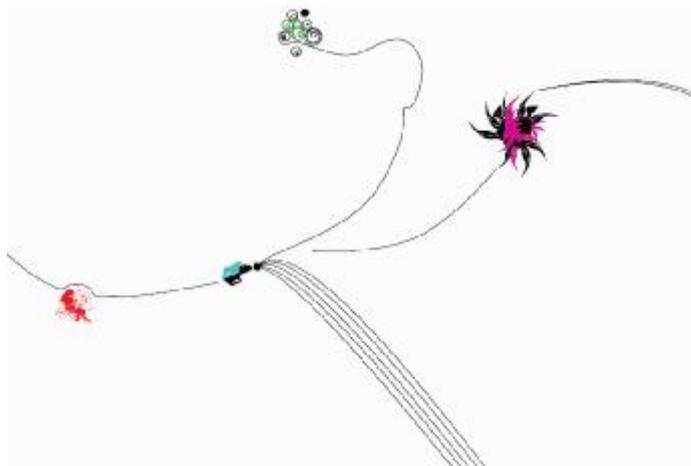


21st CENTURY SKILLS

DISCUSSION PAPER

Joke Voogt & Natalie Pareja Roblin
University of Twente



UNIVERSITEIT TWENTE.

21st CENTURY SKILLS. DISCUSSION PAPER

Joke Voogt & Natalie Pareja Roblin

This report is prepared for Kennisnet

University of Twente
Faculty of Behavioural Sciences
Department of Curriculum Design and Educational Innovation
P.O. Box 217
7500 AE Enschede
T: 053 4892022
F: 053-489 3759
E: j.m.voogt@utwente.nl

© Copyright, 2010, Joke Voogt & Natalie Pareja Roblin

EXECUTIVE SUMMARY

The main goal of this discussion paper concerns an analysis of what current theoretical frameworks say about 21st century skills, particularly with regard to its definition, implementation and assessment. In addition, the initiatives taken by different countries and international organizations are identified.

To accomplish this, a literature review was conducted on the available information about 21st century skills across five theoretical frameworks, namely: Partnership for 21st century skills (P21), En Gauge, Assessment and Teaching of 21st Century Skills (ATCS), National Educational Technology Standards (NETS/ISTE), and the National Assessment of Educational Progress (NAEP). This review was complemented with an additional search for international studies and recommendations from the European Union, OECD and UNESCO related to the need for and the implementation of 21st century skills.

Our search initially yielded 59 documents, 32 of which were analyzed in more detail. These 32 documents consisted mainly of working papers, international standards for ICT competences and reports from international studies. The results of this analysis were later on discussed in an expert meeting with the purpose of identifying key issues across frameworks, and come up with strategies and recommendations on how to support the implementation of 21st century skills.

The major findings can be summarized as follows. First, it is encouraging to see that - ultimately- the frameworks seem to converge on a common set of 21st century skills (namely: collaboration, communication, ICT literacy, and social and/or cultural competencies (including citizenship. Most frameworks also mention creativity, critical thinking and problem solving). However, this consistency is largely obscured by the use of different grouping and categorizing procedures, as well as differences in terminology chosen. This may generate confusion and ambiguity, hindering the implementation of these skills. In addition, most of the frameworks (with the exception of P21, ATCS and the European Union) seem to leave out a discussion of traditional curriculum competences and their link to 21st century skills. The little attention given to the positioning of 21st century skills within the existing curriculum shows that this is perhaps one of the most complex and controversial issues of its implementation.

Second, across the various frameworks it is acknowledged that Information and Communication Technology (ICT) is at the core of 21st century skills. Specifically, it is regarded as both (a) an argument for the need of 21st century skills, and (b) a tool that can support the acquisition and assessment of these skills. In addition, the rapid development of ICT requires a whole new set of competences related to ICT and technological literacy. Overall, the frameworks agree on suggesting that ICT holds the promise of supporting the acquisition and assessment of 21st century skills. However, this potential must be further explored through educational research initiatives.

Finally, our analyses of the frameworks revealed a large emphasis on the need for and the definition of 21st century skills, whereas only a few frameworks explicitly deal with more practical issues related to its implementation and assessment. Those frameworks that do address such practical issues refer to three major challenges: the curriculum integration of 21st century skills, the need for professional development, and the involvement of stakeholders from various sectors (public, private and educational) as a key factor for

implementation. Moreover, the adoption of new assessment models in line with the cross curricular and complex nature of 21st century skills is regarded as crucial to ensure the implementation of these skills.

Future progress can be made by addressing the following questions:

- § How the integration of 21st century skills/competences in the curriculum changes *what* and *how* is being taught at schools?
- § What does the implementation of 21st century skills demands from teachers, students, administrators and educational leaders?
- § How can different educational contexts -beyond the formal education system-, support the acquisition of 21st century skills?
- § How can ICT contribute to bridge formal and informal educational contexts?
- § What specific types of support do teachers and schools need to facilitate the acquisition of 21st century skills?
- § Are teachers and students prepared to adopt the new forms of assessments demanded by 21st century skills?
- § What changes should be made to national exams so as to include 21st century skills?

We propose that these questions should be addressed in a public debate about the implementation of 21st century skills.

TABLE of CONTENTS

EXECUTIVE SUMMARY	i
1. INTRODUCTION	1
What are 21 st century skills and why are they relevant?	1
Research questions	2
Overview of the discussion paper	3
2. METHOD	5
Literature review	5
Results	6
Criteria for analysis	7
Expert meeting	9
3. 21 st CENTURY SKILLS: WHAT SHOULD BE LEARNT AND WHY	11
Arguments for the need of 21 st century skills: Why are these skills important?	11
Overview of the frameworks	11
Discussion in the expert team	13
Recommendations from the expert team	14
Definition of 21 st century skills: What should be learnt?	14
Overview of the frameworks	14
Discussion in the expert team	19
Recommendations from the expert team	19
ICT-related competences and 21 st century skills	20
Overview of the frameworks	20
Discussion in the expert team	24
Recommendations from the expert team	25
4. 21 st CENTURY SKILLS IN EDUCATIONAL PRACTICE: IMPLEMENTATION ISSUES	27
Curriculum and Instruction	27
Overview of the frameworks	27
Discussion in the expert team	29
Recommendations from the expert team	30
Professional development	30
Overview of the frameworks	30
Discussion in the expert team	32
Recommendations from the expert team	33
Strategies and conditions	33
Overview of the frameworks	33
Discussion in the expert team	36
Recommendations from the expert team	36
5. 21 st CENTURY SKILLS OUTCOMES: ASSESSMENT ISSUES	39
New assessment models	39

Overview of the frameworks	39
Discussion in the expert team	40
Recommendations from the expert team	40
Assessment types	41
Overview of the frameworks	41
Discussion in the expert team	43
Recommendations from the expert team	44
ICT and assessment	44
Overview of the frameworks	44
Discussion in the expert team	45
Recommendations from the expert team	45
6. RECOMMENDATIONS	47
21 st century competences & assessment	47
Implementation of 21 st century competences	47
REFERENCES	49
APPENDIX 1 Guiding questions for the expert meeting discussion	51
APPENDIX 2 Examples of technology use for the implementation of 21 st century skills	53
APPENDIX 3 Examples of technology use for the assessment of 21 st century skills	54
EXPERT TEAM	56

1. INTRODUCTION

What are 21st century skills and why are they relevant?

