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Driving 21st Century Learning

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Abstract

Industry 4.0 demands competences of enterprises as are connectivity, visibility, transparency, adaptive and predictive abilities. How can educational systems prepare their participants for those future requirements? Several frameworks define and illustrate competences linked to that question. Key Competences, frequently specified as 4 Cs (Collaboration, Critical thinking, Communication and Creativity), are central elements in most programs. The article describes and discusses the 4 Cs in the context of learning and innovation processes and highlights, how learning environments can foster future competences.

Auf dem Weg zum Lernen im 21. Jahrhundert

Zusammenfassung

Industrie 4.0 erfordert Kompetenzen von Unternehmen wie Konnektivität, Sichtbarkeit, Transparenz, Adaptivität und Vorhersehbarkeit ihrer Prozesse. Wie können Bildungssysteme deren Teilnehmer/innen auf diese zukünftigen Anforderungen vorbereiten? Einige Rahmenprogramme definieren und zeigen Kompetenzen auf, die im 21. Jahrhundert diesen Ansprüchen gerecht werden können. Schlüsselfaktoren, häufig definiert als 4 Ks (Kollaboration, Kritisches Denken, Kommunikation und Kreativität), sind in den meisten Programmen zentrale Faktoren. Der Artikel beschreibt und diskutiert die 4 Ks im Kontext von Lern- und Innovationsprozessen und zeigt auf, wie Lernumgebungen die Entwicklung dieser Kompetenzen unterstützen können.

Keywords:	*Schlüsselwörter:*
Industry 4.0	Industrie 4.0
21st century learning	Lernen im 21. Jahrhundert
Communicaton	Kommunikation
Critical Thinking	Kritisches Denken
Creativity	Kreativität
Collaboration	Kollaboration

1 Introduction

Some time ago, Ján Figel, responsible member of the European Commission for Education, Training, Culture and Youth, highlights in his introduction to the key competences for lifelong learning the change in society in accessing information and services. He stresses new competences as necessary to master a whole new digital world, not only by acquiring technical skills, but also by gaining a deeper understanding of the opportunities, challenges and ethical questions posed by new technologies. (Europäische Gemeinschaften, 2007)

20 years later, there are new terms like digitalisation and Industry 4.0 indicating significant changes in the 21st century. The 21st century society is confronted with challenges as are potentials and risks, entailing the

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transformation from digitalisation to Industry 4.0, nevertheless employees have to develop competences complying with these demands. Strategic and organisational competences are increasing towards solely technological innovations. An important resource for competitive enterprises are human factors. The DESI (Digital Economy and Society Index) shows the actual state of digital economics in the partner countries all over Europe. Other studies, described in this article, focus on the transformation from digitalisation to Industry 4.0, and refer to the question "How can educational systems prepare students for future requirements?" In addition, the role of the human resources is discussed. The following chapters answers the question, which competences are necessary to meet the challenges of 21st century und how educational systems can prepare students for those future competences.

2 State of digitalisation and Industry 4.0

Industry 4.0 demands competences of enterprises as are connectivity, transparency, adaptive and predictive abilities. The Acatech Industrie 4.0 Maturity Index (Schuh, Anderl, Gausemeiser, ten Hompel & Wahlster, 2017), uses "resources" to refer to tangible, physical resources, including a company's workforce (human resources), facilities and equipment, tools, materials and final products.

The increasing use of information and communication technology in products and processes calls for an interdisciplinary approach in the way employees think and act. Employees should be more closely involved in innovation processes, providing the widest possible range of knowledge. The ongoing automation of many process steps means that in future, there will be an even greater necessity for employees to use their decision-making and creative skills – in the long-term, applied skills will no longer be enough. It will also be necessary to give employees more individual responsibility in order to speed up the learning and decision-making processes. (Schuh, Anderl, Gausemeiser, ten Hompel & Wahlster, 2017, p. 21)

