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**Title:** Creative Improvisations with Information and Communication Technology to Support Learning : A Conceptual and Developmental Framework

**Year:** 2017

**Version:**

**Please cite the original version:**

Vesisenaho, M., Dillon, P., Havu-Nuutinen, S., Nousiainen, T., Valtonen, T., & Wang, R. (2017). Creative Improvisations with Information and Communication Technology to Support Learning : A Conceptual and Developmental Framework. *Journal of Teacher Education and Educators*, 6(3), 229-250.  
<http://jtee.org/document/issue14/article1.pdf>

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## **Creative Improvisations with Information and Communication Technology to Support Learning: A Conceptual and Developmental Framework**

*(Received January 3, 2017 - Approved November 28, 2017)*

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### **Abstract**

This article is about facilitating collaborative, creative improvisations in learning with Information and Communication Technologies (ICT) and in so doing enhancing under-utilised creative possibilities in education and development in schools, universities, workplaces and in every-day life. Improvisation is defined and earlier research on supporting creative improvisations with ICT is outlined. There follows a conceptual framing where improvisation is seen as a creative outcome of certain cultural ecological interactions in learning environments. It is proposed that these creative improvisational interactions can be facilitated by ICT, and developmental ideas are presented. The purpose of the article is to review current practice and integrate it within an appropriate conceptual framework and thus outline a research and development agenda for future innovative work in the field.

**Key Words:** Improvisation, Learning, Education, Creativity, Innovation

### **Introduction**

The aim of this article is to introduce a conceptual and developmental framework for realising under-utilised potential in learning environments by facilitating creative improvisations with Information and Communication Technology (ICT). The ideas advanced in the article are a reinforcement and an extension of the empirical work presented by Dillon, Wang, Vesisenaho, Valtonen and Havu-Nuutinen (2013). The problem that the current article addresses is twofold and concerns some limitations of conventional learning situations: (i) they rarely allow enough opportunity for non-linear thinking and establishing innovative connections between ideas and practices, and/or non-traditional ways of working, and (ii) the creative possibilities arising from non-linear, non-traditional, or integrative approaches typically are poorly developed. There are many reasons why creativity and improvisation are inhibited in conventional learning environments. For example, organisational structures and protocols often suppress spontaneity in making connections and developing new ideas, and the possibili-

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ties from learning that arise ‘in the moment’ are often lost in the overall experience.

Improvisation is defined and earlier research on supporting creative improvisations with ICT is outlined. There follows a conceptual framing where improvisation is seen as a creative outcome of certain cultural ecological interactions in learning environments. It is proposed that these improvisational interactions can be facilitated by ICT and developmental ideas are outlined. The purpose of the article is to extensively review current practice and theory, integrate it within an appropriate conceptual framework, and thus outline a detailed research and development agenda for future work in the field.

### **Improvisation**

Creative potential, and thus the possibilities for improvisation, varies from situation to situation. What is needed is some mechanism for selecting for possibilities with situations that offer good creative potential. Improvisation is one means through which possibilities might be selected as a basis for developing the under-utilised potential in learning environments. Improvisation is defined as the ability to make new combinations in a given situation whilst retaining the original goal or purpose (Coker, 1964). Improvisation involves the coincidence of creative, emergent and collaborative activities and correlates with bricolage, intuition, adaptation, and innovation (Moorman & Miner, 1998). Improvisation is thus a means through which new knowledge, ideas, and concepts may be generated and new associations made between existing ideas or concepts.

Improvisation is commonly associated with jazz music (King, 1997) and theatre, although it has been applied in management and business (Crossan & Sorrenti, 1997). Although individual moments of creativity in a jazz performance are most commonly associated with improvisation, the collective endeavour drawn from the simultaneous involvement of all the musicians is equally important. Collaboration is thus an essential ingredient in learning how to improvise in jazz and it has parallels in the classroom and the workplace through the processes of both teaching and learning. Students and teachers, workers and managers, each with their unique ideas, perspectives, and ways of interpreting situations may be regarded as creative resources in learning environments. Collaborative activities provide possibilities for them to create new ideas and knowledge in ways that, for a single person, are challenging or even impossible. (Dillon et al., 2013).

Barrett (1998) has outlined the following characteristics that allow jazz bands to improvise coherently and manage creative innovation in a coordinated fashion, they:

- encourage deliberate efforts to interrupt habitual patterns;
- embrace errors as sources of learning;
- aim for minimal structures that allow maximum flexibility;
- allow for continual negotiation and dialogue towards dynamic synchronization;

- develop mechanisms that allow for making sense of situations retrospectively;
- encourage ‘hanging out’, i.e. informal membership of a community of practice.

These characteristics, along with the implications they have for managing learning given below, provide a starting point for thinking about mechanisms for ‘filtering’ and supporting improvisations. Implications for managing learning (adapted from Barrett, 1998) are:

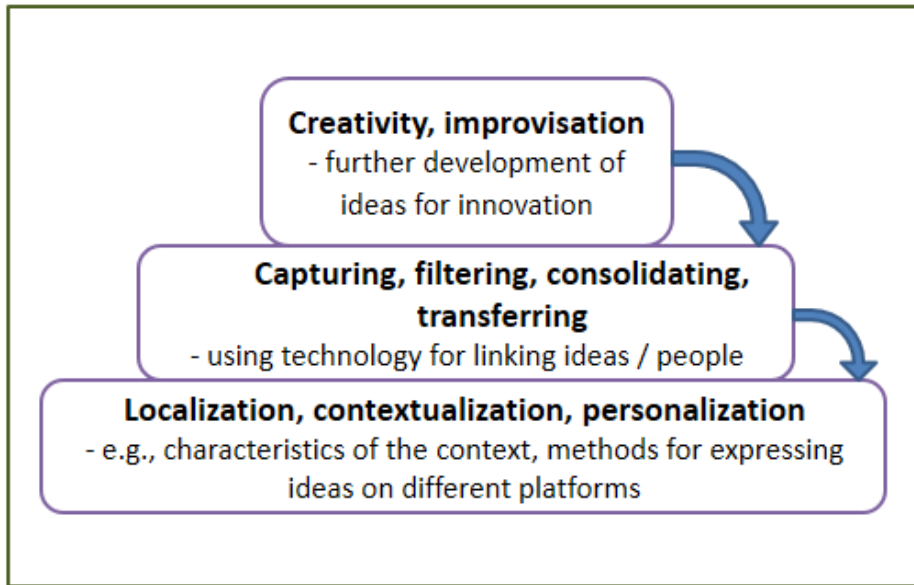
- boosting the processing of information before and after actions are implemented;
- creating incremental disruptions as occasions for stretching out into unfamiliar territory;
- ensuring that everyone has a chance to ‘solo’ from time to time;
- encouraging support for cumulative learning among participants;
- valuing errors as sources of learning;
- cultivating serious play because too much control inhibits ‘flow’.