It is generally accepted that due to the ubiquitous presence of technology our society is developing towards an information or knowledge society¹. While the information society metaphor is associated with an “explosion” of information and information systems, the knowledge society metaphor primarily refers to economic systems where ideas or knowledge function as commodities (Anderson, 2008, p. 5). Already in 1992 Reich reflected on the implications of technology for our society. He mentioned that many of the jobs for routine production workers - those who perform repetitive tasks – such as assembly line workers, will probably disappear, because of the increasing potential of technology to take over recurring tasks. At the same time there will be an increasing need for in-person service workers, such as child care workers and janitors, who provide professional services, and symbolic analysts - “mind workers” who engage in problem identification, problem solving and mediating information for a living – such as engineers and journalists (Reich, 1992). Levy and Mundane (2004) argue that for tasks that are rule based computers are an easy substitute, but computers cannot easily replace humans in tasks that require the interpretation of complex patterns. These more complex tasks can be found in many jobs – for example, the truck driver that has to find his way to deliver goods and the physician diagnosing a patient. In both tasks humans cannot be replaced by computers, but they can be supported by computer-based information at low cost. Not the exchange on information as such has become important, but a *particular understanding* of information has become an important part of many jobs (Levy & Mundane, 2006). For this reason, new competences - nowadays often referred to as 21st century skills - are being asked for. In addition, it is important to realize that society not only faces a change in the types of jobs that are needed, but that young people nowadays also need to be educated for a job that does not yet exist (Fisch & McLeod, 2009; Voogt & Odenthal, 1997). It is assumed that for many jobs key tasks are similar. For example, Anderson (2008) lists the following required skills for the knowledge society: 1. knowledge construction, 2. adaptability, 3. finding, organizing and retrieving information, 4. information management, 5. critical thinking and 6. team work. Already in 2002 the European Commission stated that all citizens of the European Union should have the opportunity to acquire a number of so called “key skills”, which are referring to the kind of skills Anderson (2008) has listed. Others (e.g. Law, Pelgrum and Plomp, 2008; OECD, 2004) refer to these skills as *lifelong learning competences*. The education ministers of OECD countries embraced the concept of lifelong learning in 2004, which covers all purposeful learning activities in a person’s life. In this paper we will use the term 21st century skills or 21st century competences as an overarching concept for the knowledge, skills and dispositions citizens need to be able to contribute to the knowledge society.

¹ In this contribution the terms information society and knowledge society, and the terms technology and Information and Communication Technology (ICT) will be used interchangeably.

Many argue (e.g. OECD, 2004; European Union, 2002; Voogt & Pelgrum, 2005) that the developments towards the knowledge society should have implications for our education systems. There is a need to change curricula so that students develop competences which are needed in the 21st century (e.g. Anderson 2008; Voogt & Pelgrum, 2005). One might argue that in addition to education also other arenas of society might provide relevant opportunities for acquiring 21st century competences. In short, the debate should not only focus on *what* important 21st century competences are, but also *where* and *how* these competences can be acquired.

Developments in the learning sciences (see, for example, Bransford, Brown, & Cocking, 2000) show the benefits of learner-centered forms of instruction. Students are expected to be more actively involved in their own learning process, which asks for different teaching strategies and a change in the responsibilities that students and teachers traditionally have held within the learning process. Voogt (2008) argues that these findings from research about the learning sciences are consistent with the importance policy makers attach to lifelong learning competences. Based on a review of the literature, she projected pedagogical approaches consistent with the expectations and values of the knowledge society. According to her the pedagogical approaches which are expected to be important should include providing variety in learning activities, offering opportunities for students to learn at their own pace, encouraging collaborative work, focusing on problem solving, and student involvement in assessment. Voogt argues that education needs to find a new balance between the pedagogical approaches that are considered useful in the industrial society and those that are deemed relevant for the information society or knowledge society.

Research questions

This study aims to identify and analyze various models that describe 21st century competences. In the conceptual framework (Travers & Westbury, 1989; Van den Akker, 2003) (Figure 1) that is used to analyze the models a distinction has been made between intentions, implementation in practice and realized outcomes. Because of the specific role of Information and Communication Technology (ICT) in the knowledge society, special attention has been given to ICT.

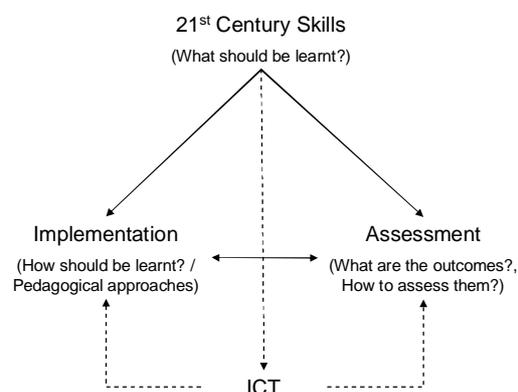


Figure 1: Conceptual Framework

This approach provides insight in similarities and differences between models (horizontal consistency) and coherence between intentions, implementation and assessment of outcomes (vertical consistency).

The following questions guide the study:

Intentions

1. Which 21st century competences – knowledge, skills and dispositions – are distinguished in the various models?
2. In what respect are these models similar or different?
3. Which ICT literacy skills do the 21st Century models distinguish?

Implementation in the curriculum

4. Do the models address implications for implementation in the curriculum? How can these practical elaborations be characterized?
 - § Is formal and informal learning addressed?
 - § Which stakeholders are identified? How are these stakeholders supported?
 - § Are these models associated with specific pedagogical approaches?
5. Which concrete experiences have been gained with the models?
6. What do the models say about ICT as a tool for the implementation of 21st Century Skills

Assessment of outcomes

7. How are 21st century competences assessed in these models?
8. What new approaches to assessment are indicated by the models?
9. Which experiences have been gained with assessment of 21st century skills?
10. What do the models say about ICT as a tool for assessing the acquisition of 21st Century Skills

Overview of the discussion paper

In the next chapter the method applied to conduct the review of the models will be described. This will be followed by a chapter describing and comparing the 21st century competences as identified in the various models. Chapter 4 describes the implementation strategies that are indicated and chapter 5 deals with assessment of 21st century competences. The report finishes with recommendations for the acquisition and implementation of 21st century competences in education.

2. METHOD

This discussion paper is based on a comprehensive literature review and an expert meeting. First, the literature review² will be described, including the searching strategies, its outcomes, and the criteria for analysis. Second, the purpose of the expert meeting and its contributions to the discussion paper are described.

Literature review

The aim of the literature review was to gather information about how different models address the need for and the implementation of 21st century competences/skills. The following models were selected:

- § *Partnership for 21st century skills (P21)*, developed in the United States with the goal of positioning 21st century skills at the center of K12 education. P21 is a national organization formed in 2001 with the sponsorship of the United States government and several organizations from the private sector (e.g., Apple Computer, Cisco Systems, Dell Computer Corporation, Microsoft Corporation, National Education Association, etc.).
- § *EnGauge*, developed by the Metiri group and the Learning Point Associates with the purpose of fostering 21st century skills in students, teachers and administrators.
- § *Assessment and Teaching of 21st Century Skills (ATCS)*, developed as part of an international project sponsored by Cisco, Intel and Microsoft. This project aims at providing clear operational definitions of 21st century skills for the design of innovative assessment tasks to be used in the classroom.
- § *National Educational Technology Standards (NETS)*, developed by the *International Society for Technology in Education (ISTE)* with the purpose of setting goals for what students, teachers, and administrators should know and be able to do with technology in education.
- § *Technological Literacy Framework for the 2012 National Assessment of Educational Progress (NAEP)*³, developed by WestEd at request of the National Assessment Governing Board of the United States. The goal of this framework is to establish what students - particularly at grades 4, 8 and 12- should know about and be able to do with technology. The framework is also intended to set forth criteria for the design of future national assessments.

² Acknowledgement. The authors wish to thank Petra van Waarden, Joscintha Ballast and Hidde Terpoorten for their contributions to the literature review.

³ The NAEP framework was added to the set of models after the expert meeting due to its significance for ICT literacy assessment (which is regarded as one 21st century skills).

Additionally, a search was conducted for international studies carried out by the European Union, OECD and UNESCO. The purpose of this latter search was to identify initiatives taken by different countries with regard to 21st century skills, as well as the recommendations of international organizations on this matter.

The search strategy undertaken for the literature review consisted basically on a comprehensive exploration of all the information about 21st century competences/skills available across the official websites of the different models and international organizations.

Results

The search yielded a total of 59 documents (Table 1) consisting of working papers (49%), international standards for ICT competences (12%), reports from international studies (7%), progress reports⁴ (8%), and implementation guides with exemplary curriculum materials for teachers (24%). From all the documents found, the working papers, the reports from international studies, and the most recent international standards for ICT competences were selected for further analysis (32 documents). These documents were selected on the base of their contribution to understand how different frameworks and/or countries address issues related to 21st century competences/skills, its implementation and assessment.

Table 1. *Overview of the search results*

Framework	Total outcome	Selected for analysis
P21	27	9
EnGauge	3	3
ATCS	8	6
NETS / ISTE	9	4
NAEP	1	1
EU	5	4
OESO	3	3
UNESCO	3	2
TOTAL	59	32

⁴ By progress reports we refer to the reports on the initiatives and actions taken by different states in the US to support the implementation of 21st century skills. These reports are based on the guidelines set by the Partnership for 21st Century Skills (P21).

From the 32 documents selected for further analysis, 15 documents addressed the definition of 21st century competences/skills and their importance to society and education, 14 documents addressed the implementation of 21st century skills, and 10 documents addressed the assessment of 21st century skills⁵.

