LEARNINGSHIFT

STATE OF THE ART AND FUTURE TRENDS ON LEARNING

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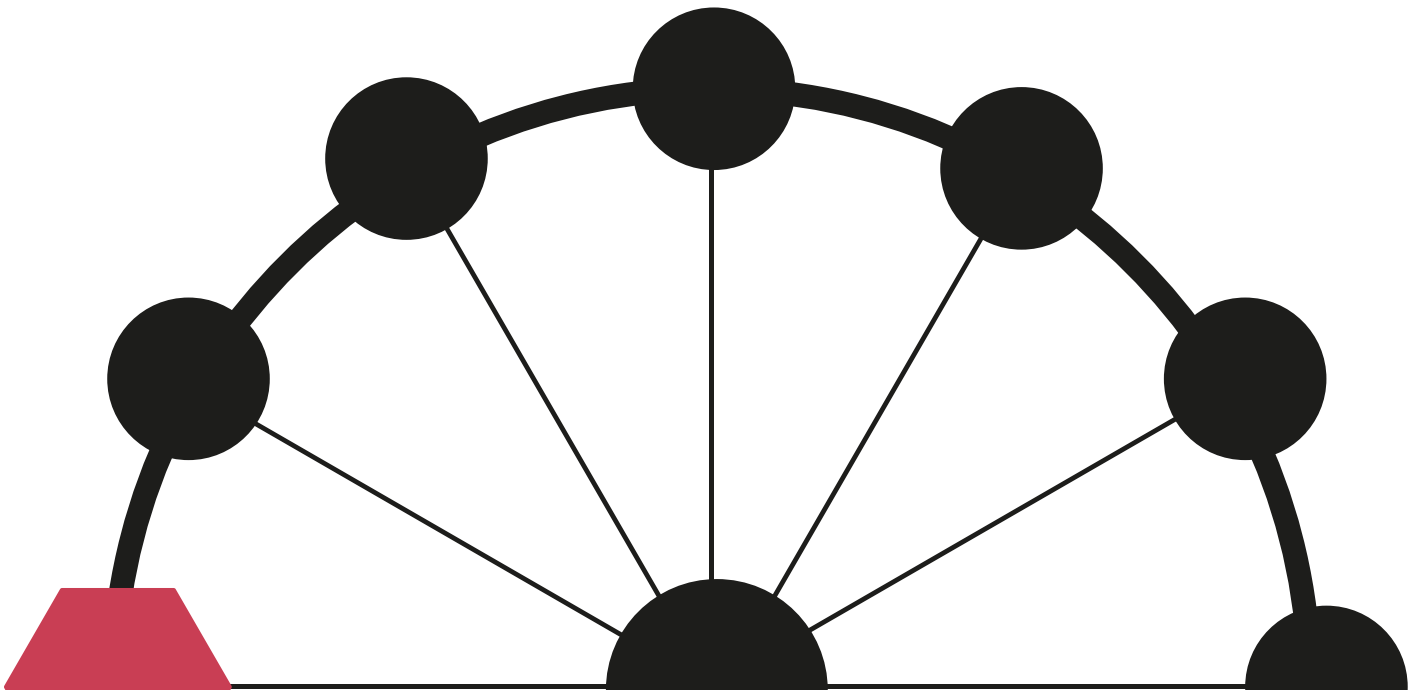

TITLE

LEARNINGSHIFT – State of the Art and future trends on learning

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SCOPE

LEARNINGSHIFT is an international project, supported by the European Commission under the Erasmus+ programme, and aims to equip educators and, through them, the learning organisations/communities with the knowledge, attitudes and competences required to design, set and facilitate learning experiences to nurture the 21st century competences development.

In this context, this document is a synthesis report about learning innovation and the future of learning and intends to set the foundations of the Future of Learning Lab – an online learning experience to empower educators as facilitators and change makers.

PARTNERS

Advancis (Portugal), Aalborg University (Denmark), Autens (Denmark), Tampere University of Applied Sciences (Finand), Kaunas University of Technology (Lithuania), CICCOPN (Portugal) are working to create and make available open educational resources to equip educators for the future of learning.

CO-FUNDING

Co-funded by the Erasmus+ Programme of the European Union

INTRODUCTION

Fuelled by a change in society's needs and values a major paradigm shift has been unfolding and accelerating in education drawing on ancient as well as modern pedagogical thought, and the advent of new disruptive technologies.

Robert Barr and John Tagg in their seminal article on the paradigm shift in education (1995) introduced the notion of a paradigm shift moving from an instructional teaching paradigm towards a learner-centered paradigm with great emphasis of the active participation on the learner and development of new roles of the teacher and the learner.

The advent of new technologies has furthered this paradigm shift by facilitating new ways of knowledge representation, self-expression and collaboration. There is, however, a gap between the potentials of new approaches to learning and the actual implementation in a lifelong learning perspective.

The European Erasmus+ project LEARNINGSHIFT is aiming at identifying and making available new pathways of learning through teacher competence development.

The purpose of this state-of-the-art and future trends report is, drawing on themes identified in the exemplary cases on innovative trends from the participating countries, to provide a compass for the themes for educational development to be implemented to meet the competencies proposed in the frameworks for 21st century skills.

The report is based on a qualitative thematic exploration of case-studies of innovative learning conducted by the project partners in the 4 countries and of reviews of reports from the EU, OECD, and relevant scientific literature - to present a baseline of current innovative practice and first-mover trends in relation to developing the educational landscape of the 21st century.

This document will provide a focus for a visionary document to inspire teacher development towards 21st century competencies.