Moorman and Milner (1998) have undertaken an extensive cross-tabulation of definitions of improvisation. They favoured a temporal definition: ‘the convergence in time of composition and execution’, and argued that different types of memory: organisational, procedural (skill memory) and declarative (fact memory) moderate the impact of improvisations in different ways. Of several different types of memory, Moorman and Miner (1998) recognize two as being particularly important to improvisation: procedural memory enhances the speed and effectiveness of improvisation but reduces its novelty; declarative memory enhances the effectiveness and novelty of improvisation but reduces its speed. The relationship between procedural and declarative modes is important in using ICT: tools may support spontaneity but there may be a skills threshold before it can be fully realised.

### **Creative Improvisation with Information and Communication Technology**

There is a limited amount of research on how to enhance and support improvisational potential in the processes of learning and innovation. We argue that successfully addressing this topic necessitates building an approach that takes into account the interplay between: 1) the overall role of creativity and improvisation in learning; 2) different ways of capturing, consolidating and transferring ideas, including mechanisms for feedback and analytics; and 3) the cumulative building of context namely localisation, contextualisation, and personalisation (Figure 1). Jointly, these perspectives provide a new way of facilitating the creation of innovations and learning about the innovation process. Earlier research has addressed each of these dimensions separately, but few studies have made attempts at merging them together with the purpose

of supporting the innovation process.



**Figure 1.** The approach, bringing together three perspectives

### *Improvisation in learning*

Attempts to develop ICT specifically for improvisation have been mainly in the field of music. For example, research has been directed at the relationship between fixed performance (i.e. following a musical score) and improvisation. Franklin (2001) developed a computational learning model for jazz based on identifying the best action for a given state in reinforcing learning and using uncertainty as a means of exploring new possibilities. Whereas the model had an element that allowed it to pursue improvisations ‘outside the chord changes’, it was limited by the extent to which it cumulatively built context. Keller, Jones, Thom and Wolin (2006) developed a computational tool to assist in composing solos of a type that could be improvised. The tool supported the process of improvisation rather than the end composition itself and allowed exploration within a rule-bound framework. There is also research related to promoting specific cognitive abilities in musical improvisation in young children, examining how a system is able to learn and configure itself according to its understanding of the learner’s behaviour (Addessi, 2013; Anagnostopoulou et al., 2012; Cardoso de Araujo et al., 2012).

In addition to music, the concept of improvisation has been studied in business and management (Crossan & Sorrenti, 1997; Magni et al., 2013) and in education (Sawyer, 2004). In these settings, improvisation is usually examined in terms of flexibility in dealing with unexpected events (e.g. Holdhus et al., 2016; Magni & Maruping, 2013),

whereas our focus is more on the use of improvisation to harness hidden innovative potential, especially in education. This can be called creative improvisation. The vision is of pedagogies that stimulate rather than direct improvisation, as has been shown, for example, in the use of shared lecture notes in an online educational community as a means of opening up learning through improvisation (Dillon et al., 2013; Vesisenaho et al., 2011), and in the learning characteristics of the ‘net generation’ (Valtonen et al., 2010). The second of these studies focused particularly on educational conditions for creative improvisation, investigating: 1) relationships between how ideas are developed individually and collaboratively, and 2) how new ideas change understanding and how they are followed through (Valtonen et al., 2010). These themes offer a starting point for developing ideas and understandings of creative improvisation.

Montuori (2003) has looked at the relationship between improvisation and creativity. He sees improvisation as an outcome of ‘the lived experience of complexity’ where the creative potential of ‘performative’ and ‘subjective’ aspects of undertaking a task can be incorporated into the formalised, ‘scripted’ aspects of the task without destabilising the task. Moreover, when it comes to applying creativity and improvisation to create solutions for practical, real-world problems, the concept of innovation comes into play. The distinction between creativity and innovation is that the process of innovation is inherently collective, and it entails both ‘creation’ and ‘implementation’ (Oddane, 2015).

### ***Capturing, consolidating and transferring ideas***

The development of technological tools for facilitating the creation, sharing, and elaboration of ideas is currently a topic of great interest. These themes are being studied in the context of different fields such as citizen science (e.g. Gould et al., 2014), creativity and design (Perteneder et al., 2013; Xu et al., 2014), creativity in learning through digital gaming (Karampiperis et al., 2014), and workplace-based feedback and assessment using learning analytics (WATCHME, 2014).

The relationship between collaborative work and individual expression is one of the key elements in facilitating improvisational learning, especially with the aim of enabling people to build onto and further develop each other’s ideas and initiatives. The goal is to design mechanisms for capturing and consolidating ‘in the moment’ experiences so that potentially useful improvisations can be identified. A starting point is the set of characteristics of improvisation defined by Peters (2009):

- drawing out differences in perspectives;
- awareness of relationships between immediate actions and overall shape and form;
- interconnecting the particular with the general;
- keeping the work ‘open’ and looking for new beginnings;
- moving into new, sometimes challenging, spaces.

For these purposes, research related to the use and sharing of both tacit and explicit knowledge is relevant, such as the re-use of knowledge and learning resources through communities of practice, being open to possibilities missed by one person but identified by another (e.g. Daele et al., 2006), as well as solutions that allow designers of innovative products to elaborate ideas and designs that have emerged through earlier work focusing especially on mechanisms for storing, reusing and reworking ideas (van Rosmalen et al., 2014).

It has been shown that it is important for all actors to co-develop strategies in teaching and learning situations (Vesisenaho & Dillon, 2013; Vesisenaho et al., 2011). Co-development might involve blending practices (including between physical and virtual situations) and community building. Thus, research related to tools that support distributed, synchronous collaborations, for example, between students ‘in the field’ and students based in a stationary location (Adams et al. 2011; Coughlan et al., 2012), is also relevant here. Earlier studies have also explored infrastructures for collaboration and networking across systems, countries and disciplines, placing emphasis on self-organised learning, which is an implied characteristic of improvisation (Klobucar, 2008; Nguyen-Ngoc & Law, 2007). Research has been done on pedagogical frameworks for exploiting the potential of technologies to foster interaction and collaboration between pupils for the promotion of enquiry/discovery learning and autonomous learning (Limanauskiene & Stuiikys, 2009).

Learning analytics and tools for providing relevant feedback play an important role in the processes of capturing, consolidating and transferring ideas. Learning analytics are currently often used to address at-risk students, that is, identifying patterns of behaviour that indicate a potential problem and then implementing an appropriate intervention that can be either computer or human-based (Wolff & Zdenek, 2012). Such approaches seek to combine data from multiple sources, interpret this, determine key intervention points for the benefit of learners and to use analytics to determine patterns of behaviour and reward contributors (e.g. Ferguson, 2012; Siemens & Long, 2011). The same kind of approach of analysis, identification, and intervention could be applied to supporting creative improvisation, which would be a novel and innovative application of analytics.