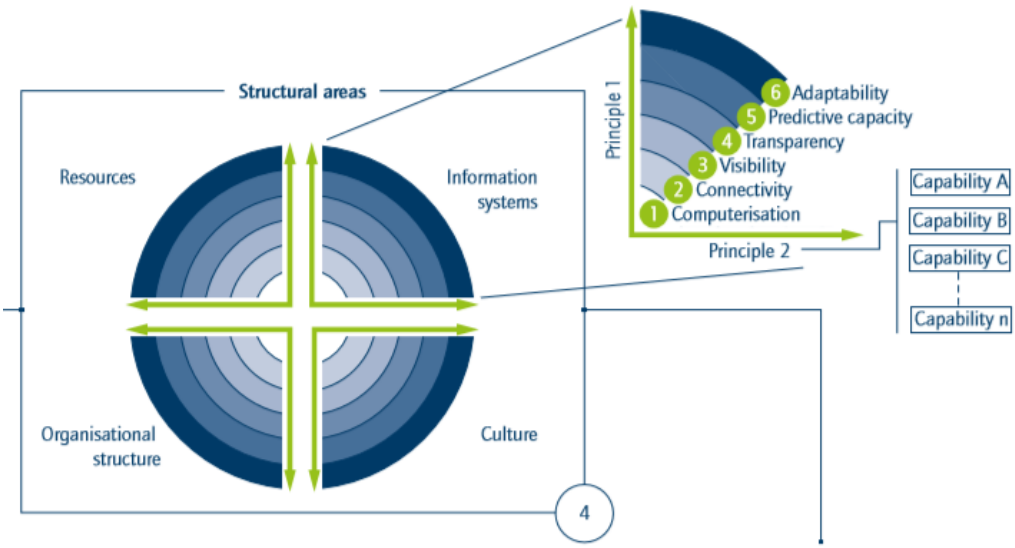

Fig. 1: Model design of the acatech Industrie 4.0 Maturity Index

When employees have to make a decision, they should be able to access, gather and process data and information in order to come to a robust final decision. The workforce should possess a common understanding of Industry 4.0, and also of the value of information in short-, medium- and long-term decision-making. As information systems and communication technologies become increasingly widespread, companies must also support their employees to acquire integrated, interdisciplinary IT skills that provide them with a basic understanding of the applications and processes used in different business domains, thereby upgrading long-established occupational profiles.

Employees working with IT systems on a regular basis often get in contact with sensitive data; thus, they have to be aware of the importance of IT security. It is a crucial part of employee training to create awareness of possible data leaks. Given the growing popularity of social media and collaborative tools, new rules must be defined and applied to internal and especially external communication. While having access to a wide data base is useful when making decisions, part of this data may form the intellectual property of the company and should not be shared with third parties. (Schuh, Anderl, Gausemeiser, ten Hompel & Wahlster, 2017, p. 22)

Another study concerning the digital transformation (Etterich, Trost, Berschneider & Schlenzig, 2016, p. 34-36) highlights the importance of strategic and organizational decisions compared to technological decisions. The digital change of enterprises requires a rethinking of employees. As well as a new culture of cooperation, an open mind for changes is necessary to succeed in digitalisation.

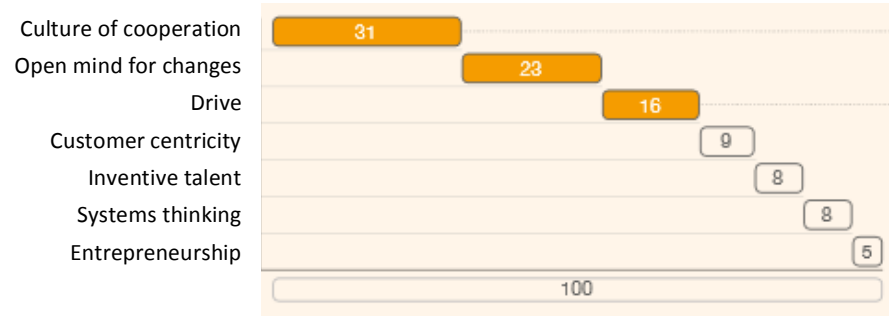

Fig. 2: Digitalisierung – Chancen und Herausforderungen für die Forschung & Entwicklung 2021, 3DSE Leitstudie (2016)

Tasks at „Shop Floor“ that cannot be automated become more ambitious. The requirements on employees increase with regard to problem identification and problem solving competences, autonomy, communication, data competences, interdisciplinary thinking, capacity for team work, reliability and social competences. (BMVIT, 2017, p. 7)

The Digital Economy and Society Index (DESI) is a composite index that summarises relevant indicators on Europe’s digital performance and tracks the evaluation of EU member states in digital competitiveness. The Connectivity dimension measures the deployment of broadband infrastructure and its quality. Access to fast broadband-enabled services is a necessary condition for competitiveness. Human Capital shows the skills needed to take advantage of the possibilities offered by a digital society. Such skills range from basic user skills that enable individuals to interact online and consume digital goods and services to advanced skills that empower the workforce to take advantage of technology for enhanced productivity and economic growth. The Use of Internet dimension highlights activities performed by citizens already online, ranging from consumption of online content to social media activities or online shopping. The Integration of Digital Technology dimension accounts for businesses’ exploitation of online sales channels. By adopting digital technology, businesses can enhance efficiency, reduce costs and better link to customers, collaborators and business partners. The Digital Public Services dimension measures the digitisation of public services (eGovernment).