This report looks both at relevant elements from prescriptive frameworks for 21st century skills that have been developed and trends which have been identified through commissioned international research and policy reports that are tasked with guiding the future development of education at both a K12 and Higher Education. Since educational trends are global, we are including material from relevant state-of-the-art and

forecasting papers from Europe as well as US, Canada and Australia.
This report is however explicitly directed towards providing a compass for further development, providing insight into existing innovative practices and challenges for the implementation.

While forecasting is often done with a view toward short time, medium and long-term developments, in this report the main focus is on mapping the near future based on identifying innovation in education in the partner countries with innovators and early adopters (Rogers, 2003). It also draw on practices that have been developed over a long term, like PBL which now playing an important role as catalyst in relation to implementation of 21st century skills in authentic learning tasks.

CONTEXT

It is estimated that by 2020, half of the core skills we do not consider important today, will be highly important by then. This situation requires new strategies and approaches for teacher training programmes and not continuing under the traditional industrial ways of training. The purpose of the project LEARNINGSHIFT is to invoke a change of paradigm in education by supplying knowledge and empowering educators to be changemakers.

The change in the educational system and the attitude towards learning starts with the educators - development of talent must be at the focus, and the LEARNINGSHIFT project seeks to equip educators with the knowledge necessary to nurture the development of 21st century competencies in the future workforce.

The partners in the project LEARNINGSHIFT come from Universities and vocational training institutions in four European Countries: Kaunas University of Technology in Lithuania,CICCOPN and Advancis Business Services in Portugal,Tampere University of Applied Sciences in Finland, Aalborg University and Autens in Denmark, and bring complementary competencies to the project.

THE THEMES

The landscape of education is changing rapidly to meet the challenges of the 21st century. This report is aimed at identifying prevalent themes in innovative education based on exemplary cases provided by the project partners triangulated with desk research drawing on research, reports and forecasts conducted by national and international agencies. The four partner countries: Portugal, Finland, Lithuania and Denmark have contributed with exemplary cases of education in innovation, where they have provided cases from their practice that they deemed relevant.

The cases were structured around the following issues: why, the major reasons for choosing the case; situation/context; challenges, change needs or development; the solution, which presents the strategy and scenario; results; major points/lessons learnt.

The cases were subjected to thematic analysis and themes were identified that were relevant to the scope and goals of the project.

In the following sections, the themes that have been identified will be outlined. The themes are all related to the notion of agents for change and how they can be used in developing 21st century learning. Employed by the teachers and learners the thematic approaches acts as catalysts in relation to changing education towards 21st century learning, and indicates areas of professional development to fully achieve the inherent potentials. Based on the themes a model is developed that can be seen as a compass for innovative learning focusing on the different themes that are in play in the partner institutions and can important in professional development for 21st century learning. In the following sections, the elements of the themes will be expanded upon, towards devising thematic areas to be in focus in teacher competence development - towards a compass for a learning shift towards meaningful learning for teachers and learners.

THE 4CS

Several frameworks for 21st century skills have been developed, the most prominent being the Partnership for the 21st century (P21) developed in the US.

Recurring elements in these frameworks (Dede 2010) are the Learning and Innovation skills: Collaboration, Communication, Creativity and Critical thinking, (4C's) represented as the essential skills of 21st century Education. The 4C's are endorsed by US government and being included in national educational policies in the EU and globally as important skills to develop regarding future employability, and active citizenship, however standard classroom teaching is often based on traditional instructional models of teaching. However many in-service teachers have not been taught how to develop lessons implementing them.

In the following, we will present the 4 C's as relevant elements for 21st century learning:

Collaboration

A widely-used definition for collaboration is "[...] the activity of working together towards a common goal."(Hesse, Care, Buder, Sassenberg & Griffin et al., 2015, p. 38, as cited in P21, 2017). A report by OECD (2013) defines collaborative problem-solving capacity as the "capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution. "

Dillenbourg (1999) defines collaboration as"a situation in which two or more people learn or attempt to learn something together."

Collaboration in a learning environment enhances the possibility for the desired outcome for the individual and their achievement of a cognitive outcome (P21, 2017). As discussed earlier, the acquiring of knowledge and ability to solve problems in the current and future workplaces stands at the core of 21st-century skills; collaboration is therefore viewed as a way for the individual to succeed in problem-solving and enhancing their intellectual development (P21, 2017). The cognitive process is a key area when describing the content of 21st-century skills and discussing the related learning persa-

nother barrier is found in developing assessments for creativity with school practice and culture being affected "[...] as it is both an enabler and a barrier for creative learning and innovative teaching." (Cachia et al., 2010), putting teachers in a position of a key role in developing learners' creative learning through innovative teaching. This furthermore stresses the need for reformed curricula to clearly define how teachers should approach and teach the content as much as it defines what should be taught (Cachia et al., 2010).pective of acquiring these skills.

There are implications when applying collaboration in the learning environment and in the P21 research is presented from Kuhn's (2015) review of research (as cited in P21, 2017) from collaboration-as-pathway. It is stated that not every student will benefit from collaboration, as some might benefit better from individual work. Furthermore, the study of effects in collaborative work is complicated – there is the possibility of there being one skilled student driving the rest of the group forward or dominating the division of activities amongst group members (P21, 2017).

Child and Stuart (2016) points to "the important distinction between the collaborative process (which is demonstrated within the collaborative activity) and the outcome (which is demonstrated by the quality of the knowledge or understanding of the group members)", and discusses its implications for the assessment of 21st century learning.

According to Shute and Becker (2010) the collaborative competencies should go beyond the cognitive and include socio-emotional skills: .....the envisioned new competencies should include not only cognitive variables (e.g., critical thinking, reasoning skills) but also non-cognitive variables (e.g., teamwork, tolerance, tenacity) as the basis for new assessments to support learning.