### ***Localization, contextualization and personalization of learning***

It is evident from earlier research that the cumulative building of context is important in realising the creative potential of learning through improvisation. The characteristics of the location, situation, and the learners determine the best ways of approaching the creation, sharing, and further development of ideas. As the contexts in which improvisational learning processes take place can range from formal educational institutions (including all levels from pre-school to higher education) to the workplace and a wide spectrum of informal settings (e.g. museums, science centres,



clubs, other leisure activities), we cannot assume that identical mechanisms will be ideal for all of them (Dillon et al., 2013). Thus, contextualization refers to taking the local environment into account when planning and implementing educational activities. Contextual learning occurs only when learners connect information to their own, locally meaningful environments. (Vesisenaho, 2009; Holdhus et al., 2016)

An opportunity to support localisation, contextualisation and personalisation of learning is through the use of mobile technologies (Stanton & Ophoff, 2013). Mobile learning involves processes that occur across multiple contexts, using personal interactive technologies (Sharples et al., 2007). This often happens individually or collaboratively in situated contexts (So et al., 2008). Such approaches offer potential for exploring and interacting with location-related information. This is also related to the act of ‘temporal sensing’, allowing flexible ‘time travel’ from the past to the future and vice versa (Coughlan et al., 2012).

Personalisation may be facilitated through open educational resources, with pedagogical designs that allow learners to use open content to work collaboratively and to structure their own learning pathways in various formal and informal learning settings. Such approaches prepare the ground for enabling the elaboration of ideas (Conole et al., 2009; Sutinen & Vesisenaho, 2006; Vesisenaho & Dillon, 2013).

A related question is that of accessibility to different learners: there has been research investigating how mobile technologies impact on the diffusion of a social model where learning and knowledge are accessible to all, regardless of social and economic background, age, gender, religion, ethnicity, or disability (Arrigo et al., 2010). Another matter of interest is how the technologies can be designed to support equitable co-located and remote learning collaboration (Adams et al., 2010).

### **Realising Creative Improvisational Potential in Learning Situations**

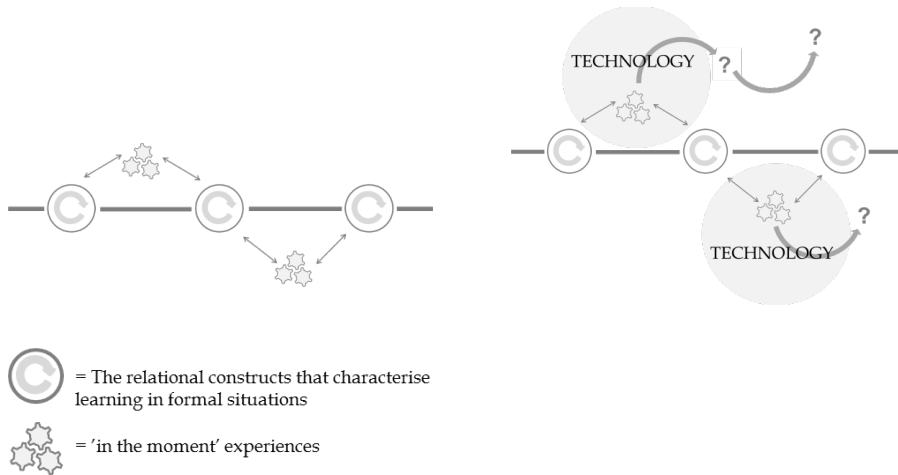
If ICTs are to be effective in supporting creative improvisations they must become integral parts of the normal, everyday life, i.e. the ‘cultural ecology’ of the environments in which they will be used. Cultural ecology is taken to mean the dynamics of people’s interactions with and within their environments (Dillon, 2008; Dillon & Loi, 2008; Loi & Dillon, 2006; Vesisenaho & Dillon, 2009, 2013). These interactions embody a continual interplay between an individual’s immediate experiences and how he/she knows the world. The instant that some individual experiences something, he/she connects the new experience with what he/she already knows and feels, i.e., the relational constructs and emotions that define the individual’s personal history. Therefore, the immediate, ‘in the moment’ experiences and the understanding developed from prior learning constantly reconstruct each other (Lave & Wenger, 1991; Brown et al., 1989). In most structured learning situations, for example schools, universities, museums, workplaces, etc., experiences are managed in favour of particular outcomes, e.g., through curricula, pedagogies, curatorial strategies, workplace routines. Typical-



ly, these objective-orientated managerial processes ‘select’ certain ‘in the moment’ experiences and consolidate them in the pursuit of educational or workplace goals. This represents both a strength of education as a managed process and a weakness. The weakness is in the loss of creative and imaginative potential of experiences not pursued (Dillon et al., 2013).

In formal learning environments, such as schools, learning is typically objective-orientated: learners are expected to build cumulatively on what they already know and can do. Alternatively, they are taught directly what to do and given limited latitude to take risks with the learning process or outcome. Either way, learners are unlikely to perform outside of the articulated or assumed norm, but rather repeat existing patterns of behaviour, playing out the roles they have already learned or to which they have been newly instructed (Dillon et al., 2013). By contrast, creative thinking emphasises the learning process generally and thus supports the ability to discover diverse functional and usable ideas in different situations. Creativity, therefore, can be characterized as the ability to uncover or formulate an outcome that is innovative and socially significant (Sternberg et al., 1999). In the cultural ecology of a learning environment, creative improvisation is a means by which students individually and collectively draw on experience, take risks, make connections, move into new learning spaces and, in so doing, open up new creative possibilities.

Figure 2 is a diagrammatic representation of creative improvisation in a cultural ecology of learning and how it might be facilitated with technology. The central lines represent collaborative learning trajectories. The left-hand graphic is typical of trajectories of learning in formal situations: ‘in the moment’ experiences are consolidated within the relational constructs that define the goals of the learning activity. This is goal-directed or objective-orientated learning. It is essentially a closed system. However, although goal-directed learning in a closed system may be important educationally, there is much under-utilised potential in the process. The right-hand graphic in Figure 2 shows a similar collaborative learning trajectory but, in this case, some of the ‘in the moment’ experiences, facilitated by technology, are allowed to break away from the main trajectory and open up the system to new possibilities. These break away experiences are improvisations. Improvisations typically: (i) involve non-linear and non-standard thinking that challenges received knowledge; (ii) identify new associations between and among existing ideas or practices; and (iii) explore and generate new knowledge, ideas and practices (Dillon et al., 2013).



**Figure 2.** Learning trajectories: left hand side objective orientated closed system; right hand side trajectory open to the possibilities of improvisation (adapted from Dillon, 2012)

Sternberg and Lubart (1999) emphasise the significance of an environment that is supportive of and rewards creative ideas and how they are represented. For new possibilities to emerge from improvisation it is necessary for teachers and learners to reflect on how learning is being opened up. This takes place through reflection on improvisations, in which educators and learners regulate the learning process, i.e. consolidate the connections and ideas and open up further possibilities. Davies et al. (2013) conclude the social aspect of the environment needs to involve the opportunities to work collaboratively with peers including through peer and self-assessment. The ability to reflect on practice is the basis for learning (Clark, 2009); reflection enables new situations to be tackled effectively (Gibbs, 1988). Reflection is a meaning-making process that moves a learner from one experience into the next with a deeper understanding of its relationships with and connections to other experiences and ideas (Rogers, 2002). Without reflection an experience may quickly be forgotten or its learning potential lost (Gibbs, 1988).