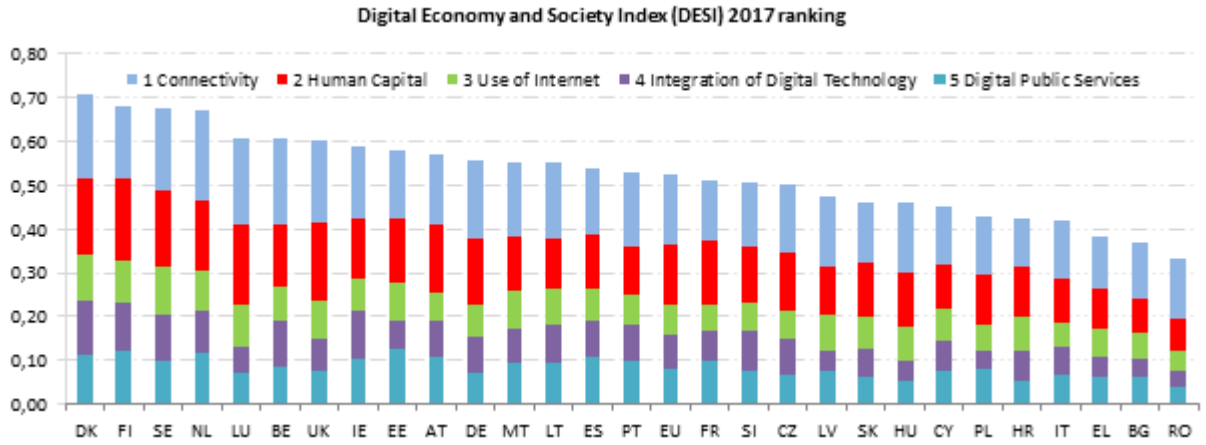

Fig. 3: Digital Economy and Society Index (DESI) 2017 ranking. Source: European Commission https://ec.europa.eu/digital-single-market/en/desi

Austria takes the 10th rank in the DESI study. In most areas, Austria is close to the EU average. Regarding the digital public services, Austria is among the Top 5 in Europe and has high scores in human capital. The use of internet services is less advanced.

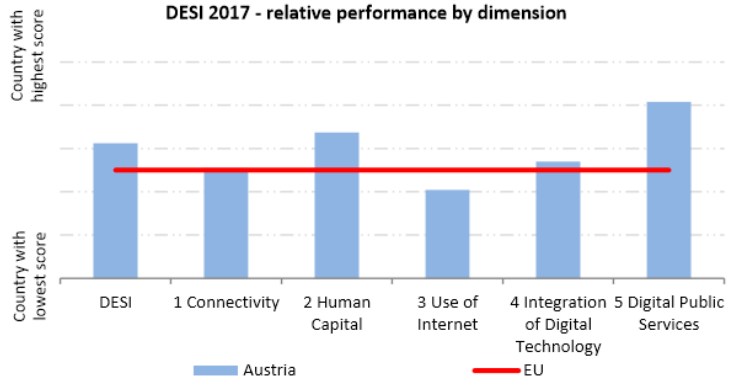

Fig. 4: DESI 2017 – relative performance by dimension. Source: European Commission https://ec.europa.eu/digital-single-market/en/desi

From all the studies mentioned it becomes obvious that a high level of education in society and enterprises are crucial conditions to avoid risks of digitalisation for employability and to use potentials of digitalisation. Milestones of a successful transformation in the educational system range from base competences to the establishment of digital thinking in all subjects, and the need of transversal social and personal competences.