On the base of the findings of the initial literature review an additional search was conducted to identify concrete projects that could illustrate the implementation and assessment of 21st century skills at the classroom level (See appendices 2 and 3).

Criteria for analysis

The analysis of the documents was focused on three major themes:

- § Skills / competences
- § Implementation issues
- § Assessment

Table 2. *Analysis criteria*

Theme	Analysis Criteria	Description
Skills / Competences	Arguments for the need of 21 st century skills	<ul style="list-style-type: none"> - <i>Why are 21st century skills important?</i> - <i>What arguments guide the discussion about the need for 21st century skills?</i>
	Definition of 21st century skills/competences	<ul style="list-style-type: none"> - <i>What are 21st century skills according to the different frameworks?</i> - <i>What are the similarities and differences between the competences stated by the frameworks?</i>
	ICT related competences	<ul style="list-style-type: none"> - <i>Are ICT skills regarded as part of 21st century skills?</i> - <i>What ICT competences do the frameworks refer to? Are there any differences?</i>
Implementation Issues	Curriculum and instruction	<ul style="list-style-type: none"> - <i>What do the frameworks say about the relationship between 21st century skills and the existing curricula?</i> - <i>How can 21st century skills be taught? What instructional approaches are more appropriated for 21st century skills?</i>
	ICT	<ul style="list-style-type: none"> - <i>How can ICT support the implementation of 21st century skills?</i>

⁵ Please note that some documents could be categorized under multiple themes. That is why the numbers do not add up to 32.

Theme	Analysis Criteria	Description
	Professional development	<ul style="list-style-type: none"> - According to the different frameworks, what competences and types of support do teachers need to implement 21st century skills? - What should be the characteristics of professional development programs to support the implementation of 21st century skills?
	Public – Private partnerships	<ul style="list-style-type: none"> - What do the models say about the different stakeholders involved in the implementation of 21st century skills? - Do the models mention anything about possible partnerships between public and private organizations?
	Strategies / Conditions for implementation	<ul style="list-style-type: none"> - According to the frameworks, what strategies could support the implementation of 21st century skills?
Assessment	Arguments for new assessment models	<ul style="list-style-type: none"> - Are new forms of assessment needed and why? - What are the functions of the assessment of 21st century skills according to the different frameworks?
	Types of assessment	<ul style="list-style-type: none"> - What type(s) of assessment are more appropriate for 21st century skills?
	Assessment Instruments	<ul style="list-style-type: none"> - How can 21st century skills be assessed?
	ICT	<ul style="list-style-type: none"> - How can ICT support the assessment of 21st century skills?
	Strategies / conditions	<ul style="list-style-type: none"> - What conditions are needed to assess 21st century skills?

As a result of the documents' analysis, several handouts were prepared with a summary of the main points addressed by the different frameworks for each of the above mentioned themes. These handouts served as a base for the discussion in the expert meeting.

Expert meeting

The aim of the expert meeting was to identify and discuss key issues that should be included in the discussion paper, and to come up with strategies and recommendations on how to support the implementation and assessment of 21st century skills.

Five experts from the United Kingdom, Germany, Belgium (Flanders) and The Netherlands met in March 2010 to join a two-day session to discuss 21st century skills/ competences, implementation, and assessment at the University of Twente. The discussion was based on the results of the literature review, and guided by several questions prepared by the project team (see Appendix 1).

The observations and recommendations of the experts, as well as their feedback on previous drafts served as an important input for the development of this discussion paper.

3. 21st CENTURY SKILLS: WHAT SHOULD BE LEARNT AND WHY

Arguments for the need of 21st century skills: Why are these skills important?

Overview of the frameworks

The prominent need for 21st century skills is a common issue across the different frameworks. This need is mostly attributed to the changes in society, and more particularly, to the rapid development of technology and its impact on the way we live, work and learn. Through Information and Communication Technology our society is changing from an industrial society to an information or knowledge society (Voogt, 2008). While in the industrial society the main focus of education was to contribute to the development of factual and procedural knowledge, in the information or knowledge society the development of conceptual and meta-cognitive knowledge is increasingly considered important (Anderson 2008). As most frameworks argue, this change has inevitable implications for our education systems.

Some frameworks also stress the changes in economy and the labor market caused by globalization and internationalization as one of the important driving forces for the need of 21st century skills (this is particularly the case for the European Union and OECD). The need for individuals to flexibly adapt to a changing society (ATCS, P21 and European Union) as well as the need for sustainable democratic development (OECD) are mentioned by a few frameworks, whereas the latest developments on educational research about learning and learning tools are regarded as an argument for 21st century skills only by P21 and En Gauge (see Table 3).

Overall, economic and societal changes closely related to the recent developments in technology -and consequently in the characteristics of the jobs and the home environment-, seem to be regarded as the most important driving forces that call for 21st century skills.

Table 3. Arguments for 21st century skills across frameworks

P21	En Gauge	ATCS	European Union	OECD
<p>Economic, technological, informational, demographic and political forces are transforming the way people live and work.</p> <p>Schools must bridge the gap between how students live and learn</p> <p>All students must have equal access to the new technological world, regardless of their economical background.</p> <p>Scientific insights of educational research must be incorporated into teaching and learning in a broad scale.</p>	<p>Given the rapid rate of change, the vast amount of information to be managed, and the influence of technology on life in general, students need to apply current skill sets, as well as develop new skill sets to cope with a changing society.</p> <p>True equity will require high levels of technology proficiency to ensure broader, more meaningful, and increasingly innovative uses of technology by all segments of the population</p> <p>Advances in the cognitive sciences show that learning increases significantly when students are engaged in academic study through authentic, real-world experiences.</p>	<p>Developments in advanced economies.</p> <p>Information and communication technology is transforming the nature of how work is conducted and the meaning of social relationships.</p> <p>Decentralized decision-making, information sharing, teamwork and innovation are key in today's society.</p>	<p>The need for economic competitiveness:</p> <ul style="list-style-type: none"> - Internationalisation/globalisation; - The rapid pace of change, and the continuous roll-out of new technologies. <p>The need to keep specific job-related skills up-to-date, but also possess the generic competences that will enable individuals to adapt to change.</p>	<p>Competences need to be appropriate for a world where:</p> <ul style="list-style-type: none"> - Technology is changing rapidly and continuously, and learning to deal with it requires adaptability. - Societies are becoming more diverse and compartmentalized. - Globalization is creating new forms of interdependence. <p>key competences must:</p> <ul style="list-style-type: none"> - Contribute to valued outcomes for societies and individuals; - Help individuals meet important demands in a wide variety of contexts; and - Be important not just for specialists but for all individuals

Discussion in the expert team

The need for 21st century skills seems to be relying mainly on private/business initiatives; however, the economic interests or the “hidden agenda” of the companies and institutions that are behind these initiatives is often not made clear or explicit. Educational leaders, practitioners and the educational community in general do not seem to actively participate on the public debate about the need for 21st century skills and its role in the curriculum.

Furthermore, there seems to be a conflict of interests between societal and individual needs as driving forces for 21st century skills. While economic and social needs are strongly stressed by most frameworks, the goals of individual learners and equity issues related to the right of every citizen to be prepared for society are less emphasized (references to this can only be found in P21 and En Gauge).

Finally, another blind spot in the different frameworks is the educational rationale behind the need for 21st century skills. The need for 21st century skills as a way to improve the quality of teaching and learning is mentioned only by the P21 and the En Gauge frameworks.

Developments in the learning sciences (see, for example, Bransford et al. 2000) show the benefits of learner-centered forms of instruction. Students are expected to be more actively involved in their own learning process, which asks for different teaching strategies and a change in the responsibilities that students and teachers traditionally have held within the learning process. These findings from research are consistent with the importance policymakers attach to “lifelong learning” and “learning-to-learn” competencies. Voogt (2003, 2008), based on a review of the literature, projected pedagogical approaches consistent with the expectations and values of the information society and showed how these might differ from those consistent with the expectations and values of the industrial society (see Table 4). According to Voogt, the pedagogical approaches which are expected to be important in the information society have, amongst others, more to do with providing variety in learning activities, offering opportunities for students to learn at their own pace, encouraging collaborative work, focusing on problem-solving, and encouraging student involvement in assessment.