### **Opening up Learning through Creative Improvisation with Technology**

For questioning and challenging existing ideas and practically applying knowledge in new and innovative combinations, opening up learning through creative improvisation is needed. This means applying practices that encourage arriving at outcomes that go beyond meeting the objectives of a given task, or allowing objectives to be met in unconventional ways. The intellectual value in thinking about tasks and problems in multiple ways soon becomes apparent: new ways of doing things often offer more logistically effective solutions, and thus new processes or products may be

created. The use of technology in supporting creative improvisation in the learning process also has added value in today's educational systems, which are under constant pressure to demonstrate how to cope with the demands of tomorrow's society. An information/knowledge society needs people who are capable of demonstrating new skills, and there is an obvious need to continually update teaching technology and methods to keep pace with changes in society. An essential aspect of this approach is to support the creative process through a variety of technologies. At the moment, several different solutions collected under the umbrella term of social media provide possibilities for learning and creativity.

Different applications of technology could support creative improvisation in learning through ICT tools and mobile and networking related technologies. Each of these elements has the potential to open opportunities for learning via improvisation. The ICT could capture learning via creative improvisation and make the processes transparent, by, e.g.:

- opening up new beginnings and new possibilities;
- drawing out differences from within similar processes;
- developing relationships between immediate actions and overall purpose;
  - capturing interconnections between ideas;
  - facilitating interconnections between specific detail in a learning task and more general and related ideas;
  - comparing and contrasting possibilities;
  - developing relationships between planned learning spaces/objective-orientated activities and unplanned learning spaces/emergent activities.

Ideally, these tools should work with specifically designed pedagogies and support materials.

Mobile technologies could allow ICT tools to be used in a variety of places and educational settings: formal, informal, non-formal, workplace. For example, creative improvisation in learning in museums or during fieldwork could be facilitated through the immediate connections with external content and lateral ideas made possible through access to mobile tools.

Technologies for networking potentially offer powerful support for social interaction, including tools such as forum, chat, wiki, tagging, blog, etc., which, in conjunction with specific tools to facilitate improvisation, could allow learning communities to be formed and reformed around the creative improvisations. Fluidity is seen to be an important aspect of improvisational learning communities, which can be distinguished from conventional communities of practice that are objective-orientated.

An integrated computer-enhanced learning structure to support creative improvisation would bring together all of the above. It could take the form of a robust plat-

form for building the tools and delivering them via the Web or mobile interfaces with pre-built functionalities that recognise a device and deliver content or tools adapted for that device. The platform could incorporate a large selection of social media tools with potential in developing pedagogical opportunities and providing support, ideas, and examples. The platform would need to be flexible and open-ended, allowing it to be tailored to different needs. The strength of such a platform would be that all systems and resources would be available to the learner from a single, personalised, user interface.

The first stage in developing such a platform would be to design mechanisms for filtering ‘in the moment’ experiences so that potentially useful creative improvisations can be identified. A starting point is the set of characteristics of improvisation defined by Peters (2009): drawing out differences in perspectives; awareness of relationships between immediate actions and overall shape and form; interconnecting the particular with the general; keeping the work ‘open’ and looking for new beginnings; and moving into new, sometimes challenging, spaces. These characteristics could be used in conjunction with a ‘learning analytics’ approach to identify patterns of behaviour and then implement an appropriate computer or human-based intervention.

For creative improvisations that are identified and selected, it will be necessary to design mechanisms for using them to facilitate learning, based on relevant educational literature and existing knowledge about conditions that support improvisation. These mechanisms could be based specifically on ways in which learners and teachers reflect on experience and give attention to the detail of what is happening ‘in the moment’. Special attention should be given to connecting ideas and concepts, non-linear thinking, and the relationships between declarative and procedural modes of working.

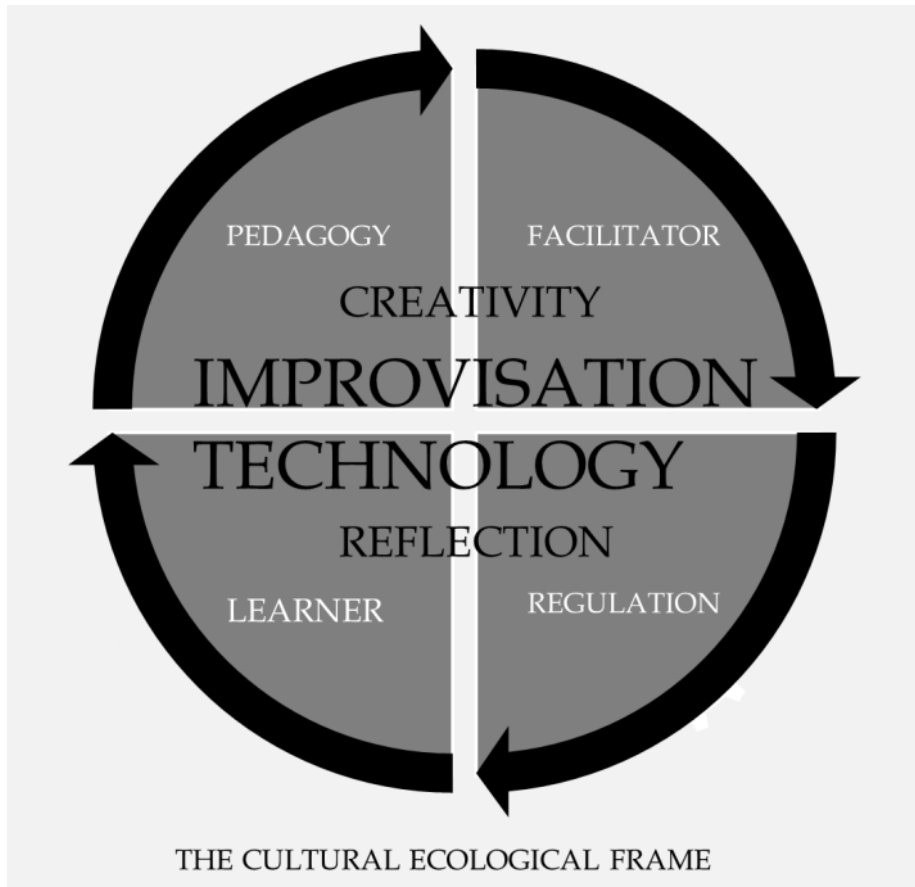
### **A Research and Development Agenda**

In order for new technological resources to change the dynamics of the cultural ecology of learning, they need to be reinforced through, for example, pedagogy and teacher-student relationships. Our earlier research has shown the importance of the involvement of teachers and students in the co-development of teaching and learning strategies. (Vesisenaho & Dillon, 2013) Student understanding of learning is crucial, and learning as a concept should be seen as a process of creative improvisation. However, the students do not always make the connections (Dillon et al, 2013). Co-development typically involves blending practices (including between physical and virtual situations) and community building. The vision is of pedagogy that stimulates rather than directs or focuses improvisation. Initial familiarisation and experimentation that is free of association with formalised structures may open up possibilities not just for creative improvisations but also for learning across the boundaries of institutions (e.g. school, college, home, the workplace, etc.) and physical and virtual situations.