3 21st Century learning

In cooperation with the OECD Project Education 2013[2] Fadel et al. (2017) conducted a meta-analysis among 32 frameworks dealing with 21st century learning all over the world.[3] The study found a consistence in the

[2] OECD has started the new initiative "Education 2030: the OECD Key Competences Framework. Die OECD intends to develop the competence framework by comparing and analysing worldwide curricular frameworks. This global framework project is meant as a support for countries aspiring curricula reforms. (http://www.oecd.org/edu/school/education-2030.htm)

dimensions knowledge, skills and character and another, fourth dimension as postulates meta-learning shown and explained in figure Nr 5.

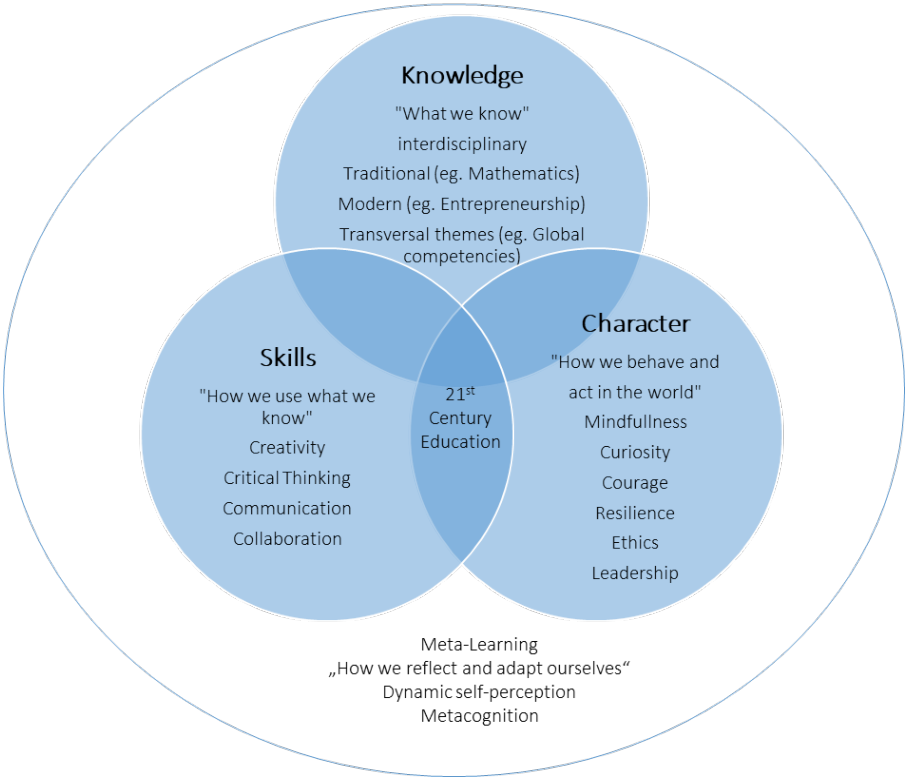

Fig. 5: CCR Framework. Source: CCR (Center for Curriculum Redesign)

Effective learning means a qualitative implementation of all dimensions. Global Learning requires the integration of Knowledge, Skills, Character and all embracing Meta-Learning. The learner develops intentions and reasons for his acting depending on his own perspectives. Human learning is characterised by an open mindset and the situation, it depends on the learner's biography and the learning context. As human acting is implemented in social relations, there are no activities which are not situated. (Moser, 2014, p. 19) Learning is a situated activity and legitimates "peripheral participation". (Lave & E., 2001, p. 29) Situated learning is experienced in social contexts as are provided in communities of practice and furthermore, it has a dynamic character, based on interaction between participants.

That means that a specific dimension can be strengthened in specific learning environments. The competence model of higher and middle vocational schools in Austria defines social (social responsibility, communication, cooperation, conflict management, leadership and personal performance) and personal competences as are self-responsibility, learning and working behavior and life management. Vocational acting competences are an important element of the curricula. (BHS, 2017)

[3] OECD Skills for Innovation, OECD DeSeCo, OECD Social & Emotional Skills, OECD PISA, OECD PIAAC, EUReference Framework Key Competences, UNESCO Global Citizenship Education, P21, ATC21S, Asia Society/CCSSO, Hewlett Foundation Deeper Learning Competences, ACT WorkKeys (WK)-NCRC Plus-CWRC Skills Assessments, CPS Employability Assessment (EA), AAC&U Essential Learning Outcomes (LEAP), CCSSO-Innovation Lab Network (ILN) State Framework, National Work Readiness Credential, CAE College & Work Ready (CWRA) & Collegiate Learning Assessment (CLA), EnGauge, Character Counts! Coalition, CharacterEd.Net, Character Education Partnership, Facing History and Ourselves, KIPP Schools, Center for the Advancement of Ethics and Character, Collaborative for Academic, Social, and Emotional Learning, The Jubilee Center for Character and Virtues, Young Foundation, China Ministry of Education, Singapore Character and Moral Education (CME), South Korea Moral Education, Swedish National Agency for Education, Thailand Philosophy of Sufficiency Economy