Collaboration is a skill to be learned, and to fully take advantage of its implications for student-centred learning; collaboration may have to be scaffolded with a focus on the development of social skills to support the process.

Communicative skills

Technology has transformed the way we communicate – previously communication

research has focused on teacher-student communication with educational television aimed at the part of the population with communicative impairments doing the same. Future intervention must base themselves on the fact that society evolves and "[...] we can no longer assume communicative competence is something that our students will learn "on their own."(P21, 2017, p. 1).

With a wide variety of technologies appearing, computer-mediated communication (CMC) has gained attention – individuals can now communicate through and with technology, now moving away from teacher-to-student communication to inter-student communication (P21, 2017).

For schools to focus on classroom communication is important on the basis of communication is a key component in 21st century skills, especially interpersonal immediacy behaviours have proven useful in classroom communication with student motivation and satisfaction increasing when using teacher immediacy, meaning responsive behaviour as nodding, eye contact and in general acknowledgement of the student (P21, 2017).

As mentioned, technology today plays a significant role when we communicate, and it is therefore of utmost importance for educational institutions to create an environment in which students can acquire the necessary skills for communicating in a digitized world. Technology today presents a before unimaginable aspect of communication for past generations – it needs to be taught how to safely and responsibly use technology when communicating today which requires protocols and norms of the many different digital tools that exist and intrapersonal communicative skills needed to interact with a diverse group of people (P21, 2017).

Though requiring new frameworks for learning, technology provides unique possibilities for facilitating communication and collaboration amongst students. By creating access to online communities, it fosters the exchange of ideas and practices among both educators and students – "Digital teaching platforms have been found to provide powerful support for collaborative learning.... Since representations of student thinking

and work can be rapidly distributed in a networked classroom, teachers have the opportunity to direct everyone's attention to specific participants and their contributions." (Dede, 2014, as cited in Ontario, 2016, p. 35).

Schools can no longer ignore the impact of technology on how students today interact with the world – it has become such an embedded part of modern youths' lifestyle that for schools to stay relevant, they have to find a way to incorporate these new technologies into the curriculum. These innovations that connect us require new skills, knowledge and social behaviours to make sure these tools promote deeper learning (Ontario, 2016).

Creative classrooms

When addressing the concept of creativity, there are many different definitions, with some convergence on whether it is defined from the perspective of the process or the product of the creativity. Stein (1953) has defined it as "that process which results in a novel work that is accepted as tenable or useful or satisfying by a group at some point in time."

Plucker, Beghetto and Dow (2004) defined it (as cited in P21, 2017, p. 1) being "Creativity is the interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context."

Though the topic of creativity presents a wide variety of definitions, they do share common features with the example of these two definitions both being based on the importance of the social context of the work being done and how well it is accepted at that given time. Nevertheless, creativity is a key 21st-century skill and it is a globally desired outcome for many educational institutions looking to implement creativity in the learning environment to ready their students for the knowledge-based and highly innovative economies (P21, 2017).

A Vygotskian social-constructivist approach has provided an understanding of creativi-

ty as human competence that can be developed (Vygotsky, 2004) and how the human creative behaviour "makes the human being a creature, oriented toward the future, creating the future and thus altering his own present"

Adobe a world leader in creative technologies, did a 2016 survey on Gen Z in the Classroom: Creating the Future which found (Adobe 2016) that: A vast majority of teachers as well as students wish that there was more of a focus on creativity in the classroom; that creativity as essential to students' future careers; that their careers will involve creating; that they very likely to have careers that does not exist today; and that they learn best by creating and hands-on experiences.

So which role does creativity play in existing approaches to education? Enhancing students' creative competence requires that some conditions are met and taken into account in educating students. Research points to personal and environmental factors influencing creative development and enhancement – an example of these environments being the learning environment that educators can use to support some key personal factors in students creating a pathway for creative confidence, willingness to take risks, and knowledge-development (P21, 2016). Then the challenge educators face, is utilizing the learning environment to support creative learning, which brings us to defining what defines a creative classroom.

The creative classroom is defined by two concepts, innovation and creativity; more specifically innovative teaching and creative learning (Bocconi et al., 2012), innovative teaching meaning addressing creativity and applying it to teaching methods and the content, whereas creative learning is more oriented towards developing learners' thinking skills and providing them tools to learn in new creative ways. As with the necessity of 21st-century skills to compete in an ICT embedded world, "'Creative classrooms' are innovative learning environments that fully embed the potential of ICT to innovate and modernize learning and teaching practices." (Bocconi et al., 2012, p. 7).

Research has shown that there are some major obstacles to implementing creative learning in education – one barrier identified by educational stakeholders is the issue of subjects through curricula still being addressed separately. The amount of content knowledge is addressed by teachers as a problem, and an overloaded curriculum is assessed by experts to be a major factor in the lack of flexibility, risk and innovation needed in the creative classroom (Cachia, Ferrari, Mutka & Punie, 2010).

Creative inquiry - makerspaces

When addressing creative inquiry, makerspaces have gained serious momentum in recent years in schools worldwide. Makerspaces are physical environments where technologies are enabling opportunities for hands-on learning and creation that foster the development of 21st century skills. These maker spaces are leveraged by educators to engage learners in problem-solving through design, construction and iteration - producing innovative solutions to pressing issues in the world is at the core of makerspaces (Horizon K-12 edition, 2017).

Technology in makerspaces are only enablers in the process of design and creation; the real focus lies in getting the hands-on experience and accepting failure as a part of the learning process - an idea that has not yet been ingrained in school culture.
Makerspaces are becoming more widely accepted, but research is still needed to yield evidence on how learning through this ideology is improved, and also creating strategies for applying this type of learning that benefits best practice.
This research is currently on the way - it cannot yet supply sufficient data for final conclusions, but early conclusions do find that "[...] the environment must be configured in a manner that nurtures creativity and collaboration while promoting both self-directed and peer-to-peer learning." (Horizon K-12 edition, 2017, p. 41), just assigning open spaces is not sufficient enough.