Table 4. *Overview of pedagogy in an industrial society versus an information society (source Voogt, 2003)*

Aspect	Less (pedagogy in an industrial society)	More (pedagogy in the information society)
Active	Activities prescribed by the teacher	Activities determined by the learner
	Whole class instruction	Small groups
	Little variation in activities	Many different activities
	Pace determined by the program	Pace determined by the learner
Collaborative	Individual	Working in teams
	Homogeneous groups	Heterogeneous groups
	Everyone for him/herself	Supporting each other
Creative	Reproductive learning	Productive learning
	Apply known solutions to problems	Find new solutions to problems
Integrative	No link between theory and practice	Integrating theory and practice
	Separate subjects	Relations between subjects
	Discipline-based	Thematic
	Individual teachers	Teams of teachers
Evaluative	Teacher-directed	Student-directed
	Summative	Diagnostic

Recommendations from the expert team

- § Beyond the need to meet the economic and societal demands of a globalized world, the changing role of schools in society as well as the need for continuous improvement of the quality of education should be regarded as driving forces for including 21st century skills in the curricula of various types of schools.
- § Equity issues should be carefully taken into account while analyzing the need for and the importance of 21st century skills.

Definition of 21st century skills: What should be learnt?

Overview of the frameworks

All the frameworks seem to be largely consistent in terms of what 21st century skills are and what should be added to the curriculum. However, each framework has a different focus and areas of emphasis within the overarching skills (Dede, 2010).

The Partnership for 21st Century Skills (P21), as well as the recommendations from the OECD and the European Union about “key competences” could be regarded as more generic frameworks that provide a conceptualization of 21st century skills from which the other frameworks are built. The ATCS and the NAEP frameworks have a clear emphasis on the assessment of 21st century skills, whereas NETS, En Gauge and UNESCO focus more on issues

related to digital literacy and the integration of technology in the curriculum. Consequently, the importance assigned to a specific set of skills varies within the range of what all frameworks agree to call 21st century skills.

While all the frameworks refer to similar skills, it is important to acknowledge that the categories used to group these skills can not be easily compared due to the differences in emphasis and lines of reasoning. Within the limitations that this provides for comparison, we attempted as much as possible to arrange the different frameworks within a structure that depicts the overall connections irrespective of the differences in the terminology chosen (see Table 5).

In order to clarify the similarities and differences between frameworks, Table 6 presents an overview of those skills mentioned by all frameworks (using the same or comparable terminology) as opposed to those that are regarded as important only by a few frameworks.

As found in other studies that compare different frameworks for 21st century skills (Trier, 2002; Dede, 2010; Anderson, 2008), there are strong agreements on the need for skills in the areas of communication, collaboration, ICT literacy, and social and/or cultural awareness. Creativity, critical thinking, problem solving and the capacity to develop relevant and high quality products are also regarded by most frameworks as important skills in the 21st century.

Differences between frameworks emerge mainly from the way of categorizing and grouping the skills, as well as from the importance attributed to them. An additional difference concerns the competences that are related to the core subjects, and especially whether or not to consider them while addressing 21st century skills. References to “core subjects” or the “core curriculum” can only be found (explicitly) in P21 and ATCS, and (implicitly) in the European Union recommendations.

Table 5. Conceptualization of 21st century skills in different frameworks⁶

P21	En Gauge	ATCS	NETS / ISTE	EU	OECD
Learning and innovation skills 1. Critical thinking and problem solving; 2. Creativity and innovation; 3. Communication and collaboration	Inventive thinking 1. Adaptability, managing complexity and self-direction; 2. Curiosity, creativity and risk taking; 3. Higher order thinking and sound reasoning.	Ways of thinking 1. Creativity and innovation; 2. Critical thinking, problem solving, decision making; 3. Leadership to learn, meta-cognition	Creativity and Innovation <i>Creative thinking, construct knowledge, and develop products and processes using technology</i>	Learning to learn	
	Effective communication 1. Teaming, collaboration and interpersonal skills; 2. Personal, social and civic responsibility; 3. Interactive communication	Ways of working 1. Communication; 2. Collaboration (teamwork)	Critical thinking, problem solving and decision making		
Information, media and technology skills 1. Information literacy; 2. Media literacy; 3. technology literacy	Digital-age literacy 1. Basic, scientific, economic and technology literacies; 2. Visual and information literacies; 3. Multicultural literacy and global awareness.	Tools for working 1. Information literacy; 2. ICT literacy	Technology operations and concepts <i>Sound understanding of technology concepts, systems and operations.</i>	Digital competence	Using tools interactively 1. Use language, symbols and text interactively; 2. Use knowledge and information interactively; 3. Use technology interactively
			Research and information fluency <i>Apply digital tools to gather, evaluate and use information.</i>		
Life and career skills 1. Flexibility and adaptability; 2. Initiative and self-direction; 3. Social and cross-cultural skills; 4. Productivity and accountability; 5. Leadership and responsibility	High productivity 1. Prioritizing, planning and managing for results; 2. Effective use of real world tools; 3. Ability to produce relevant, high quality products.	Living in the world 1. Citizenship – local and global; 2. Life and career; 3. Personal and social responsibility (including cultural awareness and competence)	Digital citizenship <i>Understand human, cultural and societal issues related to technology.</i>	Cultural awareness and expression Social and civic competences Sense of initiative and entrepreneurship	Acting autonomously 1. Act within the big picture; 2. Form and conduct life plans and personal projects; 3. Defend and assert rights, interests and needs.

⁶ Please note that the UNESCO and NAEP frameworks are not included in this comparison. The reason for this is that neither of them provides a definition of 21st century skills. UNESCO builds from the skills defined by P21, and NAEP focuses exclusively on skills related to technological literacy.

P21	En Gauge	ATCS	NETS / ISTE	European Union	OECD
<p>Core Subjects</p> <p>1. English, reading or language;</p> <p>2. Foreign languages;</p> <p>3. Arts;</p> <p>4. Mathematics;</p> <p>5. Economics;</p> <p>6. Science;</p> <p>7. Geography;</p> <p>8. History;</p> <p>9. Government and civics</p>		<p>Core curriculum</p> <p>1. Home language</p> <p>2. Mathematics</p> <p>3. Science</p> <p>4. History</p> <p>5. Arts or Humanities</p>		<p>1. Mathematical</p> <p>2. Basic competences in science</p> <p>3. Basic competence in technology</p> <p>4. Communication in mother tongue</p> <p>5. Communications in foreign languages</p>	
<p>Interdisciplinary themes</p> <p>1. Global awareness;</p> <p>2. Financial, economic, business and entrepreneurial literacy;</p> <p>3. Civic literacy;</p> <p>4. Health Literacy and environmental literacy</p>					

Table 6. *Similarities and differences between frameworks*

Mentioned in <i>all</i> frameworks	Mentioned in <i>most</i> frameworks (i.e., P21, EnGauge, ATCS and NETS/ISTE)	Mentioned in a <i>few</i> frameworks	Mentioned only in <i>one</i> framework
<ul style="list-style-type: none"> - Collaboration - Communication - ICT literacy - Social and/or cultural skills; citizenship 	<ul style="list-style-type: none"> - Creativity - Critical thinking - Problem solving - Develop quality products / Productivity (except in ATCS) 	<ul style="list-style-type: none"> - Learning to learn (ATCS, EU) - Self-direction (P21, En Gauge, OECD) - Planning (En Gauge, OECD) - Flexibility and adaptability (P21, EnGauge) <p>Core Subjects:</p> <ul style="list-style-type: none"> - Mathematics; communication in mother tongue; science (EU, P21, ATCS); - History and arts (P21 and ATCS) 	<ul style="list-style-type: none"> - Risk taking (En Gauge) - Manage and solve conflicts (OECD) - Sense of initiative and entrepreneurship (EU) - Interdisciplinary themes (P21) - Core Subjects: economics; geography; government and civics (P21)

Discussion in the expert team

Despite similarities and connections which can be identified across frameworks, different terms and definitions are often used to describe a skill or set of skills, causing ambiguity and confusion. Explicit references to a specific educational level (primary, secondary, and tertiary education) or educational environment (formal or informal education) while talking about 21st century skills are missing. Most of the frameworks address education in general, without a further discussion on the importance of different skills at different levels, the expected educational outcomes for each skill across levels, or how to transfer skills from informal to formal settings and vice-versa.

Furthermore, the links between “new” and “old” skills are still unclear. As a consequence, the place of 21st century skills in the “traditional” curriculum is uncertain. How are 21st century skills linked to the current curriculum?; should all these skills be part of the curriculum of compulsory education?; if so, what should be left out (if any) to make room for the new skills? These and other controversial issues related to the implementation of 21st century skills will be analyzed in more detail further on.