Based on situated learning concepts, teaching and learning examples have been developed for different competence areas. The tasks can be implemented in learning and teaching settings, they support hands-on learning and focus on specific vocational skills. Furthermore, they initiate cooperative and autonomous learning, real life is simulated by case studies.

As studies concerning digitalisation and 21st century learning models have shown, there is a big demand of skills defined in the 4Cs. The following section describes and discusses learning and innovation skills focusing the 4 C (creativity, critical thinking, communication and collaboration), and showing learning environments fostering future competences.

3.1 Creativity

Csikszentmihalyi und Wolfe (Csikszentmihalyi & Wolfe, 2000) postulate a systemic view of creativity, with original ideas and products being accepted and appreciated by society. Creativity means the result of interaction between culture (saving experiential knowledge), person (adding something new) and society (recognising innovation). Stimulating, challenging and an enriched environment are important not only for creativity development in childhood and youth but also in workplaces.

The cognitive psychology highlights the analyses as creative process (Perkins, 1981)and explains creativity as interaction of talents, knowledge skills, intrinsic motivation and individual attributes and supporting environmental conditions. (Amabile, 2017) In contrast, Weisberg (1993) defines creative products as results of learning and exercise processes. Inspired by chaos theory, creativity is based on self-organisation. (Simonton, 1988) In this concept, creative problem-solving processes result first from various combinations of elements by chance (“chance permutation”) and second by transformation (“configuration formation”). Elements of mental associations become saved in mind as small bricks of creativity, they can be manipulated by attention and furthermore, connected with other elements. That enables creative mechanisms as are relevant for scientific and technological findings.

The following figure shows a taxonomy for creativity in learning situations with increasing complexity from imitation to an individual original creation.

Score of creativity	Definition
Imitation	Creation by identic imitation as a base ability that is often the initial issue for creative tasks.
Variation	Creation by changing of one or several aspects of an object, while the remaining aspects are imitated in the same way.
Combination	The connection of two or more objects to a new one.
Transformation	Transformation of an existing object into another medium or another representation.
Individual original creation	Creation of a new object that is only vaguely or not related to existing objects.

Fig. 6: Examples of creativity in classrooms, CCR, adapted by Nilsson 2011

3.2 Critical Thinking

The U.S. National Council for Excellence in Critical Thinking defines critical thinking as

“(1) a set of information and belief generating and processing skills, and (2) the habit, based on intellectual commitment, of using those skills to guide behavior. It is thus to be contrasted with: (1) the mere acquisition and retention of information alone, because it involves a particular way in which information is sought and treated; (2) the mere possession of a set of skills, because it involves the continual use of them; and (3) the mere use of those skills ("as an exercise") without acceptance of their results.” (Scriven & Paul, 1987)

In his famous opus defining critical thinking, Dewey (1910) describes stereotypes and prejudice, decisions based on wrong information restraining critical thinking, thus, reflection of thoughts is a necessity. Curiosity is a supporting element leading to more reflection. Dewey emphasizes metacognition as thinking about learning.

A very popular and pragmatic description of categories of critical thinking is represented by the taxonomy of learning objectives by Bloom (1976); he categorised them from low to high complexity. Based on that taxonomy other approaches have been developed and become part of some competence-orientated curricula (eg. Austria's curricula of higher and middle vocational schools). They all describe learning objectives ranging from a reproducing score to a higher meaning understanding and valuing.