Makerspaces have been adopted around the world to influence students to produce in

ways that suit and benefits their personalities. The idea is, that there must be a meaningful outcome for the students when working and executing different ideas in the context of learning - makerspaces provide this through dynamic development to expose students to the latest technologies and giving the opportunity for hands-on experience, which is also a driving factor to why makerspaces attract interest worldwide (Horizon K-12 edition, 2017).

Critical Thinking

Learning to apply critical thinking stands as a core skill together with problem-solving. According to educationists, policy makers and the industry it is an imperative skill to be able to live and work in the 21st century, but finding a consensus on the definition of critical thinking is yet to happen. In Kadir (2017) it is stated that there was an attempt to find a common consensus on the definition though without any luck – the definition stretched as far and wide as the expert participants' field of expertise, and at the core of these differences was the academic background with the different starting points being a philosophical perspective and on the contrary a psychological perspective. The main differences between these approaches are defined by looking at their focus – the psychological approach focusing on empirical research whereas philosophy relies on theorizing and logical reasoning.

Kadir (2017) lists a few definitions from each respective academic camp – a few definitions from philosophy being:

- "Active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends ... [it] includes conscious and voluntary effort to establish belief upon firm basis of evidence and rationality." (Dewey, 1938, p. 9, as cited in Kadir, 2017).
- "Reasonable reflective thinking that is focused on deciding what to believe and do." (Ennis, 1985, p. 45, as cited in Kadir, 2017).
- "Thinking that facilitates good judgement because it relies upon criteria; is

self-correcting, and is sensitive to context." (Lipman, 2003, as cited in Kadir, 2017).
On the other side, he lists definitions from psychology, a few of them being:

- "An active process involving a number of denotable mental operations such as induction, deduction, reasoning, sequencing, classification and definition of relationships." (Sigel, 1984, p. 18, as cited in Kadir, 2017).
- "A sequence of internal symbolic activities that leads to novel, productive ideas or conclusions." (Ericson & Hastie, 1994, p. 38, as cited in Kadir, 2017).

As the above indicates, critical thinking involves several mental processes.Mulnix (2012) argues that critical thinking is a type of thinking and not thinking in general.
This arguing leads to a different type of problem concerning critical thinking, which is teaching critical thinking – Mulnix presents an argument from Wellingham (2007) where educators (as cited in Mulnix, 2012) have been misled in the belief that critical thinking is a skill to be taught as much as any other skill, which he believes is doomed to failure. According to Willingham critical thinking is intertwined with domain knowledge, and therefore it is non-transferable across disciplines.

With this in mind, the question is, how critical thinking is taught, if the educators are dealing with the problem of misconception on how to teach critical thinking in their subject matter? Returning to Kadir (2017) questions are raised accordingly to the need of an adequate teacher knowledge base when implementing critical thinking and teaching thinking – he presents Nickerson's (1988) argument on the subject matter raised earlier, saying: "[...] it is no more reasonable to expect an individual who does not know a lot about thinking to teach thinking effectively, than to expect one who does not know a lot about math, or physics, or literature to be an effective teacher in any of these areas." (as cited in Kadir, 2017, p. 82).

Moore (2013) presents seven definitions on the term by work from three academic disciplines: history, philosophy and cultural studies. These seven definitions on critical thinking...

Are as follows:

- “as judgement;
- as scepticism;
- as simple originality;
- as sensitive readings;
- as rationality;
- as activist engagement with knowledge;
- and as self-reflexivity.” (p. 1).

These points do provide a wider understanding, taking multiple disciplines into account, on a very complicated subject matter. Working out how to teach critical thinking is, as described in this section, a difficult task, but a great suggestion for dealing with this, is grasping it as: “[...] an extra edge of consciousness – that we should hope to encourage in our students, and also in ourselves, and in the world generally,.” (Moore, 2013, p. 23).

PLAYFUL AND GAME-BASED

Learning through play

Zosh, Hopkins, Jensen, Neale, Hirsh-Pasek, Solis and Whitebread (2017) discusses play in early childhood to be of great importance affecting their development all through to adulthood and prepares them for the challenges to come later in life. The play is observed throughout the animal kingdom to be a natural part of the different species' learning.

The term playful learning is therefore introduced – an umbrella term which in their model contains three degrees of play that are free play, which is entirely child-led; guided play, which is a child-led activity scaffolded by an adult; and lastly games, which are designed and scaffolded by adults – it contains a strict set of rules for navigating the play.

Flanagan and Nissenbaum (2014) states (as cited in Durvasi, 2016) that modern videogames have become the media paradigm of the 21st century and therefore their influence will be felt through all areas of society. With games impacting so much of society today, it also creates a new way of learning waiting to be exploited: [...] video games bestow cognitive benefits that are transferrable to real-world contexts, operates as sites to apply problem-solving skills and enhance creativity." (Durvasi, 2016).

Zosh et al. (2017) have listed five characteristics setting the framework for playful learning being:

- Joyful, as the most predominant emotion in play when discussing play in learning. Importantly joy is not defined as something that does not involve any negative emotions at all – on the contrary, frustration with a certain problem can be necessary because joy happens in breaking down the problem and finally solving it. For example, the emotion of joy enhances memory, creativity and motivation through increased dopamine levels in the brain's reward system.
- Meaningful, is finding meaning and connecting what is experienced to something familiar. Authenticity in learning comes to play when creating meaning –

from working with concepts on a theoretical level to applying them to real-world situations.