Recommendations from the expert team

- § Clear labels and definitions for each skill and set of skills should be provided. These labels should be highly accessible and easy to communicate in order to ensure a common understanding between the different stakeholders involved in the implementation of 21st century skills.
- § Core subjects, interdisciplinary themes and generic 21st century skills should be identified and clearly defined, starting from what is already being taught at schools. Links between these have to be explicitly explained so as to depict how the “new” skills are integrated into the curriculum.
- § Generic 21st century skills/competences should be defined in terms of knowledge, skills, attitudes, values and ethics (as proposed by the KSAVE framework⁷), and should be realized through core subjects.
- § Interdisciplinary themes should allow linking school’s core subjects with what is going on in society, while at the same time contributing to the acquisition of generic 21st century skills. These themes should be regarded as dynamic and in continuous change, since they must reflect contemporary societal issues.
- § Individual differences should be considered while determining the expected educational outcomes or achievement targets for each skill. Additionally, the links between formal and informal learning environments as well as their contributions to the acquisition of 21st century skills should be explored.

⁷ KSAVE is a framework developed by the ATCS to provide measurable descriptions of each skill in terms of knowledge, abilities (skills), attitudes, values and ethics.

ICT-related competences and 21st century skills

Overview of the frameworks

It is without a question that ICT has a primary place when talking about 21st century skills. The development of technology is not only regarded as an argument for the need of new skills by all frameworks, but it is also associated to a whole new set of competences about how to effectively use, manage, evaluate, and produce information across different types of media.

With more or less detail, all frameworks refer to the three domains of what Anderson (2008) refers to as 'applied ICT literacy', namely: a technical domain (related to the basic operational skills needed to use ICT), a knowledge domain (which refers to the use of ICT with a particular knowledge related purpose) and an information literacy domain (related to the capacity to access, evaluate and use information). However, the emphasis given to these domains varies across frameworks (see Table 7). While some of them emphasize the technical and information literacy domains (P21, ATCS), others call attention to more integrative approaches where the development of ICT skills is embedded within other 21st century skills, such as critical thinking, problem solving, communication and collaboration (this is clearly the case for the NETS/ISTE framework).

Table 7. *ICT-related competences across frameworks*⁸

P21 (Information, media and technology skills)	En Gauge (Digital Age Literacy)	ATCS (Tools for working)	NETS / ISTE (Technology standards and performance indicators for students)	NAEP (Technological Literacy)	European Union (Digital competences)
Information Literacy <i>1. Access and evaluate information; 2. use and manage information.</i>	Information Literacy <i>1. Evaluate information across a range of media; 2. Recognize when information is needed; locate, synthesize, and use it effectively</i>	Information Literacy <i>1. Access and evaluate information; 2. Use and manage information.</i>	Research and information fluency <i>Apply digital tools to gather, evaluate and use information.</i>		<i>Ability to search, collect and process information and use it in a critical way; ability to access, search and use Internet-based services.</i>
Media Literacy <i>1. Analyze media; 2. create media products.</i>			Creativity and Innovation <i>Use technology to construct knowledge, develop innovative products and processes.</i>	Developing solutions and achieving goals <i>Use a wide range of technological tools; apply technological concepts; collect and analyze data to develop a solution.</i>	<i>Skills to use tools to produce, present, and understand complex information</i>
			Critical Thinking, problem solving and decision making <i>Use appropriate digital tools and resources to conduct research, manage projects and solve problems.</i>		<i>Use ICT to support critical thinking, creativity and innovation.</i>

⁸ Please note that the OECD framework is not included in this comparison since it does not consider ICT as part of 21st century skills, but rather as a separate set of skills (namely, *ICT functional skills* and *ICT skills for learning*). The UNESCO framework is not included because it does not provide an explicit definition of ICT skills/competences.

P21 (Information, media and technology skills)	En Gauge (Digital Age Literacy)	ATCS (Tools for working)	NETS / ISTE (Technology standards and performance indicators for students)	NAEP (Technological Literacy)	European Union (Digital competences)
ICT Literacy <i>1. Apply technology effectively;</i> <i>2. Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information technologies.</i>	Technological Literacy <i>Knowledge about what technology is, how it works, what purposes it can serve, and how it can be used efficiently and effectively to achieve specific goals.</i>	ICT Literacy <i>1. Apply technology effectively;</i> <i>2. Create media products;</i> <i>3. Apply and employ technology with honesty & integrity.</i>	Technology operations and concepts <i>Sound understanding of technology concepts, systems and operations.</i> Digital citizenship <i>Understand human, cultural and societal issues related to technology.</i>	Understanding technological principles <i>Understand the nature of technology; be aware of the appropriate use of various digital tools; know how technology is created and how it shapes and is shaped by society.</i>	
	Interactive communication <i>Generate meaning through exchanges using a range of tools and processes.</i> Effective use of real world tools <i>Use real world tools to communicate, collaborate, and solve problems.</i>		Communication and collaboration <i>Use digital media and environments to communicate and work collaboratively.</i>	Communicating and collaborating <i>Use a variety of media and formats to communicate ideas and to collaborate with peers and experts.</i>	

Overall, most frameworks refer to three types of technology literacy while defining ICT related skills: Information literacy, technological literacy and ICT literacy. However, the operational definitions of these concepts can differ between frameworks.

Information literacy refers to the capacity to access information efficiently and effectively, to evaluate information critically and competently, and to use information accurately and creatively (Information Literacy Standards for Student Learning, 1998). A similar conceptualization can be identified in the P21, En Gauge and ATCS frameworks.

References to ICT literacy are mainly found in P21 and ATCS, whereas En Gauge and NAEP prefer to use the term technological literacy. ICT literacy in its traditional form refers to the technical skills related to the use of technology (Anderson, 2008). However, this term can also be conceptualized in a much broader way as the use of digital technology, communication tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society (International ICT Literacy Panel, 2002). In a similar way, technological literacy can be defined as the capacity to use, understand, and evaluate technology as well as to understand technological principles and strategies needed to develop solutions and achieve goals (NAEP, 2010). According to the Committee on Technological Literacy (2002), a technologically literate citizen should: be able to recognize technology in its many forms; be familiar with basic concepts important to society; know something about the engineering design process; and, recognize that technology influences changes in society and that society also shapes technology.

The main difference between these two concepts lies in their precise emphasis with regard to the competences needed to function in a knowledge society. Technological literacy emphasizes the interplay between technology and society, as well as the importance of understanding the technological principles needed to develop relevant solutions and achieve goals. Conversely, ICT literacy focuses mainly on how to make an effective and efficient use of digital technologies.

Another characterization of literacy types related to technology is the one proposed by Mioduser, Nachmias & Forkosh-Baruch (2008). These authors argue that the knowledge society calls for seven new literacies, namely:

- § *Multimodal information processing.* Skills and knowledge required to understand, produce, and negotiate meanings in a culture made up of words, images, and sounds.
- § *Navigating the infospace.* Ability to know when and why there is a need for information; how and where to find it in, and retrieve it from the vast infospace; and how to decode, evaluate, use, and communicate it in both an efficient and ethical manner.

- § *Interpersonal communication.* Skills required for mindful, knowledgeable, and ethical use of a wide range of communication means, using multiple communication channels, in various interaction configurations, for different purposes.
- § *Visual literacy.* Ability to decode, evaluate, use, or create images of various kinds using both conventional and twenty-first century media in ways that advance thinking, reasoning, decision making, communication, and learning.
- § *Hyperacy.* People's ability to deal, either as consumers or as producers, with nonlinear knowledge representations.
- § *Personal information management literacy.* Process by which an individual stores his/her information items to retrieve them later
- § *Coping with complexity.* Skills and methods required to perceive phenomena as complex (e.g., recognizing multiple actors or multiple layers), to study and understand these phenomena (e.g., devising multiple alternatives and strategies), and to implement the gained understanding for coping with them.

Discussion in the expert team

The need for ICT skills/competences is clearly stressed by all frameworks; however its link to the other 21st century skills is not always clear. An integrative approach, as the one suggested by the ISTE/NETS and the En Gauge frameworks, should be adopted so that ICT skills are not regarded as a separate set of skills, but embedded in and across the other 21st century skills and the core subjects.

Closely linked to the "place of ICT skills" in the overall definition of 21st century skills, is the need to acknowledge the multiple roles technology can have in the curriculum. Technologies can be used to support learning (learning *with* technology), or to deliver education (learning *through* technology), but they can also be regarded as a curriculum content in itself (learning *about* technology).