Developing a technological infrastructure that supports these characteristics of

creative improvisation is challenging. There needs to be sufficient structure to realise goals, but there also has to be some flexibility, or more precisely adaptability, to support people in breaking out of routines and established ways of doing things (Dillon et al., 2013). In the jazz analogy, the song provides the essential form and structure and organizes what the musicians play. Improvisations happen as the musicians try out harmonies and slip in and out of the melody (King, 1997). So, whereas learning needs a 'song', a structure, it also must provide the opportunity of stepping in and out of it and of re-originating information, ideas, etc. Montuori (2003) calls this 'a dance of constraints and possibilities'. The technology developed needs to provide better tools for capturing and concretising creative improvisation in ways that are easy to process and redefine for use in new creative and innovative situations. Special emphasis is placed on ways that these tools support creative improvisation as a collaborative activity wherever needed.

We suggest design-based research (figure 3) as an appropriate framework for developing, testing, and refining ICT and support materials. Design-based research focuses on theory-driven design to generate complex interventions that also contribute to theory building and can be improved through empirical study (Design-Based Research Collective, 2003; Sandoval & Bell, 2004; Wang & Hannafin, 2005). Design-based research is situated in authentic learning contexts (Barab, 2006; Barab & Squire, 2004; Brown, 1992; Collins et al., 2004) where advances in theory and practice are generated through progressive improvement in skills and knowledge arising from attention to the detail of change in the research situation. Multiple overlapping and parallel forms of data, both quantitative and qualitative, including a unique interplay of data analytics and neuroscience research methods, are collected, increasing the reliability of the study and enabling emerging issues to be clarified (Barab, 2006). Analyses may lead to change in activity during the design process (Roth, 2005) allowing data collection to follow paths of non-linear thinking, non-traditional modes of operation, and emergent dimensions. This is both compatible with the cultural ecological frame and central to the characteristics of creative improvisation.



**Figure 3.** A design cycle within a cultural ecological framework

The research and development framework and agenda set out above would address a number of important questions concerning creative improvisation in learning. In the following, we outline some key questions and discuss how they can be approached (extended and refined from Dillon et al., 2013):

*1. What are the generalisable characteristics of creative improvisation and how are they related to ‘in the moment’ experiences?*

We have defined these characteristics in the article, but more research is in progress. One area of interest is the extent to which technological tools create ‘learning moments’ or ‘teachable moments’ (Watson et al., 2011) that open up new opportunities and enhance the learners’ motivation to explore new directions.

*2. What are the relationships between generalized characteristics of creative improvisation, ‘in-the-moment’ experiences, and realising under-utilised possibilities in learning situations?*

Vesisenaho and Dillon (2013) analysed lived experiences and abstractions in applying ICT in education with teacher students using the cultural ecology model. The study offered viewpoints about utilized and under-utilized potential emerging from lived experiences, but additional research cycles are needed to refine the model.

One approach to realising under-utilised possibilities in learning situations is that of identifying hidden capabilities and skills in different learners. Some promising experiences have been obtained from applying non-traditional teaching approaches such as game-based pedagogies to allow learners to express themselves in a broader range of ways (Nousiainen et al., 2015). This matter is worth further exploration also from the point of view of creative improvisation; when we design technological tools to facilitate improvisation, we should ensure that these tools are able to bring out individual learners’ capabilities and allow them to use their full potential as creative learners.

*3. How can knowledge about creative improvisation in learning be incorporated into the design of ICT tools?*

The developmental work needs a robust platform for building / linking tools and delivering them via the ubiquitous / web or mobile interfaces with pre-built functionalities that recognize a device and deliver content or tools adapted for that device. The platform also needs to incorporate a large selection of social media tools that can be utilised in developing pedagogical and workplace opportunities and providing support, ideas, and examples.

The development of networked mobile technologies could follow the ideas of the agile software development method. Agile software development mainly targets complex systems and projects with dynamic, non-deterministic and non-linear characteristics. These basic arguments and previous industrial experiences, learned from years of successes and failures, have helped shape agile software’s adaptive, iterative and evolutionary development (Larman, 2004). The approach fits well with the nature of creative improvisation because, applied to learning, final outcomes are not entirely predictable and the tool development is deeply dependent on pilot analysis and feedback from the end users.

*4. What is the added value of creative improvisation in education in terms of new knowledge, ideas and concepts, and new associations between existing ideas or concepts?*

The research of Havu-Nuutinen and Tahvanainen (2013), and Havu-Nuutinen et al. (2014) focuses on creativity, but creative improvisation and knowledge construc-



tion processes have similar features. When considering the role of creativity and ICT in early years' education, both creative learning processes and inquiry-based learning have similar foundations. Creative improvisation has high value in effective knowledge construction processes and supports the individual learning process.

When considering teachers' attitudes, competencies, and readiness to adopt mobile learning approaches, Rikala, Hiltunen and Vesisenaho (2014) identified teacher's pedagogical and technological beliefs and willingness to change as important factors. Lack of confidence reduced willingness to adopt mobile learning approaches. Similar results have been found in the context of game-based learning, but it was found that perceived educational ICT self-efficacy only predicted whether a teacher actually used game-based approaches, not whether he or she considered them valuable in general (Hamari & Nousiainen, 2015).

*5. How might unplanned incidents, so-called 'intuitive reactions' be accommodated within a structured and deliberated learning framework?*

The cultural ecology model/framework developed by Vesisenaho and Dillon (2013) offers a relevant basis for further research, but the data they had was limited. According to Erickson (2011), in order for creative improvisations to work in classroom settings, the teacher and the students need to share the same understanding of the pre-existing structures guiding the improvisation. This will allow 'teachable moments' - that is, unexpected events that reveal an opportunity for learning - to be built and expanded upon in a meaningful way (c.f. Watson et al., 2011).

From our perspective, one especially interesting question pertains to the relationship between situational, ad hoc improvisation (Holdhus et al., 2016; Magni & Maruping, 2013) and more structured forms of creative improvisation (e.g. Dillon et al., 2013), and whether and how these could be supported with technological tools. In organizational contexts, Cunha, Neves, Clegg, and Rego (2015) refer to ad hoc improvisations as episodic; they respond to a certain unexpected event or episode, vanishing after the act. On the other hand, semi-structured improvisations are more formal and framed, closely related to an organisation's strategy related to responding to spontaneous departures and unexpected opportunities. When looking at the interplay between these different forms of improvisation, technological tools could play a role when we aim to understand "how isolated micro-responses may eventually give rise to organisational, macro-learning, improvisatory capabilities" and to facilitate this transformation (Cunha et al., 2015, p. 12).

*6. How can it be ensured that creative improvisation in learning, although free and extemporaneous, has a kind of logic and context that links with established elements of teaching and learning and makes them coherent?*

Future skills are not just subject-based, they include, for example, competences such as flexibility, adaptability, initiative, and self-direction (Partnership for 21st Century Learning, 2015); phenomenon-based new curricula (Lonka, 2015; cf. Kearney, 2014); and learning processes blending formal and informal elements (e.g. Vesisenaho & Dillon, 2013; Vesisenaho et al., 2010). For example, Voogt and Pareja Roblin (2012) have made an extensive summary of research on future learning and 21st century skills.

The distinction between creativity and innovation is that the process of innovation is inherently collective, and it entails both ‘creation’ and ‘implementation’ (Oddane, 2015). Innovations are a final output of creative improvisation. There are several questions to be addressed related to the theme: What kind of environment is needed to move from creative improvisation to innovation? What is the role of data gathering and connection tools (i.e., technology) in boosting the processes and making them coherent?