- Active engagement, presents a perspective of this where the children are 'minds on' whether or not their bodies are active – this is required by active learning – instead of explicit instructions. It is defined as being the mindset of the children. For children to develop an active mindset is crucial which can be accommodated through play. Active engagement increases the brain activity regarding to decision-making and flow, and it enhances memory encoding and retrieval including learning processes.
- Iterative, leads to deeper learning through hypotheses testing and trying out different possibilities – this is supported through children's play as they through activities explore the unknowns and test their hypotheses. This characteristic leads to increased brain activity regarding flexible thinking and creativity.
- Socially interactive, is about building more powerful relationships – a deeper understanding through direct communication by sharing knowledge and ideas. It is seen as a possible key to learning as evidence show that social partners are a major player when supporting learning. One of the 21st century competencies being supported through social interaction is the more complex critical thinking. Being able to tap into the mental states of others is another benefit when acquiring critical thinking through social interaction.

Game-based learning

Farber and Schrier (2017) present research stating that it has been observed that those who play digital games more frequently are more adept in regulating their emotions contrary to those playing more infrequently.

We have seen that the educational system shifts towards teaching academic skills away from the more creative and child-centered – that direct instructions are preferred, and an increasingly larger focus on math and literacy skills as seen in the United States (Zosh et al., 2017), but research is mounting showing that play in learning supports the skills required in the 21st century.

Games cannot be overlooked when the fact is that learning happens when playing games – whether it is physical or digital. Games contain certain rules and boundaries; these require active engagement and the narrative of the world support some form of social interaction resulting in facilitating the development of critical learning and thinking (Farber & Schrier, 2017).

Games can be used to simulate and explore real-world situations - as educational live-action role-play EDU-LARP with impact on motivation, creativity and collaboration (Gjedde 2014). A technology supported the so-called epistemic games that employ an epistemic frame of knowledge, skills, values, and identity connected to a professional epistemology, for instance, forensic scientist or according to Shaffer(2007)“ decades of research on epistemic games has shown that players can learn concepts and principles, and acquire practices and ways of thinking by learning to solve real problems the way professionals do.“

Games to enhance and motivate learning has long been a prominent topic with the term gamification, but this way of teaching practice might only provide superficial elements from gaming through rewards and entertainment. The report Innovating Pedagogy (2013) presents a term intrinsic integration with new approaches on how to incorporate the full potential of digital games in teaching and learning. Through this, the motivational elements of games are linked to specific learning activities - this can be achieved when developers design the games by incorporating the different motivational aspects, e.g. challenge, personal control and curiosity to match the pedagogy.

Games are not new to the world of education as it has been present since the 18th century where games as chess were used as a way of intellectual self-improvement, and educational theorists as Vygotsky and Piaget have also linked play and learning (Sharples et al., 2013). Though today, we have the possibility of involving digital media, making it possible to learn within a virtual environment and learning with simulations, which promotes creativity and development of 21st century skills. Effectively utilizing the games’ virtual environment for learning, balances between these must be obtained

through flow which balances “[...] the challenge and their skill level, the merging of action and awareness, the existence of clear goals, clear feedback, focused concentration, a sense of control, a loss of self-consciousness, a reduced awareness of time and a sense that the activity is intrinsically rewarding.” (Sharples et al., 2013).

Another aspect of the benefits from games and learning, affinity groups are presented as a term to depict the bond created between learners. This concept can be applied in other settings, online or face-to-face. The concept is, that since all participants are seen as learners, there is a two-way exchange of knowledge, participants are both mentors and being mentored. In affinity groups, people are bonded through shared endeavours and is not affected by nationality, race or gender (Sharples et al., 2013).

The successful support of learning through affinity groups can, for instance, be seen in the virtual communities of Minecraft, where children across the world are brought together with the common goal of “[...] developing digital media skills, exploring their creativity and developing online social skills.” (Sharples et al., 2013, p. 31) Attractive for learners developing 21st century skills. For learners to be able to break down and evaluate flow, and the use of affinity groups to successfully apply best practice of gaming within a learning environment support the knowledge- and skill development relevant within games (Sharples et al., 2013).

The empirical evidence on games’ effect on behaviour, attitudes and empathy skills is still limited and leaves room for research in the future (Farber & Schrier, 2017), but current research does find connections between games for learning and preparing children for life in the 21st century. A child-centred approach in the preschool through play, ranging from free play to games designed and scaffolded by adults, creates a more solid foundation for later learning focusing more on the academic alone (Zosh et al., 2017).
Design and implementation of the analogue or digital games is an important factor about the learning potentials (Durvasi, 2016) but in reality “ [...] is that gaps persist

between good intentions, policies and actual practices." (Zosh et al., 2017, p. 29), which point to the need for developing scenarios and learning designs for playful learning and learning through games.

Foster Empathy through E-Learning (FEEL) is an approach created from the understanding where improving the relations in groups of people is bound by the development of empathy in-group members (Ferguson et al., 2017). Game-based learning plays a role in fostering empathy through designing for intergroup empathy - this can be done in numerous ways, to mention a few roleplaying, presents an approach where participants are forced to tackle issues in new ways; gamification, breaks down anxiety of interaction " [...] by introducing a non-threatening virtual context." (Ferguson et al., 2017, p. 23).

STE(A)M

STEM presents a framework for interdisciplinary and applied approaches to the four disciplines — science, technology, engineering and mathematics —STEM. The concept integrates the disciplines into a cohesive learning paradigm based on problem-based learning with authentic applications.

Through a STEM approach the need for citizens to solve pressing problems in the world today and make sense of complex information can be met - the combination of Science, Technology, Engineering and Math is an enabling factor for the success of reaching these goals. What STEM can do is develop scientific skills needed to meet the demand for STEM-skilled employees in the current economy, and it can contribute to personal growth and understanding of what a scientist is, which then promotes critical thinking, reflection and understanding of the scientific method (Ferguson et al., 2017).