Although the acquisition of some ICT skills can be facilitated through learning activities that require the use of technology (i.e., learning *with* technology), other skills may need to be addressed in a more specific way (i.e., learning *about* ICT). These roles should be differentiated and their contribution to the acquisition of ICT skills should be explained.

Finally, the potential role of ICT as a "bridge" between formal and informal learning environments should also be considered. What students learn *from* and *about* ICT outside schools should be contemplated in the curriculum. In the same way, what students learn at the school about ICT should be transferred to their daily lives.

Recommendations from the expert team

- § An integrative approach similar to the one proposed by the En Gauge and NETS/ISTE frameworks could be adopted. ICT skills should not be regarded as a separate set of skills, but embedded within and across the other 21st century skills and core subjects.
- § The multiple roles of ICT in the curriculum -as well as the ways in which these roles may contribute to the acquisition of ICT related skills/competences- should be taken into account.
- § The need for different types of literacy in the knowledge society must be acknowledged. Beyond the differences between Information Literacy, ICT literacy and Technological Literacy addressed across the frameworks, the seven literacies for the knowledge society distinguished by Mioduser, Nachmias & Forkosh-Baruch (2008) could be used as a reference.

4. 21st CENTURY SKILLS IN EDUCATIONAL PRACTICE: IMPLEMENTATION ISSUES

When talking about the implementation of 21st century skills, three main issues seem to be the focus of attention across the different frameworks: (a) curriculum and instruction; (b) professional development; and, (c) strategies and conditions for the implementation of 21st century skills both at a national and school level.

Curriculum and Instruction

Overview of the frameworks

One of the most controversial issues of 21st century skills' implementation is defining their role and place within the curriculum. What education should emphasize as its core outcomes (Dede, 2010), and how to directly and explicitly address the discourse of 21st century skills in curriculum development (Trier, 2002) are some of the complex questions raised when considering the implementation of 21st century skills.

A number of frameworks refer to different approaches that can guide the curricular integration of 21st century skills (see Table 8). Essentially, these approaches suggest that 21st century skills can either: (a) be added to the already existing school curriculum as new subjects or as new content within traditional subjects; (b) be integrated as cross curricular competences that both underpin the subjects of school curriculum and place emphasis on the acquisition of wider key competences; or (c) be part of a new curriculum in which the traditional structure of school subjects is transformed and schools are regarded as learning organizations.

Table 8. *Approaches to the curriculum integration of 21st century skills*⁹

P21	ATCS	European Union	UNESCO
<ul style="list-style-type: none"> - Emphasis on core subjects as defined by “No Child Left Behind” in the US - Emphasis in learning skills defined as: information and communication; thinking and problem solving; interpersonal and self-directional skills - Teach and learn 21st century content, emphasizing: global awareness; financial, economic and business literacy; civic literacy. These contents should be infused into core subjects or used in contextual learning experiences. 	<p><i>Additive change.</i> Addition of new skill objectives and new curriculum content. Changes to the existing curricula will be required to make room for additions.</p> <p><i>Assimilative change.</i> Existing curricula and teaching methods are modified to place greater emphasis on critical thinking, problem solving, collaboration and so forth.</p> <p><i>Systematic change.</i> Instead of incorporating new elements, schools are transformed into 21st century organizations (i.e., learning organizations)</p>	<p><i>Key competences defined as special subjects.</i> Key competences are included as separated subjects in the curriculum.</p> <p><i>Key competences defined as optional subjects.</i></p> <p><i>Key competences defined within traditional subjects.</i> Key competences are included in the descriptions of the requirements for particular (core) subjects.</p> <p><i>The whole school approach.</i> Focus on cross curricular key competences. Requires that the school level curriculum is designed in a way that links between subject domains are created.</p>	<p><i>Technology literacy approach.</i> Changes in the curriculum are oriented towards improving basic literacy skills through the integration of various technologies, tools and e-content as part of whole class, group and individual activities.</p> <p><i>Knowledge deepening approach.</i> Changes in the curriculum emphasize depth of understanding over coverage of content and assessment emphasizes the application of understanding to real world problems. Class periods and classroom structure are more dynamic.</p> <p><i>Knowledge creation approach.</i> Curriculum goes beyond a focus on school subjects to explicitly include 21st century skills. Schools are transformed into learning organizations.</p>

⁹ Please note that only the frameworks that make explicit references to the approaches for the curriculum integration of 21st century skills are included in this comparison

Although different approaches are acknowledged, most frameworks recommend integrating 21st century skills/competences across the curriculum. This approach is consistent with what the OECD (Ananiadou & Claro, 2009) and the European Union (Gordon et al., 2009) have found in the national policies about 21st century skills adopted by the countries participating in their studies.

Differences are mainly found with regard to the emphasis that should be given to the diverse skills in the curriculum. While most frameworks are rather general, P21 recommends to emphasize a specific set of competences regarded by this framework as “learning skills” (i.e., information and communication; thinking and problem solving; interpersonal and self-directional skills). Another important difference can be found in the ways ICT related skills/competences are integrated in the curriculum. As opposed to the cross curricular character attributed to most 21st century skills, ICT related skills/competences are often treated as optional courses in the curriculum (Gordon et al., 2009; Ananiadou & Claro, 2009).

Overall, and irrespective of the approach adopted for its integration, all frameworks suggest that 21st century skills demand significant changes in the curriculum. These changes are related to restructuring the curriculum in order to make room for 21st century skills, but also to the need for new teaching methods and assessment procedures.

According to P21 and the European Union frameworks, the acquisition of 21st century skills can be best supported by specific pedagogic techniques, such as problem-based learning, cooperative learning, experiential learning, and formative assessment. Next to these innovative teaching approaches, most frameworks also emphasize the need for a comprehensive use of technology to enhance student learning and to promote the mastery of 21st century skills.

Anderson (2008) and Dede (in press) provide some illustrative examples on how technology can be used to support the mastery of 21st century skills. Some of these examples include the use of groupware tools to support collaboration, and the use of simulations based on Multi User Virtual Environments (MUVE) to support problem solving and critical thinking (See Appendix 2 for other examples on the use of technology to support the acquisition of 21st century skills).

Discussion in the expert team

The integration of 21st century skills entails important changes in the curriculum and the school culture. It calls for an interdisciplinary vision that goes beyond the traditional divisions between subject domains. To accomplish this, new teaching methods as well as stronger collaboration and knowledge sharing structures need to be developed at school level.

Although most frameworks recommend a cross-curricular approach for the integration of 21st century skills, the emphasis that should be given to these competences in the curriculum as well as their link to core subjects is only explicitly discussed in P21 and in ATCS.

Another blind spot across frameworks is related to the consequences of integrating 21st century skills/competences into core subjects, and the responsibilities of each subject in achieving these competences. How does the integration of 21st century skills/competences change *what* and *how* is being taught at schools? What is the importance of these competences compared to the subject-related competences? These issues are not discussed in detail by the frameworks.

Finally, little or no references can be found with regard to the role of diverse educational contexts (beyond the formal education system) in the acquisition of 21st century skills (for example, the role of families, peers, leisure activities, etc.).

Recommendations from the expert team

- § As suggested by most frameworks, 21st century skills should be integrated across and within core subjects; however the changes this entails for subject-bound knowledge, instructional methods and assessment procedures should be explicitly explained.
- § The weight of 21st century skills in the curriculum and across the whole range of schooling should be specified, identifying the levels of proficiency expected for each skill at different stages (i.e., assessment targets).
- § The role of non formal and informal education contexts in supporting the acquisition of 21st century skills should be acknowledged and taken into account. Strategies to link what is learnt *in* and *outside* the school should be developed.
- § Technology should be regarded as a powerful learning resource that can support the acquisition of 21st century skills. ICT facilities ought to be made available in quantity and in quality at schools to guarantee the opportunities for technology use in the classrooms.

Professional development

Overview of the frameworks

The key role of teachers in the implementation of curriculum innovations has been widely acknowledged in the past decades (cf. Ben-Peretz, 1990; Fullan, 2001; Lieberman & Pointer Mace, 2008; Dede, 2009). Teachers' attitudes, beliefs, competences and practices are determinant factors in the realization of change in teaching and learning.

With more or less detail, references to the central role of teachers in the implementation of 21st century skills and the consequent need for teacher support can be found in all frameworks. These skills pose many didactical challenges for teachers related to its cross curricular nature, the ability to use ICT to support learning, and the need to master various teaching strategies and assessment procedures (Trier, 2002). Furthermore, according to the recommendations from the European Union (Gordon et al, 2009), teachers are not only expected to facilitate the acquisition of 21st century skills in their students, but they are also expected to possess these skills.