Learning analytics and tools for providing relevant feedback play an important role in the processes of capturing, consolidating and transferring ideas. Such approaches seek to combine data from multiple sources, interpret this and determine key intervention points for the benefit of learners and to use analytics to determine patterns of behaviour and link them in meaningful ways (see Ferguson, 2012; Siemens & Long, 2011).

*7. How can (i) creative improvisation facilitated through ICT tools and (ii) networked mobile technology tools in support of creative improvisation be adapted to local contents and services to ensure localisation / contextual sensitivity in education and business?*

Havu-Nuutinen et al. (2014) studied local environments in early years’ science. The pupils took photos with iPads and had opportunities to use them creatively. The technology provided a new perspective for learning and increased creative improvisation among the children’s learning process. Earlier studies have also explored infrastructures for collaboration and networking across systems, countries and disciplines, placing emphasis on self-organised learning, which is an implied characteristic of creative improvisation (e.g. Klobucar, 2008; Nguyen-Ngoc & Law, 2007).

It is possible to take into account the personal learning paths and contextualize and sustain them for local contexts. Mobile technologies that allow individual or collaborative processes to occur across many contexts provide opportunities for supporting localisation, contextualisation and personalisation of learning, for example, by making it possible to explore and interact with location-related information (c.f. Sharples et al., 2007; So et al., 2008; Stanton & Ophoff, 2013). Another matter of interest is how the technologies can be designed to support equitable co-located and remote learning collaboration (Adams et al., 2010).

Personalisation may also be facilitated through open educational resources, with

pedagogical designs that allow learners to use open content to work collaboratively and to structure their own learning pathways in various formal and informal learning settings. Such approaches prepare the ground for enabling the elaboration of ideas. (cf. e.g. Conole et al., 2009; Green et al., 2005; Sutinen & Vesisenaho, 2006; Vesisenaho & Dillon, 2013).

Creatively improvised, collaboratively elaborated, learning processes are a challenge, but they offer great opportunities for unexpected new openings.

## References

- Adams, A., Coughlan, T., Lea, J., Rogers, Y., Davies, S. & Collins, T. (2011). Designing interconnected distributed resources for collaborative inquiry based science education. In *Proceedings of the IEEE/ACM Joint Conference on Digital Libraries (JCDL)*; pp. 395–396. ACM.
- Adams, A., Davies, S., Collins, T. & Rogers, Y. (2010). Out there and in here: design for blended scientific inquiry learning. In *Proceedings of the 17th Association for Learning Technology Conference (ALT-C 2010)*. Retrieved from [http://oro.open.ac.uk/27397/3/out\\_there\\_and\\_in\\_here.pdf](http://oro.open.ac.uk/27397/3/out_there_and_in_here.pdf) 3.11.2017.
- Addressi, A. R. (2013). Child/machine interaction in reflexive environment. The MI-ROR platform. In R. Bresin (Ed.), *Proceedings of the Sound and Music Computing Conference 2013 (SMC2013)*; pp. 95–102. Berlin, Germany: Logos Verlag Berlin GmbH.
- Anagnostopoulou, C., Alexakis, A., & Triantafyllaki, A. (2012). A computational method for the analysis of musical improvisations by young children and psychiatric patients with no musical background. In E. Cambouropoulos, C. Tsougras, P. Mavromatis, K. Pasiadis (Eds.), *Proceedings of the 12th International Conference on Music Perception and Cognition and the 8th Triennial Conference of the European Society for the Cognitive Sciences of Music (ICMPC and ESCOM)*; pp. 64–68. Retrieved from [http://icmpc-escom2012.web.auth.gr/sites/default/files/papers/64\\_Proc.pdf](http://icmpc-escom2012.web.auth.gr/sites/default/files/papers/64_Proc.pdf) 3.11.2017
- Arrigo, M., Di Giuseppe, O., Fulantelli, G., Gentile, M., Merlo, G., Seta, L. & Taibi, D. (Eds.) (2010). *MOTILL Mobile technologies in lifelong learning: Best practices*. Palermo, Italy: Italian National Research Council - Institute for Educational Technology. Retrieved from [http://motill.eu/images/stories/motillbooklet\\_en.pdf](http://motill.eu/images/stories/motillbooklet_en.pdf) 3.11.2017
- Barab, S. A. (2006). Design-based research: A methodological toolkit for the learning scientist. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 153–169). New York, US: Cambridge University Press.
- Barab, S. & Squire, K. (2004). Design-based research: Putting our stake in the ground. *Journal of the Learning Sciences*, 13(1), 1–14.
- Barrett, F.J. (1998). Creativity and improvisation in jazz and organizations: implications for organizational learning. *Organization Science*, 9(5), 605–622.
- Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges

- in creating complex interventions. *Journal of the Learning Sciences*, 2(2), 141–178.
- Brown, J.S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18(1), 32–42.
- Cardoso de Araujo, R., & Addressi, A.R. (2012). *A study about children's musical improvisation in an interactive reflexive musical context*. Paper presented at the 30th ISME World Conference in Music Education, Thessaloniki, Greece. Retrieved from [http://www.mirrorproject.eu/content/docup/SimCam\\_CARdosos%20Addressi,%202013.Definit.pdf](http://www.mirrorproject.eu/content/docup/SimCam_CARdosos%20Addressi,%202013.Definit.pdf) 3.11.2017
- Clark, P. G. (2009). Reflecting on reflection in interprofessional education: Implications for theory and practice. *Journal of Interprofessional Care*, 23(3), 213–223.
- Coker, J. (1964). *Improvising jazz*. New York, US: Simon & Schuster.
- Collins, A., Joseph, D. & Bielacysc, K. (2004). Design research: Theoretical and methodological issues. *The Journal of Learning Sciences*, 13(1), 15–42.
- Conole, G., Wilson, T. McAndrew, P., Culver, J., Brasher, A. & Cross, S. (2009). New methods and approaches to the design and evaluation of open educational resources. In *Proceedings of EDEN Annual Conference 2009*. Retrieved from [http://oro.open.ac.uk/21131/1/olnet\\_workshop\\_abstract\\_final.pdf](http://oro.open.ac.uk/21131/1/olnet_workshop_abstract_final.pdf) 3.11.2017
- Coughlan, T., van der Linden, J. & Adams, A. (2012). Local connections: designing technologies for discovery and creativity within the community. *Interactions*, 19(1), 18–22.
- Crossan, M. M. & Sorrenti, M. (1997). Making sense of improvisation. *Advances in Strategic Management*, 14, 155–180.
- Cunha, M. P., Neves, P., Clegg, S. R., & Rego, A. (2015). Tales of the unexpected: Discussing improvisational learning. *Management Learning*, 46(5), 511–529.
- Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P. & Howe, A. (2013) Creative learning environments in education – A systematic literature review. *Thinking Skills and Creativity*, 8, 80–91.
- Daele, A., Erpicum, M., Esnault, L., Pironet, F., Platteaux, H., Vandeput, E. & Van de Wiele, N. (2006). An example of participatory design methodology in a project which aims at developing individual and organisational learning in communities of practice. In E. Tomadaki and P. Scott (Eds.), *Innovative approaches for learning and knowledge sharing 2006. Workshops proceedings* (EC-TEL; pp. 272–277). Retrieved from <http://ceur-ws.org/Vol-213/paper39.pdf> 3.11.2017
- Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 32(1), 5–8.
- Dillon, P. (2008). Creativity, wisdom and trusteeship – niches of cultural production. In A. Craft, H. Gardner & G. Claxton (Eds.), *Creativity and wisdom in education* (pp.105–118). Thousand Oaks, CA, US: Corwin Press.
- Dillon, P. (2012). Framing craft practice cultural ecologically: tradition, change and emerging agendas. In M. Ferris, (Ed), *Making futures: The crafts as change-maker in sustainably aware cultures* (pp. 72-78). Retrieved from [https://www.researchgate.net/publication/283707901\\_Framing\\_craft\\_practice\\_cultural\\_eco](https://www.researchgate.net/publication/283707901_Framing_craft_practice_cultural_eco)

