to solve it as well as a creative product).
Social context	ratio of individual and collaborative learning	Individual learning: first phases of conducting the experiments; community sharing: discussing the results of the remote experiment online with the community members
Technical systems	social media	online community platform; portal: learning management system Moodle; for discussions: forums; for reporting: wiki and blogs

PeTEX's objective was to design an experimental online learning prototype that includes experimental design, test set-ups support observation and analysis of acquired measurements and data. The remote experiments are remote controlled and monitored through video cameras. Interfaces to the remote labs provide the possibility to change input parameters and access output results. One challenge was to implement Internet-mediated real experimentations from almost every computer workstation and to customize the pedagogical concept regarding creativity for an e-learning scenario. The central educational concept is the reflective learning approach with instructions for beginners, problem-based learning students at the intermediate level and research-based learning for advanced level. At all levels, students plan and conduct a remote-configurable experiment in Mechanical Engineering (cutting, welding, or forming). The difference from the pedagogical viewpoint is that a) the beginners get more support with instructions while the others learning levels get less instructions and b) within the process creativity is required at different times: beginners have the task to reflect a given experiment; in the intermediate level, the problem is given but creativity is necessary to solve the problem and in the advanced level, nothing is given, here creativity is required for the entire process (students get the task to find the research lack, an appropriate question, the problem and a solution, and to reflect the process).

A virtual interactive online environment was implemented for using the experimental data. Learners may monitor the progress of the experiments since the equipment is supplemented with synchronized video recording cameras located at different positions and constantly sending the instant images of running experiments. This required the development of an appropriate learning tool, a module oriented layout, instruction, learning tasks, observation, discussions in forums, and experimental tasks. The PeTEX team decided to use Moodle an online platform that has the potential to integrate modularized teaching objects. The platform is a multi-linguistic, internationally spread Open Source learning management system. It offers the integration of learning materials and learning activities via Internet interfaces. Such an online learning approach also demands an appropriate balance between teaching input, instructions, in particular learning activities, and qualified feedback (from peers as well as instructor): more student activities than in blended learning, or face-to-face settings are required (Jahnke et al., 2010).

4.2 InPUD – informal learning supported by forums

An information and communication system, InPUD (Informatics Portal University of Dortmund, Germany) was implemented to solve information deficiencies by supporting knowledge sharing among novice (new) and expert (senior) students, study advisors, as well as faculty members (teachers, dean officers, administration officers). The InPUD-community is a community system for computer science students. The InPUD-community differs from other informal, pure online communities which are built in people's spare time and are not a part of an institution. In contrast, InPUD is an extension of a Department (a supplement to the formal structure). According to Preece's four areas (2004) the InPUD-community is a) characterized by a large size, b) shares knowledge about computer science, hints about 'how to study successfully', and study management at the university, c) has an extended lifespan, and d) delivers a space for online communication.

The InPUD-community includes both an information space as well as communication opportunities. InPUD provides an overview of all classes and lectures that are offered during the course of a semester. The way that the information is structured is the same for each lecture or seminar. The information pertains to lectures, including any tutorials that are being held (and when), course materials, notices for examinations, lecturer contact information, and often a free discussion forum as well as news and search functions. The information portal about the study management domain is combined with online discussion boards. The boards are embedded in an information website that includes facts about course guidance as well as graphical maps of how to study which course at which time.

The communication in InPUD is predominantly online and asynchronous. InPUD has more than 1,500 members (out of 2,000 students at the faculty). It provides private identity (login is possible with nick names, email addresses are not shown) but enables public accessibility. The discussion boards exist for both lectures (to discuss exercises or content) and study organization. The decision about the topic mainly depends on what the students want to discuss. It ranges from discussions about course content, definitions or solutions for exercises to organizational issues (where/when is the next learning group, what could come up in the examinations?). Table 3 demonstrates the InPUD community reflecting the fostering of creativity in higher education.