Bloom (1956)	Anderson & Krathwohl (2001)	Marzano & Kendall (2006)	PISA (2000)
Evaluation	Creating	Critical Self	Communicating
Synthesis	Evaluating	Metacognition	Constructing and evaluating
Analysis	Analysing	Knowledge exploitation	Integrating
Application	Applying	Analysis	Directing
Understanding	Understanding	Understanding	Accessing
Knowledge	Remembering	Retrieval	

Fig. 7: L. M. Greenstein, Assessing 21st Century Skills

In contrast to Bloom's original postulate, current learning research emphasises that all levels can be combined effectively in learning activities. (Anderson & Krathwohl, 2001)

Critical thinking can appear in different forms in classroom situations, from a curriculum fostering sensibility and trial of components of critical thinking to project work or similar learning environments supporting interpretation of information, analysing elements of the whole, analyses and syntheses, proofing evidences, changing perspectives, identifying stereotypes and understanding abstract ideas. (Greenstein, 2012) Providing critical thinking is often connected with the development of reflective and metacognitive competences because both can strengthen each other. (Kuhn, 1999)

3.3 Communication

Forms of interactive communication are closely linked to critical thinking in context of requirements of Industry 4.0, eg. handling data security as a necessary requirement on future employees. Furthermore, solving tasks in a collaborative way is crucial for the development of communication skills, eg. getting feedback. (Fadel, Bialik & Trilling, 2017, p. 138)

Another method to develop authentic communication skills are peer tutoring systems; Hattie (2013, p. 126) found effects on students' motivation by deploying tutors, giving feedback and building friendships. Immediate feedback shows whether peers have understood the content and whether the communication was successful. In the digital world communication is directed (1) to media competence for improvement of learning by focusing students' life environments and knowledge-building approach and; (b) meeting learning styles of students' especially with multicultural background and (3) supporting creativity, personal expression, teamwork and the development of qualifications for working life. (Hobbs & Frost, 2015)

3.4 Collaboration

In some didactic models, cooperation and collaboration are used interchangeable, but there are differences in definitions. Cooperation means that a common task is split into different subtasks, each person or group takes some responsibility; whereas in collaborative forms the tasks are not definitely divided – everyone contributes to solving the overall task with his individual skills and knowledge. (Schmalz, 2007, p. 9) In cooperative learning environments, partner and group works require a synchronous or asynchronous (eg. with social media),

coordinated, co-constructive activity to develop a common solution of a problem or getting a common understanding of a situation. The terms „cooperative learning", „group work", „learning in groups" are not defined consistently. (Pauli & Reusser, 2000; Reinmann-Rothmaier & Mandl, 2002)

Although there is no common definition in learning forms concerning acting together, the effects on learning are indisputable. Learning taking responsibility is a central goal for cognitive and moral development both for one's own learning and the learning of the group. (Slavin, 1995; Piaget, 1980; Kohlberg, 1984) Another effect aims at civic education, based on Dewey's (1910) understanding of democracy. Joint research of students is the origin of a democratic learning culture and emphasizes democracy as well as it qualifies for the work environments. Furthermore, working in groups is a necessary element for evaluation. Evaluation happens when group members discuss goals attained und the effectiveness of their relations within the group, that gives a feedback for future behavior.

In contrast to other theories of learning psychology, "situated learning" analyses activation system where individuals participate as members of social groups by interacting with material resources. (Greeno, Collins & Resnick, 1996, p. 40) Activation systems have mostly the following characteristics: (1) learning is an active and constructive process; (2) this process is directed to the learner's knowledge sharing within the social learning group; (3) learning is getting analysed in learning environments with multiple contexts and is described as adaption to the restrictions and stimulations of the context; (4) those adaptions are based on the participation of the learning group members that are firstly peripheral and become more and more central with increasing expertise; (5) analysis of situated learning focused on effective learning environments and their characteristics. (Lave & Wenger, 2001)

Kuhn (2015) presents a classification of research on collaboration in education settings and identifies two categories. (1) Collaboration as a process leading to other desired individual and group outcomes, such as successful problem solving and enhanced intellectual development. These researches focus on group sizes and their effects on cognitive outcomes. (2) Collaboration is a valuable educational outcome in itself, stresses (a) the ability to work effectively and respectfully in diverse teams, (b) flexibility and motivation to meet common goals, (c) taking responsibility for collaborative work, (d) evaluation of individual contributions of team members.

4 Learning environments meet 4 C

The following section describes a learning arrangement supporting the development of the 4 Cs. COOL (Cooperative Open Learning) is situated at an institutional level, it is implemented in a larger concept based on the theories of Helen Parkhurst's Dalton Plan und Freinet's pedagogy. The implementation began 20 years ago and many innovations have since followed.