logically\_tradition\_change\_and\_emerging\_agendas 3.11.2017

- Dillon, P. & Loi, D. (2008). Adaptive educational environments: theoretical developments and educational applications. *UNESCO Observatory Refereed E-Journal*, 3.
- Dillon, P., Wang, R., Vesisenaho, M., Valtonen, T. & Havu-Nuutinen, S. (2013). Using technology to open up learning and teaching through improvisation: Case studies with micro-blogs and short message service communications. *Thinking Skills and Creativity*, 10, 13–22.
- Erickson, F. (2011). Taking Advantage of Structure to Improvise in Instruction: Examples from Elementary School Classrooms. In R. K. Sawyer (Ed.), *Structure and Improvisation in Creative Teaching* (pp. 113–132). New York: Cambridge University Press.
- Ferguson, R. (2012). Learning analytics: drivers, developments and challenges. *International Journal of Technology Enhanced Learning*, 4(5/6), 304–317
- Franklin, J. A. (2001). Learning and improvisation. In T. Dietterich, S. Becker, & S. Ghahramani (Eds.), *Neural information processing systems*, 14. Cambridge, MA, US: MIT Press. Retrieved from <http://papers.nips.cc/paper/2079-improvisation-and-learning.pdf> 3.11.2017
- Gibbs, G. (1988). *Learning by Doing: a guide to teaching and learning methods*. London, UK: Further Education Unit.
- Gould, S.J.J., Furniss, D.J., Jennett, C.I., Wiseman, S., Iacovides, I. & Cox, A.L. (2014). MOODs: building massive open online diaries for researchers, teachers and contributors. In Conference on Human Factors in Computing Systems. In *Extended Abstracts on Human Factors in Computing Systems 2014* (CHI EA '14; pp. 2281–2286). New York, US: ACM.
- Green, H., Facer, K., Rudd, T., Dillon, P & Humphreys, P. (2005). *Personalisation and Digital Technologies*. Bristol, UK: Futurelab. Retrieved from [http://www.futurelab.org.uk/resources/documents/opening\\_education/Personalisation\\_report.pdf](http://www.futurelab.org.uk/resources/documents/opening_education/Personalisation_report.pdf) 3.11.2017
- Hamari, J. & Nousiainen, T. (2015). Why Do Teachers Use Game-Based Learning Technologies? The Role of Individual and Institutional ICT Readiness. In *Proceedings of the 48th Hawaii International Conference on System Sciences* (pp. 682–691). Washington, DC, US: IEEE.
- Havu-Nuutinen, S., & Tahvanainen, S. (2013). D4.3 *Country reports. Country report on the in-depth field work in Finland*. Retrieved from [http://www.creative-little-scientists.eu/sites/default/files/02\\_Country%20Report\\_Finland.pdf](http://www.creative-little-scientists.eu/sites/default/files/02_Country%20Report_Finland.pdf) 3.11.2017
- Havu-Nuutinen, S. Fiqueras, K. Järvinen, H. Kontkanen, S. Kummunmäki, M. Pöntinen, S. Rätty-Zaborsky, Savolainen, R. & Valtonen, T. (2014). Children as creative natural scientists-ICT tools in early years' science education. In H. Juuso, A.Lindt, M. Hasari, K. Kumpulainen, K-P. Lapinoja, P. Pirilä, S. Raappana & O. Tiainen, O. (eds.), *Research-based school and teacher education* (pp. 74–83). Publications of Finnish Teacher Training Schools.
- Holdhus, K., Høisæter, S., Mæland, K., Vangsnes, V., Engelsen, K.S., Espeland, M.



- & Espeland, Å. (2016). Improvisation in teaching and education – roots and applications, *Cogent Education*, 3(1). Retrieved from <https://doi.org/10.1080/2331186X.2016.1204142> 3.11.2017
- Karampiperis, P., Koukourikos., A., & Panagopoulos G. (2014). *Creative stories: A storytelling game fostering creativity*. Paper presented at the 11th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2014), Porto, Portugal. Retrieved from <http://cru.iit.demokritos.gr/sites/cru.iit.demokritos.gr/files/IC75.pdf> 3.11.2017
- Kearney, C. (Ed). (2014) *Keyconet's conclusions and recommendations for strengthening key competence*. Development in policy and practice. European Schoolnet. Retrieved from [http://keyconet.eun.org/c/document\\_library/get\\_file?uuid=78469b98-b49c-4e9a-a1ce-501199f7e8b3&groupId=11028](http://keyconet.eun.org/c/document_library/get_file?uuid=78469b98-b49c-4e9a-a1ce-501199f7e8b3&groupId=11028) 3.11.2017
- Keller, B., Jones, S., Thom, B. & Wolin, A. (2006). *An interactive tool for learning improvisation through composition*. Technical Report HMC-CS-2005-02. Harvey Mudd College. Retrieved from <http://www.cs.hmc.edu/~keller/jazz/improvisor/ImprovisorPaperRev04.pdf> 3.11.2017
- King, J (1997). *What Jazz is? An insider's guide to understanding and listening to jazz*. England: Penguin.
- Klobucar, T. (2008). iCamp Space – An environment for self-directed learning, collaboration and social networking. *WSEAS Transactions on Information Science and Applications*, 5 (10), 1470–1479.
- Larman, C. (2004). *Agile and iterative development: A manager's guide*. Boston, Addison-Wesley.
- Lave, J. & E. Wenger (1991). *Situated learning - Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
- Limanauskiene, V. & Stuiikys. V. (2009). The enhancement of reusability of course content and scenarios in unified e-Learning environment for schools. *Electronic Journal of e-Learning*, 7(2), 137-146. Retrieved from <http://issuu.com/academic-conferences.org/docs/ejel-volume7-issue2-article148> 3.11.2017
- Loi, D. & Dillon, P. (2006). Adaptive educational environments as creative spaces. *Cambridge Journal of Education*, 36(3), 363–381.
- Lonka, K. (2015). Working document I. In European Parliament (Ed.), *Innovative Schools: Teaching & Learning in the Digital Era – Workshop Documentation* (pp. 5–46). Brussels: European Parliament. Retrieved from [http://www.europarl.europa.eu/RegData/etudes/STUD/2015/563389/IPOL\\_STU\(2015\)563](http://www.europarl.europa.eu/RegData/etudes/STUD/2015/563389/IPOL_STU(2015)563) 3.11.2017
- Magni, M. & Maruping, L. (2013). Improvisation in working teams: how empowering leadership and overload matter. *Human Resource Management*, 52 (5), 715–739.
- Moorman, C. & Miner, A. (1998). Organizational improvisation and organizational memory. *Academy of Management Review*, 23(4), 698–723.
- Montuori, A. (2003). The complexity of improvisation and the improvisation of complexity: Social science, art and creativity. *Human Relations*, 56(2), 237–255.
- Nguyen-Ngoc, A. V., & Law, E.L.-C. (2007). Evaluation of cross-cultural computer-supported collaborative learning: Preliminary findings for iCamp challenges. In