Table 3. InPUD community with regard to the creativity approach

Elements	Description of elements	InPUD
Fostering of creativity…	Fostering a new thinking culture (*focused on No 5 from 6 ingredients*)	Knowledge sharing about how to study successfully, discussing aspects, make them available for all students
Session	Elements around the formal curriculum are changed	Online communication space supported by forums
Educational elements: Mode	Online	Online forums
Learning process	When is creativity needed	Open problems, students post problems, questions, discussions

Social context	Ratio of individual and collaborative learning	Individual problems, group could have answers
	Learning atmosphere	Facilitator, given framework for rules of discussion and posting
Technical system	Social media	Forums (with special topics) and portal (including information by the Department)

The community has been analyzed in detail through a longitudinal study (Jahnke, 2010). The results show that the InPUD-community is helpful; the degree of the learner satisfaction with the STC; and type and quality of use. The STC is an appropriate and enhanced platform for students to share knowledge. The answer of the question, whether the STC is an appropriate means for supporting knowledge sharing, is 'Yes'. The cultivation of such a community has enabled a new learning culture:

- The InPUD-community transformed the "jungle of information" in the higher education institution into a 'National Park with many ways to go'.
- InPUD changed the existing social structures into a flexible communication space for learners.

The community, consisting of both, an information portal (Web 1.0 condition) with flexible communication spaces (Web 2.0 conditions), fosters critical and reflective thinking. Students ask questions, discuss and reflect about their study planning and conducting. They discuss about exercises and tasks from courses, and reflect solutions and own ideas. According to Jahnke's study, more than two-thirds of the community-members use InPUD often or very often for "learning to handle different opinions". More than half of the members also use InPUD for exchanging knowledge, information with others, and for helping others. Such a community is an appropriate communication space for learners since it supports me-centricity and personalizes knowledge sharing. The InPUD-community makes it easier for a community member to obtain the relevant information that s/he needs at a given time. This reduces the social complexity and information overload from the official institution.

4.3 The example of mind mapping

The third example of fostering creativity in higher education is a more general one. In order to support multi-perspectives (focused on No 1 out of 6 ingredients of the conceptual framework), a web based online tool for collaborative mind mapping actions can be used (Mindmeister or Freemind). Students are given the task to create a mind map collaboratively. For instance, an appropriate guided question for a physics course is the discussion about a planet: "What is a planet? What properties are essential? Please discuss regarding Mars." The mind map supports different perspectives. Students in small groups with at least one laptop

or iPAD get the task to create a definition with arguments and statements of reasons. Then, they have to convince the other students why their own definition is the best one. So, a complex mind map with different perspectives is created. Students learn that they must be flexible and move beyond their own viewpoint during the process of definition finding. They also learn that there is a need to be more open to others.

5 Lessons learned and next steps

The conceptual framework of fostering creativity in media-enhanced learning and the three examples installed in higher education show the multi-layered dimensions of creativity in a specific context. Creative action means that people think about new possibilities and solutions when they are in situations where no general and standard solution can be applied. In such situations, self-determination and responsibility are required – educated people who do break out of the receptive consumption-oriented behavior are needed. With regard to the creativity-model, we have exemplified the diversity and multiplicity of creative thinking and actions in higher education and its fostering with three examples. A proposition for fostering creativity in higher education, which follows Jackson (2010), Jackson and Shaw (2006) as well as the authors' empirical studies, is shown in table 4.

Table 4. Fostering creativity in higher education (six ingredients)

Fostering creativity in higher education	Description	What instructors/teachers can do to foster creative learning cultures (Jackson 2010)	Supporting students to do 'creative thinking and creative actions' (Jackson und Shaw, 2006)
Original, entirely new ideas	The production of many ideas can be encouraged through creativity techniques and appropriate environment: 'enable the possibility of arrival'; Allowing and encouraging mistakes.	"Enabling students to appreciate the significance of being able to deal with situations and to see situations as the fundamental opportunity for being creative. They need to be empowered to create new situations individually and with others by connecting people and transferring, adapting and integrating ideas, resources and opportunities, in an imaginative, willful and productive way, to solve problems and create new value."	"Being original. This embodies the quality of newness, for example inventing and producing new things or doing things no one has done before."
Fostering a new culture of thinking and actions	To take many perspectives; change of perspective, break through routines and patterns of habit, take a different attitude, reduce prejudice, integrate provocations, dealing with ambiguities, reflection on one's own creativity and thought-structure,	"Helping students develop and explain their understandings of what creativity means in the situations in which they participate or create, and values and recognizes their awareness and application. Preparing them for and gives them experiences of adventuring in uncertain and unfamiliar situations, through which they encounter and learn to deal with situations that do not always result in success but which do not pe-	"Being imaginative – generating new ideas, thinking out of the boxes we normally inhabit, looking beyond the obvious, seeing the world in different ways so that it can be explored and understood better. Being able to take value from feedback and use it constructively to improve ideas."