Table 9. *Characteristics of professional development that supports 21st century skills*

P21	NETS/ISTE	European Union	UNESCO
Professional development programs should ensure that teachers / educators:			
<ul style="list-style-type: none"> - Understand the importance of 21st century skills and how to integrate them into daily instruction. - Are aware of how deeper understanding of subject matter can enhance problem solving, critical thinking and other 21st century skills. - Have the ability to identify students' particular learning styles and intelligences. - Develop their abilities to use various strategies to reach different students as well as to create environments that support differentiated teaching and learning. - Have the opportunity to see how 21st century skills look like in real classrooms. - Have the ability to take advantage of 21st century tools, such as rich media examples, video, simulations, etc. - Have the opportunities to share knowledge within communities of practitioners using face-to-face, virtual and hybrid exchanges. 	<ul style="list-style-type: none"> - Facilitate and inspire student learning and creativity. - Design and develop digital age learning experiences and assessments - Model digital age work and learning - Promote and model digital citizenship and responsibility - Engage in professional growth and leadership 	<ul style="list-style-type: none"> - Embrace their new roles as collaborators, facilitators of learning and lifelong learners. - Possess the same key competences defined as learning objectives for students. - Continuously develop and modernize their repertoire of teaching methods. - Feel appreciated, have adequate pay schemes and develop an increasing teaching professional prestige. 	<ul style="list-style-type: none"> - Develop <i>technological literacy</i> skills so as to integrate the use of basic ICT tools into the standard school curriculum, pedagogy and classroom structures. - Develop skills to use more sophisticated methodologies and technologies that emphasize <i>depth of understanding</i> and application of school knowledge to real world problems. - Develop sophisticated professional skills to support students who are <i>creating knowledge</i> products and are engaged in planning and managing their own learning goals and activities. This is accomplished within a school that is, itself, becoming a continuously learning organization.

Despite the fact that all frameworks acknowledge the central role of teachers and the need for professional development to support the implementation of 21st century skills, the characteristics that teacher training programs should have and/or the competences teachers need are only addressed in detail by P21, NETS/ISTE, European Union and UNESCO (See Table 9). Within these frameworks, two common features can be identified: (a) the need to develop teachers' abilities to use various teaching methods; and (b) the need to develop teachers' abilities to make use of ICT tools to support student learning.

In addition, P21 stresses the need for teachers to understand the importance of 21st century skills and how to integrate them in the curriculum. To do so teachers should be provided with the opportunity to observe real examples and share knowledge within communities of practice. Moreover, the European Union calls attention to the need for recognition, prestige and adequate pay schemas for teachers. Together with UNESCO, the European Union also suggests on-going and work related professional development initiatives.

Discussion in the expert team

Teacher professional development and adequate support structures are key issues for the implementation of 21st century skills. Although all frameworks agree on this, there is still insufficient clarity about what specific types of support are needed and how this support can best be provided.

While defining the characteristics teacher training programs should have in order to support the acquisition of 21st century skills, emphasis is mostly placed in the development of teachers' pedagogical and technological knowledge. However, little is said about the need to develop teachers' abilities to teach from an interdisciplinary perspective, and what this entails for teachers' content knowledge.

Furthermore, the need to develop teachers' abilities to diagnose students' prior knowledge and learning styles with regard to 21st century skills, as well as their abilities to conduct formative assessment do not receive much attention. References to this can only be found in P21.

Professional development programs that aim to support the implementation of 21st century skills must also be based on these skills. As highlighted by the European Union, teachers do not only need to be able to facilitate the acquisition of 21st century skills, but they should also possess them. Teacher training programs should give teachers the opportunity to develop 21st century skills themselves, and at the same experience how these skills can be brought into the classrooms.

The implementation of 21st century skills brings along high expectations from teachers and poses many challenges to them. Teachers need intellectual, emotional and social support to meet these challenges and to cope with the uncertainties and complexity of change. However, the need for this type of support receives little attention in the different frameworks.

Recommendations from the expert team

- § A sense of ownership should be developed by involving teachers throughout the implementation of 21st century skills, starting from the discussion of its importance, to the definition of its role and place in the curriculum, and its assessment.
- § A new approach to teacher professional development -based on 21st century skills- should be adopted, both at pre-service and in-service training programs. Teachers should be given the opportunity to develop 21st century skills themselves and to experience how these skills can be brought into the classrooms.
- § Besides teacher training, ongoing support structures should be strengthened so as to facilitate teacher collaboration and knowledge sharing. Already existing teacher networks and organizations should be considered as a starting point to accomplish this. In addition, the potential of online networks to encourage teacher collaboration and knowledge exchange should be further explored.

Strategies and conditions

Overview of the frameworks

The strategies and conditions that may support the implementation of 21st century skills are only discussed in detail in the documents from the European Union and P21. Some references to this can also be found in the En Gauge framework, where general strategies for educational leaders and policymakers are briefly mentioned.

Both, the European Union and P21 frameworks start by identifying the key stakeholders involved and their role in supporting the implementation of 21st century skills (See Table 10).

Table 10. Key stakeholders in the implementation of 21st century skills

P21	European Union
In the public sector: <ul style="list-style-type: none"> - Federal policy makers - State policy makers - Local policy makers In the private sector: <ul style="list-style-type: none"> - Business - Parents and families In education: <ul style="list-style-type: none"> - K12 education leaders - Higher education - Schools of education - Researchers - Youth serving organizations - Content providers - Professional educational organizations 	<ul style="list-style-type: none"> - European Commission and its agencies - Governments in the Member States - Regional and local authorities - Teacher education professionals - Research community - Teachers and school leaders

The key stakeholders identified by P21 and the European Union are: policy makers, schools of education, researchers and school leaders. Additionally, P21 calls attention to the involvement of the private sector, while the European Union gives emphasis to the role of international organizations and teachers.

The acknowledgement of all these stakeholders shows that the implementation of 21st century skills requires an active participation and involvement of different sectors (private, public, education), and not only schools. Therefore, the strategies for implementation must address the responsibilities of the different stakeholders implicated in this process.

Both P21 and the European Union consider school leadership as a key factor to support implementation. Other strategies suggested by these two frameworks refer to: defining goals and standards in national documents regulating the curriculum; embracing a powerful vision; providing adequate professional development; and, encouraging collaboration between different sectors (see Table 11).

Ensuring equitable access to 21st century education and ongoing assessment of the progress made by schools with regard to 21st century skills are pointed out by P21 as important issues for implementation. On the other hand, the European Union emphasizes the need to specify transversal skills and inter-subject links, together with the need to stimulate teacher collaboration as a pre-condition for the implementation of the cross curricular approaches demanded by 21st century skills. Finally, En Gauge suggests starting from already existing work and focusing on what is “doable”.

Overall, the frameworks indicate that the implementation of 21st century skills requires a combination of strategies at different levels (national policies, schools and classroom practices) and an active involvement of stakeholders from the public, private and educational sector.

Table 11. *Strategies to support the implementation of 21st century skills*

P21	En Gauge	European Union
<ul style="list-style-type: none"> - Embrace a powerful vision of public education that includes 21st century skills. - Align leadership, management and resources with educational goals. - Assess where the schools are on the spectrum of 21st century skills and chart a course for more effective integration of these skills. - Develop priorities for 21st century skills - Develop a professional development plan for 21st century skills - Make sure students have equitable access to a 21st century education - Develop assessments to measure student progress in 21st century skills - Collaborate with outside partners - Plan collectively and strategically for the future. 	<ul style="list-style-type: none"> - Stay focused - Take on something doable - Build bridges - Honor and extend existing work - Make decisions at the system level 	<p>A key feature of strong implementation strategies is a simultaneous intervention in the following areas:</p> <ul style="list-style-type: none"> - The definition of appropriate goals and standards in national documents regulating curriculum; - The creation of learning environments that enhance competence development and the use of appropriate pedagogy through supporting innovations and developing institutional leadership; - The alignment of assessment and evaluation methods, procedures and frameworks with the goal of competence development; - The renewal of professional development of teachers so that it could effectively enhance the development of relevant teacher competences. <p>At a school level, the following elements contribute to the implementation of key competences:</p> <ul style="list-style-type: none"> - Key competences are more likely to be acquired when the school level curriculum specifies transversal skills and inter-subjects links. - School organization stimulates collaboration among teachers, which is a decisive precondition for cross-curricula, cross-subject approaches. - School democracy is instrumental for civic competence and for the role of innovation and creativity. - Contacts among schools, exchange of information, promotion of good practice, peer learning and networking help innovative schools.