STEM has a focus on developing learners skills by working collaboratively with coherent real-life use of otherwise separate disciplines. The STEM subjects can be brought into play through real-life problems and made meaningful by the application of learning in real-world scenarios.

In an OECD working paper (2013): Kiira Kärkkäinen and Stéphan Vincent-Lancrin

Explores how a broad mix of skills can be developed. They suggest that five technology-supported pedagogic models will have the potential to improve students' learning outcomes in STEM:

- gaming,
- virtual laboratories,
- international collaborative projects,
- real-time formative assessment
- and skills-based assessment.

STEAM

The need for developing creativity and innovation and engaging learners deeply in STEM has led to a concept which integrates arts with science and technology subjects: science, technology, arts, engineering and mathematics: STEAM

STEAM is the inclusion of ARTS into the STEM framework. STEAM can be understood as a transdisciplinary approach that incorporates skills and knowledge from individual STEAM disciplines to solve real-world problems (Yakman, 2008; Winterman & Malacinski, 2015). One of the goals of STEAM is to prepare students to solve problems "through innovation, creativity, critical thinking, effective communication, collaboration, and ultimately new knowledge" (Quigley & Herro, 2016).
STEAM learning is a way for schools to place school subjects in real-world situations and contexts. It is engaging the students to creatively design problem solutions through own inquiry. (Horizon K-12 edition, 2017).

Introducing the A in STEM leaves more room for valuing the learning process itself and flexible outcomes through a more trial-and-error oriented learning method that invokes more student-initiative. Combining the arts with the more scientific methods has yielded results in which where students that "[...] acted out a math equation by creating a story out of it, they better understood the measurements." (Horizon K-12 edition, 2017, p. 22).

Planning and collaboration between universities in introducing STEAM are helping developing programs creating international standards and skills in cross-disciplinary work to which other industries' training-programmes can be aligned to help solve real-life problems (Horizon K-12 edition, 2017).

Learning Environments

The built environment has to support new learning approaches to fully release the potential for innovative learning practices.
Diana Oblinger (2006) makes explicit the potentials of learning environments in relation to educational development: 'Spaces themselves are agents for change. Changed spaces will change practice.' and further reflect that the learning environments designed in last century may not reflect the needs of students today

A number of studies has explored the role of the learning environment in relation to innovative and creative learning.

Higgins et al. (UK 2005) concludes in their report on The Impact of School Environments that:

"There is an implication in many studies that the empowering process of re-designing and taking ownership would spill over into motivation and empowerment in other areas, encouraging creativity and experimentation in the curriculum, raising motivation towards academic and social goals. However, there has been limited longitudinal work looking at the positive effects of change, although there is an emerging literature on the negative impacts of externally generated curriculum and pedagogical change (e.g., Angus, 2004, Fisher, 2004, Rossides, 2004). "

Through the 4Cs, the environment has a major impact on teachers' ability to innovative teaching and learners' creative learning – creating a new, re-designed learning environment for innovative teaching, requires some form of adaptation for both teacher and student. It is described in Blackmore et al. (2011a) that there is very little recognition towards the amount of preparation required of both teacher and students when transitioning into new learning environments. Schools that have innovative curricula but traditional learning environments are non-ideal for innovative teaching hence it may force teachers to fall back to default pedagogies rather than innovative (Blackmore et al., 2011a).

Looking at the learning environment and students' learning outcome, Blackmore et al. (2011b) conclude that there is no simple answer to the link between their learning outcome, innovative learning environments (ILEs) or flexible learning spaces. Creating an ILE is not necessarily requiring completely newly built spaces, and the other way around newly built spaces do not constitute ILEs – what is needed, is the best pedagogical approach to these spaces. The change of teaching practice and engagement with learning is to be in focus in combination with how to utilize the environment to create innovative teaching and creative learning, "[...] physical and spatial designs can function

as a provocation for imagining the possibilities of innovative learning and collaboration." (Blackmore et al. 2011b,).

The report by Higgins et al. (2005) recommends that "Environmental improvement in schools should be locally driven, user-led and embedded in pedagogy– Investment in change should be seen as an iterative process, rather than a five-year programme to cover the needs of a subsequent generation. Building Schools for the Future, pre-supposes a commonly held view of what the future will look like: unless this is generated collaboratively and implemented flexibly, there is a significant risk of expensive failure."

When addressing the importance of learning environments in teaching, there has been a shift in focus in the 21st century - a rethinking of how existing learning spaces is to be used and how emerging schools design incorporating the new forms of teaching, learning and technology that has emerged in the 21st century (Horizon K-12 edition, 2017).

Learning spaces today has shifted from the traditional forward-facing rows with a teacher-centred learning approach to a more modular arrangement with the possibility of manipulating and fitting the learning spaces to support the learning that is desired, with a more student-centred approach that supports collaboration and more self-directed learning (Horizon K-12 edition, 2017).

Technology also influences how learning-environments are designed and the pedagogical approaches these technologies call for. Schools are being designed with that in mind, that all space is being optimized for invoking learning, and easy-to-access technology has a central role in connecting the students to the full potential of the different learning spaces (Horizon K-12 edition, 2017).

Technologies and learning

Technology has a great impact on how we interact with the world and therefore has a

significant role when defining the 21st century learning and competences, "[...] development and ubiquity of digital tools are having an impact on how students both interact with and respond to the world." (Ontario, 2016, p. 37). Laar, Deursen, Dijk and Haan (2017) did a literature review examining the relation between 21st century skills and digital skills with the goal of providing a framework for the knowledge worker under the term 21st century digital skills. As they argue, the term 21st century skills are broader than digital skills (Laar et al., 2017) since it extends beyond just being able to turn on a computer, log a file or surf the internet.