	knowledge about the inner-workings of the brain, perpetually scrutinizing.	nalize 'mistakes' or failure to reach a successful outcome Encouraging participants to behave ethically and with social responsibility promoting creativity as means of making a difference to people or adding value to the world. "	
Fostering constructive learning, where students create something	Where students create something; creation of, for example, workshops, products designed by students, research-mode learning projects, aid and outreach projects; planning a conference.	"Enabling students to experience and appreciate knowledge and knowing in all its forms, and enables them to experience and appreciate themselves as knower, maker, player, narrator and enquirer."	"Being able to combine, connect, synthesize complex and incomplete data/ situations/ ideas/ contexts in order to see the world freshly/ differently, to understand it better. Being able to represent ideas and communicate them to others – the capacity to create and tell stories, pitch and sell ideas, empathize with others and show people possibilities, opportunities and solutions in ways that make sense to them or capture their imagination."
Fostering fascination (research curiosity); increasing motivation to learn	Enabling situated learning, use experiences of students, developing interesting ways to pose questions or problems; variety; establish a link to practice; use of metaphors, humor; individualization in larger courses.	"Giving students the freedom and empowers them to make choices so that they can find deeply satisfying and personally challenging situations that inspire and require their creativity. A curriculum should nurture their spirit: their will to be and become a better more developed person and create new value in the world around them."	"Being curious with an enquiring disposition – willing to explore, experiment and take risks. The attitude and motivation to engage in exploration and the ability to search purposefully in appropriate ways in order to find and discover. It is necessary to work in an uncertain world and often requires people to move from the known to the unknown."
Fostering the ability to work autonomously	Enabling the individual student to set the acquisition of knowledge in motion; Enabling students to learn that they are responsible for steering the processes of learning; enabling to make one's own decisions.	"Engendering a commitment to personal and cooperative learning and the continuing development of capability for the demands of any situation and the more strategic development of capability for future learning."	"Being resourceful – using knowledge, capability, relationships, powers to persuade and influence, and physical resources to overcome whatever challenge or problems are encountered and to exploit opportunities as they arise."
Fostering independent, self-reflective learning (critical thinking)	Learner 'constructs' knowledge oneself rather than adopting it; enabling students to hold an internal dialog, breaking out of a receptive posture, supporting lateral and critical thinking.	"Enabling students to develop and practice the repertoire of reflective learning including communication and literacy skills they need to be creative in a modern world. "	"Being able to think critically and analytically in order to distinguish useful ideas from those that are not so useful and make good decisions. Being inventive with someone else's ideas – recreation, reconstruction, re-contextualization, redefinition, adapting things that have been done before, doing things that have been done before but differently; and, the idea of significance and value – there are different levels and notions of significance and utility and value are integral to the idea."

In order to foster creativity, the design of a totally new course is not always required. A small change of just some elements, implementing a mind mapping tool for example, can greatly affect creative efforts. With regard to the level of teaching and learning cultures, changeable elements for fostering creativity in higher education were provided (section 3.2). The four elements are: educational elements - mode of course as well as learning process (when in the process is creativity needed), social context and technical systems/tools. Furthermore, elements of a session, a complete session, several sessions or a complete course can be changed.

Social media can play a significant role in promoting creativity. Online applications have the potential to enable new ideas for fostering creativity in higher education. The barrier for fostering creativity is low when using a simple and easy-to-use Web 2.0 application. So, Social Media can promote creative learning cultures towards education 2.0. But is also needs a creativity approach like the conceptual framework presented in this chapter. The combination of an appropriate educational 'ingredient' (Table 6) and the right choice of Social Media is needed for successful media-enhanced creativity design.

What kind of creativity do you want to foster in higher education 2.0? This question must be answered first, before designing and implementing sociotechnical-educational learning. The conceptual framework developed here means that answers are easier.

One essential next step regarding fostering creativity in higher education is creating a sound feedback questionnaire for both teachers and students. The framework in table 6 can be operationalized and transformed into a measuring tool for evaluating creativity-designed courses.

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