4.1 COOL (Cooperative Open Learning) – the learning environment

COOL was developed as a dynamic concept based on the progressive pedagogical approaches of Helen Parkhurst and Celestin Freinet. (Popp, 1999) The high participation rate of 65 certified schools in Austria (middle and higher vocational schools, comprehensive schools, gymnasiums and vocational schools in the dual system) und six certified schools in Germany (vocational schools and seminars), approximately 1000 teachers and COOL classroom practice in about 200 schools confirm the success of the concept.

One important character of COOL is the class council, where students plan and organise learning themselves. The class council is an agency of self-determination in which all students participate with equal rights. Additionally, three principles of Parkhurst's Dalton Plan, freedom, cooperation and budgeting time, are crucial elements of COOL. Freedom means that students can choose the organisation of their tasks, cooperation, workplace, tools and time management. Freedom is contextualised with taking responsibility and therefore, release from fixed structures interrupting the work flow and the learning intensity. Cooperation as a social principle in COOL is not a prescription of partner or group work, it is rather a decision of the students how and

with whom they work together. Budgeting time expresses the idea of learning an autonomous organisation of the work.

The following list shows, how the concepts of Dalton Plan and Freinet pedagogy is implemented in COOL schools: (www.cooltrainers.at)[4]

- Teacher cooperate in class teams. In regular intervals they come together in team meetings, have a yearly closed meeting where they reflect, plan and develop teaching.
- Students work with written and often interdisciplinary assignments with definition of learning objectives first.
- In a third of regular classroom time, in COOL hours, the students can decide when, where and how they work on their tasks.
- In COOL phases teachers mute from lecturers to facilitators and coaches of students' learning processes.
- Methods of eLearning (eCOOL) enrich and support a differentiated classroom work (electronic assignments, feedback, ePortfolio, …)
- In periodical classroom councils learners discuss their wishes, reflect their learning progress and train to discuss.
- Teachers regularly give individual feedback on the learning process.
- Beside summative forms of assessments (eg. tests), formative methods of assessment (eg. portfolios) are used to enable the change of the students' perspective from consumer of education to autonomous learners.
- In regular work with parents, they become inspired to participate in learning processes.
- eCOOL connects social media elements with eLearning and combines the advantages of COOL with technical tools. eCOOL assignments, ePortfolios, electronic feedback and the use of learning platforms increase the flexibility, interactivity and transparency of cooperative working.

4.2 The 4 Cs in the context of COOL

(1) As **creativity** is defined as the interaction of the person with its attributes and the environment, the strong time limitations in public schools can restrict the development of creativity. COOL provides an open time organisation giving room for trying out things and combining elements as shown by Simonton (1988). Creative behavior implies original ideas and products. Making those ideas and products public by eCOOL activities, eg. ePortfolios and social media, society gets to know these ideas and products. Creativity is caused by the combination of elements, interdisciplinary approaches as "thinking school subjects together" lead to a deeper dispute of problems.

(2) **Critical thinking**: In class councils, students get encouraged to formulate desires and to reflect on their individual learning processes as well as on group processes. In most of the taxonomies, assessing 21st century skills evaluation, critical self-evaluation rank very high. For a democratic development, as Dewey postulated, those communicative processes about the self and its interactions in groups are crucial.

(3) **Communication** in COOL processes depends on one's personal attitudes. As there are many suggestions, how, with whom, where and when a student works, students can choose out of various communicative methods. This choice is an individual one and important in developing one's identity. In a digital world, there is an overload of different ways to communicate (eg. with social media), therefore it is necessary to reflect communication methods. This ability stands in a close connection with critical thinking.

(4) **Collaboration:** Working and thinking together has several synergetic effects on optimizing learning products, identifying interfaces in information exchange between students and teachers, presentations of products and services as well as taking and giving feedback (between teachers and

[4] Website of the initiative for Cooperatives Offenes Lernen (COOL)

students and between students). eCOOL learning platforms provide many services, eg. chatrooms, wikis, padlets, flipped classrooms etc. enable an open mind for collaboration und furthermore, to be successful in the 21st century.

5 Conclusion

How can educational systems prepare students for those future requirements?
In conclusion to all requirements of digitalisation and Industry 4.0, which will be part of humans' working and personal environment, it is obvious that tasks become more complex and get more connected. As studies about Industry 4.0 found out, creativity, critical thinking, collaboration and communication are important resources for enterprises on one hand and crucial skills on the other hand to avoid risks of digitalisation for employability and to use potentials of digitalisation. Learning environments have to support students by developing the 4 Cs as a base for their future in 21st century.

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