In the Ontario (2016) paper, a table visualizes the connections between technologies, learning practices and 21st century skills, listing the specific subclauses for the different main categories giving a visual overview on how they are related.

Condensation of table 2 in Ontario (2016) paper

TECHNOLOGIES	KEY TRANSFORMATIONAL LEARNING PRACTICES/CONTEXTS	21ST CENTURY COMPETENCIES
Social and Collaboration - Blogs - Online forums - File sharing	- Authenticity - PBL - Student-centred learning	- Collaboration - Communication - Critical thinking - Digital citizenship
Hybrid and Mobile - Tablets - Laptops - Cloud technology	- Student-centred learning - Authenticity - Student-driven inquiry - Accessibility	- Productivity - Analysis - Decision making - Information literacy
Visualization - 3D printers - Interactive maps - Graphic tools	- Differentiation - Elimination of barriers - Learner autonomy - Makerspaces	- Coordination - Communication - Analysis - Problem-solving

Storytelling and Creation • Video/music tools • Presentation tools	• Student-centred learning • Authenticity • Collaboration	• Communication • Collaboration • Creativity • Innovation • Digital literacy • Digital citizenship • Character building
Immersive Media and Simulation • Virtual Worlds • Interactive games	• Authenticity • Student-centred learning • Personalized learning	• Cooperation • Curiosity • Problem-solving • Creativity/innovation • Critical thinking

Developments in educational technologies are continuously monitored by the New Media Consortium (NMC) who publish the Horizon reports forecasting on future trends in education. To sort out which technologies are to be monitored, an expert panel has narrowed it down to seven categories of technologies, tools and strategies in which these educational technologies are added or merged into (Horizon K-12 edition, 2017). The criteria for technologies to make a list, and the timeline for adoption is one of them, are near-term, which is adoption achieved in a year or less; mid-term, two to three years and; far-term, which is within four to five years. The Horizon (2017) report does state that some technologies might not meet the criteria for making it into the categories, this being if they are already in widespread use in K-12 education or if it is more than five years from widespread adoption.

The list of categories are as follows from the Horizon (2017) report:

- Consumer technologies, which initially are not created for educational use. These are for recreational or professional use, but they appear in education because consumers are using them at home or in other contexts;
- Digital strategies, are not directly technologies, they are ways of using them to enhance learning and teaching;
- Enabling technologies, are ways of expanding the reach of the technologi-

cal tools, creating more useful and capable tools. Technological innovation becomes visible in this category; it can be tools enabling creative co-creation of content.

Internet technologies are where interaction with the network becomes transparent and more intuitive. It consists of techniques and essential infrastructure to support this;

- Social media technologies, have associations to the consumer technologies category, but has achieved a category by being so widely used and present in society - its rapid development provides new ideas and tools;
- Visualization technologies is a way to make the complex simple. It taps into the ability of the brain to process visual information and data patterns to order complex situations. Infographics or more complex forms of visual data can support this.

Problem-Based Learning (PBL)

Problem-based learning creates a meaningful focus for students and teachers using a complex, real-world problems case study approach. The approach has been developed first in Medical Education and has been adapted into other areas of Higher Education, like engineering as well as K12. Aalborg University holds the Unesco Chair in Problem Based Learning and describes the key components as follows:

“Problem-Based Learning (PBL) is an innovative method to organize the learning process in such a way that the students actively engage in finding answers by themselves. During the past 40 years, PBL has evolved and diversified resulting in a multitude of variations in models and practices. However, the key principles remain the same everywhere. identify The main PBL principles are identified as follows (Kolmos & De Graff (2003),De Graaff E. & Guerra A. 2015):

1. Problem orientation 2. Project organization through teams or group work 3. Participant-directed 4. Experiential learning 5. Activity-based learning 6. Interdisciplinary learning and 7. Exemplary practice.

Wirkala, Clarice & Kuhn, Deanna (2011) reports that “Enthusiasm for problem-based lear-

ning (PBL) is widespread, yet there exists little rigorous experimental evidence of its effectiveness, especially in K–12 populations. Reported here is a highly controlled experimental study of PBL in a middle school population. Between- and within-subject comparisons are made of students learning the same material under three instructional conditions: lecture/discussion, characteristic small-group PBL, and solitary PBL. Assessments of comprehension and application of concepts in a new context nine weeks after instruction showed superior mastery in both PBL conditions, relative to the lecture condition, and equivalent performance in the two PBL conditions, the latter indicating that the social component of PBL is not a critical feature of its effectiveness."

The cognitive skills and dispositions that PBL might foster warrant analysis in their own right, as does an experimental analysis of the still multicomponent process that PBL consists of. Although the present work focuses on outcomes rather than process, we believe our findings indicate that the more laborious process observations and analyses warrant the investment.

A core part in PBL is the learner's ability to develop viable solutions to a specific problem using skills and knowledge in combination with theoretical and practical insight. Though PBL is not a specific skill under 21st century learning, there are aspects of the two relating them to each other - the essentiality of collaboration being one of them (Savery, 2015).

The AAU PBL model follows a set of basic principles consisting of a framework, practice and support functions - all parts in creating the model recognized around the world (Aksehave, Prehn, Pedersen & Pedersen, 2015).

The framework for PBL in the AAU model is defined by three characteristics educational vision, ensuring that students at the faculty all have the necessary support to work with the AAU model in practice - it provides a clear vision for PBL through all study programmes; curriculum, which ensures that PBL is incorporated into all curricula which means all students' project work revolves around PBL; assessment, is done through assessing the students work, whether it is individually or in groups, by examining them and assessing their individual knowledge, skills and competencies.