- C. Montgomerie & J. Seale (Eds.), *Proceedings of EdMedia: World Conference on Educational Media and Technology 2007* (pp. 1887–1896). Association for the Advancement of Computing in Education (AACE).
- Nousiainen, T., Vesisenaho, M., & Eskelinen, P. (2015). “Let’s do this together and see what we can come up with!” : Teachers’ Views on Applying Game-based Pedagogy in Meaningful Ways. *eLearning Papers*, 44, 74–84.
- Oddane, T. A. W. (2015). The collective creativity of academics and practitioners in innovation projects. *International Journal of Managing Projects in Business*, 8(1), 33–57.
- Partnership for 21st Century Learning. (2015). P21 Framework Definitions. Retrieved from [http://www.p21.org/storage/documents/docs/P21\\_Framework\\_Definitions\\_New\\_Logo\\_2015.pdf](http://www.p21.org/storage/documents/docs/P21_Framework_Definitions_New_Logo_2015.pdf) 3.11.2017
- Perteneder, F., Hahnwald, S., Haller, M. & Gaubinger, K. (2013). Systematic integration of solution elements: How does digital creativity support change group dynamics? In P. Kotzé, G. Marsden, G. Lindgaard, J. Wesson & M. Winckler (Eds.), *Human-Computer Interaction – INTERACT 2013, Proceedings, Part I, Lecture Notes in Computer Science 8117* (pp. 547–565). Heidelberg, Germany: Springer.
- Peters, G. (2009). *The philosophy of improvisation*. Chicago, US: Chicago University Press.
- Rikala, J., Hiltunen, L., & Vesisenaho, M. (2014). Teachers’ attitudes, competencies, and readiness to adopt mobile learning approaches. In *Proceedings of 2014 IEEE Frontiers in Education Conference 2014* (pp. 2529–2536). IEEE.
- Rogers, A. (2002). *Learning and adult education*. In R. Harrison, F. Reeve, A. Hanson, A. & J. Clarke (Eds.), *Supporting lifelong learning* (pp. 8–24). London, UK: RoutledgeFalmer / The Open University.
- Roth, W. (2005). *Doing Qualitative Research: Praxis of Methods*. Rotterdam, NL: Sense Publishers.
- Sandoval, W. A., & Bell, P. (2004). Design-based research methods for studying learning in context: Introduction. *Educational Psychologist*, 39(4), 199–201.
- Sawyer, R.K. (2004). Creative teaching: collaborative discussion as disciplined improvisation. *Educational Researcher*, 33(2), 12–20.
- Sharples, M., Taylor, J., & Vavoula, G. (2007). A theory of learning for the mobile age. In R. Andrews & C. Haythornthwaite (Eds.), *The Sage Handbook of E-Learning Research* (pp. 221–247). London: Sage.
- Siemens, G., & Long, P. (2011). Penetrating the fog: Analytics in learning and education. *Educause Review*, 46(5), 30–32.
- So, H.-J., Kim, I., & Looi, C.-K. (2008). Seamless mobile learning: Possibilities and challenges arising from the Singapore experience. *Educational Technology International*, 9(2), 97–121.
- Stanton, G., & Ophoff, J. (2013). Towards a method for mobile learning design. *Issues in Informing Science and Information Technology*, 10, 501–523.
- Sternberg, J. R. & Lubart I. T. (1999). The concept of creativity: Prospects and paradigms. In J. Sternberg (ed.), *Handbook of creativity* (pp. 3–16). Cambridge, UK:



Cambridge University Press.

- Sutinen, E. & Vesisenaho, M. (2006) Ethnocomputing in Tanzania: Design and analysis of a contextualized ICT course. *Research and Practice in Technology Enhanced Learning*, 1(3), 239–267.
- Valtonen, T., Dillon, P., Hacklin, S. & Väisänen, P. (2010). Net generation at social software: challenging assumptions, clarifying relationships and raising implications for learning. *International Journal of Educational Research*, 49(6), 210–219.
- van Rosmalen, P., Boon, J., Bitter-Rijkema, M., Sie, R. & Sloep, P. (2014). Supporting co-creation with software, the idSpace platform. *Computers in Human Behavior*, 37, 413–422.
- Vesisenaho, M. (2009). *Developing contextualized ICT education*. Case Tumaini University, Tanzania. Köln, Germany: Lap Lambert Academic Publishing,
- Vesisenaho, M. & Dillon, P. (2009). Information and communication technology contextualised in a cultural ecological view of learning. In *Proceedings of the 39<sup>th</sup> Frontiers in Education conference (FIE 2009)*; pp. T4D1–5). St. Antonio, US: IEEE.
- Vesisenaho, M. & Dillon, P. (2013). Localizing and contextualizing information and communication technology in education: A cultural ecological framework. *Pedagogy, Culture & Society*, 21(2), 239–259.
- Vesisenaho, M., Dillon, P. & Valtonen, T. (2011). Collaboratively constructed lecture notes. Does the process of construction promote improvisation in learning? In *Proceedings of Koli calling international conference on computing education research* (pp. 107–111). New York, US: ACM.
- Vesisenaho, M., Valtonen, T., Kukkonen, J., Havu-Nuutinen, S., Hartikainen, A. & Kärkkäinen, S. (2010). Blended learning with everyday technologies to activate students' collaborative learning. *Science Education International* 12(4), 272–283.
- Voogt, J. & Pareja Roblin, N. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies* 44(3), 299–321.
- Wang, F. & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development*, 53(4), 5–23.
- WATCHME. (2014). WATCHME. Project summary. Retrieved from <http://www.project-watchme.eu/aim-summary-and-components/> 3.11.2017
- Watson, W. R., Mong, C. J., & Harris, C. A. (2011). A case study in-class use of a video game for teaching high school history. *Computers & Education*, 56, 466–474.
- Wolff, A. & Zdenek, Z. (2012). Improving retention by identifying and supporting “at-risk” students. *Educause Review Online*. Retrieved from <http://www.educause.edu/ero/article/improving-retention-identifying-and-supporting-risk-students> 3.11.2017
- Xu, Y., Perteneder, F., Leong, J., Schwaiger, E.-M., & Haller, M. (2014). Using grid visualization to organize visual data. In *Proceedings of the Second International Symposium of Chinese CHI* (pp. 50–56). New York, NY, US: ACM.