In practice, there are defining criteria to be supported - students, where AAU provides early introduction to the AAU model of PBL and the reason behind it and that they in their process are supported among other; academic staff, ensures that all academic staff members teach according to the AAU model and implement in their pedagogical activities; external relations, is a way for the university to work with authentic issues by keeping a close collaboration between the university and external organisations.

Looking at the principle of support functions, the university provides access to resources, that provides students with access to information relevant to use in their project work, provide the environment necessary for students to cooperate among other things; student organisation and programme administration, is a way to ensure cooperation between schools, student councils and study boards which is implemented to ensure knowledge is provided to students about the AAU PBL model to implement this in through their studies, involving academic staff, students and support staff in the evaluation of semesters; research in PBL, is a way for AAU to document the effect of PBL for internal and external purposes, document the impact of the model and relate the model from practice to theory - it is a way for AAU to evaluate and develop the model through research and evaluation results (Akshave, Prehn, Pedersen & Pedersen, 2015).

Agents for change - summing up towards the future

With technology being increasingly embedded into schools and classrooms, information no longer comes from one source, the educator. Their work tasks have moved beyond assessing students' knowledge - they now address different factors affecting student learning, i.e. social and emotional factors. Beyond that, they are acting as mentors guiding students towards adopting lifelong learning habits by motivation and modelling responsible citizenship. Digital tools and resources have become important in teaching practice, enabling educators to collaborate inside and outside schools enabling them to share knowledge and understanding of the challenges they are faced, teaching in the 21st century classroom (Horizon K-12 edition, 2017).

Challenges in problem-solving can be listed in different categories depending on the difficulty of the given problem - Horizon (2017) has divided the challenges into three different categories as solvable challenges, which are challenges that are known and which we understand; difficult challenges, which are more elusive in how they are to be solved, but we still understand the prospects of, and; wicked challenges, which are of a complex nature and can be difficult to even define without going into more depth by collecting more data.

Some of the solvable challenges addressed in the Horizon (2017) report that has to some extent been implemented involve authentic learning and an extension to that the improvement on digital literacy, which the first-mentioned relies on in many aspects. Creating an authentic learning experience is reliant on digitally upskilling students - 21st century society and workforce have become embedded with technology, and being able to navigate in this and simulate real-world challenges through authentic learning requires being able to use technology, thus the need for improving digital literacy.

With the importance of digitally upskilling students, schools today are charged with developing students' digital citizenship which includes ensuring responsible use of technology and online etiquette including digital responsibilities and rights in online learning settings. As the Horizon (2017) report states, it is a challenge for schools to implement this comprehensive approach, as digital literacy contains a multitude of elements. Developing students' autonomy in the digital landscape to enable them to contribute is, therefore, a driving factor for schools, and to this frameworks have been designed for schools to identify areas in which students need support to obtain this autonomy.

The report on 21st century learning: research, innovation and policy
directions from recent OECD analyses (OECD 2003a:) took as a point of departure that:
"The explosion of knowledge about the brain and the nature of learning, combined with

the growing power of technology, create the potential to transform even the most fundamental unit of education - the interaction of the teacher and the learner. (OECD 2003a:)"

"While the integration of these 21st-century skills in classrooms is encouraged by theorists and policymakers, in practice, teachers often lack the skills and the space to teach their students 21st-century skills" (Voogt et al., 2013). Furthermore, their development requires substantial changes to pedagogical approaches and assessment practices (Binkley et al., 2012)."

Towards a compass of learning innovation and professional development

Through a synthesis of the research and forecast for education in the 21st century we have been identifying areas that can point towards tools to facilitate interactions in meaningful ways and areas to further professional development to expand teachers competencies.

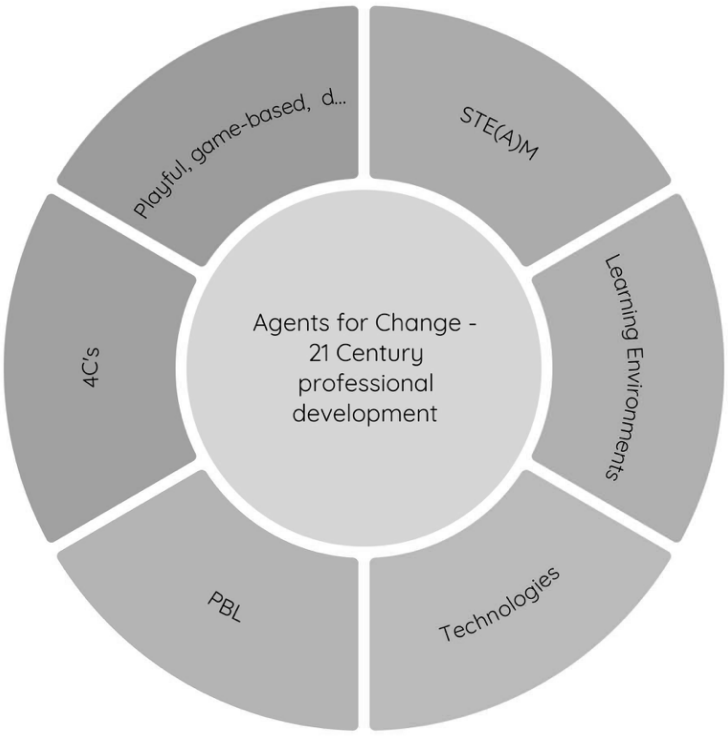

Fig. 1 A compass for developing innovative learning competencies in the 21st century.

The areas we have covered are interrelated and overlapping but can be addressed through working with the separate themes in the model that has been developed - which can be used a compass for further inquiry and professional development in an educational context.

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2017-1-PT01-KA203-035851

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