Discussion in the expert team

The strategies recommended by the P21 and European Union frameworks provide good insights on some of the aspects that must be taken into account to support the implementation of 21st century skills, as well as the stakeholders involved in this process. However, the tension between the urgency of change and the pace of change is not discussed in the frameworks. How to cope with this tension? How to generate ownership among key stakeholders? These issues require further debate.

Another blind spot in the frameworks is related to the acknowledgement of the changing role of teachers and students. As mentioned earlier, the implementation of 21st century skills poses many challenges for teachers, and also for students. Clear strategies on how to support them in adopting the new roles that the implementation of 21st century skills demands should be specified.

Recommendations from the expert team

- § *Create awareness about the importance of 21st century skills.* Encourage a public debate about the importance of 21st century skills, stimulating the participation of different stakeholders. To accomplish this, the following initiatives could be developed:
 - Encourage collaboration between different institutions such as Kennisnet, SLO, teacher training programs, and university researchers.
 - Organize teacher conferences and interdisciplinary working groups to engage teachers in the debate about 21st century skills.
 - Organize conferences and debates to create awareness about the importance of 21st century skills among students.
- § *Develop a national framework for 21st century skills.* A clear definition of 21st century skills and the strategies to support its implementation should be included in the national documents regulating the curriculum. The emphasis of 21st century skills across educational levels and the assessment targets for each skill should be explicitly described in this national framework.
- § *Build on what is already there.* Initiatives for the implementation of 21st century skills should build on previous research and schools' work. Earlier innovative educational projects developed at schools should be acknowledged and regarded as a starting point for the development of new initiatives.
- § *Start with a small scale implementation.* Encourage small scale projects at the schools so as to build awareness and a growing understanding of how to integrate 21st century skills across subjects. These projects would also allow teachers to gain a better understanding of the educational gains and challenges associated with the implementation of 21st century skills. Through follow up studies, the factors for success and failure in these small scale projects could be identified in order to inform the development of new initiatives.

- § *Encourage collaboration and networking.* Collaboration and knowledge sharing within and between schools, between schools and researchers or experts, and between schools and other organizations from the public and private sector should be emphasized. For this purpose, the creation of partnerships and networks should be encouraged.
- § *Develop exemplary strategies.* Propose multiple ways to approach the implementation of 21st century skills, giving schools flexibility to decide how to proceed. School adaptation of national guidelines should be encouraged.

5. 21st CENTURY SKILLS OUTCOMES: ASSESSMENT ISSUES

Together with professional development, assessment is seen by all frameworks as a crucial element for the implementation of 21st century skills. Even so, further recommendations on how to assess 21st century can only be found in the documents of ATCS, P21, NAEP and the European Union. Although these frameworks deal with the assessment of 21st century skills from very different perspectives, three common themes can be identified across them: (a) the need for new assessment models; (b) how to assess 21st century skills (assessment types); and, (c) technology and assessment.

New assessment models

Overview of the frameworks

The failure of current assessment models to evaluate complex competences as the ones required in the 21st century is acknowledged by P21 and ATCS. Existing assessments and tests focus mostly on measuring discrete knowledge rather than on students' abilities to transfer their understandings to real world situations, to solve problems, to think critically or to work in a collaborative way (Dede, 2010).

Both P21 and ATCS frameworks affirm that the assessment of 21st century skills requires a shift in the assessment models currently used. According to these frameworks, emphasis should not only be on accountability measures, but also on the ways assessment can add value to education by helping teachers and students to become aware of *what* and *how* is being learnt, thereby providing opportunities to revise and improve teaching and learning.

As stated by P21 and ATCS, standardized tests and large scale assessments are still considered important for accountability purposes, but alone they are not enough to assess 21st century skills. The measures that result from standardized tests must be complemented with other forms of assessment that should be aligned with the complex and cross curricular nature of 21st century skills.

ATCS describes the essential characteristics that the assessment of 21st century skills should have, emphasizing that the issues of *what* and *how* to assess are closely linked to what students need to know and be able to do once they graduate. Basically, ATCS suggests that assessments should: (a) be aligned with the development of significant 21st century goals; (b) be adaptable and responsive to new developments; (c) be largely performance based; (d) provide productive and usable feedback for all intended users and contribute to capacity building of teachers and students; (e) meet the general criteria for good assessments (i.e., be fair, technically sound, valid for purpose, and part of a comprehensive and well-aligned system of assessments at all levels of education).

The growing importance given to 21st century skills in national policies has also resulted in an increasing focus on its assessment, as acknowledged by P21. Although the studies conducted by OECD (Ananiadou & Claro, 2009) and the European Union (Gordon et. al, 2009) reveal that up until now most countries do not have clear assessment policies with regard to 21st

century skills, some recent initiatives at national and international levels are aiming to include (some) 21st century skills in large scale assessments.

One of these initiatives is the DeSeCo (*Definition and Selection of Competences*) project set off by the OECD, with the purpose of guiding the development of a long-term strategy for internationally comparative assessments of key competences. Another initiative is the development of a Technological Literacy Framework as an addition to the National Assessment of Educational Progress (NAEP) in the United States. The main purpose of this framework is to establish what students should know about and be able to do with technology, and to set forth criteria for the design of future assessments.

Discussion in the expert team

Assessment is the cornerstone for the implementation of 21st century skills. Even though most frameworks may seem to converge on this conclusion, surprisingly only a few maintain an active focus on it.

The implementation of 21st century skills calls for a profound transformation of the roles and models for student assessment. Traditional emphasis on accountability is now shifted to an increasing understanding of assessment as a means to contribute to student learning and to the overall improvement of educational quality (i.e., assessment for learning).

From what is discussed in the frameworks, it is clear that the traditional models of assessment are no longer valid. New forms of assessment should be adopted in schools, so that the focus no longer relies on discrete subject-related knowledge, but on broader cross curricular competences. One pre-condition for this is to develop operational definitions for each key competence, specifying what students are expected to achieve in terms of knowledge, skills, attitudes, values and ethics¹⁰.

In addition, changes to national and international standardized tests should be made so as to include 21st century skills. It is well known that in most cases “what gets assessed in national exams gets taught in schools”. Therefore, 21st century skills should be part of national exams, aligning what is being asked from students, teachers and schools with what is actually being valued by the educational system.

Recommendations from the expert team

- § An operational definition of each competence should be provided, so as to determine what students are expected to achieve and what the focus of assessment should be.
- § Multiple forms of assessment should be encouraged and supported by clear national policies.
- § Adaptations should be made to national exams, so as to include 21st century skills.

¹⁰ An example of how to operationalize these skills can be found in the White Paper about 21st century skills of ATCS (available at <http://www.atc21s.org/white-papers/>) and on the NAEP framework (available at http://www.edgateway.net/cs/naepsci/view/naep_nav/9)

Assessment types

Overview of the frameworks

One of the most difficult issues related to 21st century skills/competences concerns the ways of assessing them. Its complexity and cross curricular nature poses many challenges to traditional assessment types.

According to P21 and ATCS, 21st century skills can be assessed through summative and formative assessments. In both frameworks, summative assessment is seen as an accountability measure, whereas formative assessment is regarded as a means to improve educational practices, by making students' learning visible throughout the process and providing feedback that can contribute to the capacity building of both, teachers and students.

In Table 12 and Table 13, the goal and main characteristics of summative and formative assessment according to the P21 and ATCS frameworks are briefly described and compared.

Table 12. *Summative assessment*

P21	ATCS
<p><i>Goal:</i> The primarily goal of summative assessment is to determine whether the learning that was intended actually occurred.</p> <p><i>Characteristics:</i></p> <ul style="list-style-type: none">- Focus on 21st century skills and content- Provide useful information about student achievement by measuring comprehension, absorption, and application of higher order concepts. The assessment must be tied to previously establish learning goals for the teaching unit.- Be valid. The assessment should measure what it is supposed to measure.- Be reliable. The assessment should provide student scores that are not affected by arbitrary factors.- Be fair. The assessment must give the same chance of success to all students.- Be administrated widely.	<p>Summative assessments are very important as an accountability mechanism for schools, teachers and students.</p>

Table 13. *Formative assessment*

P21	ATCS
<p><i>Goal:</i> The primarily goal of formative assessment is to make student learning and understanding readily apparent, so that a teacher can adapt teaching strategies to meet student needs. Formative assessment helps educators determine their students' current knowledge, understandings, misconceptions, and thinking processes.</p>	<p><i>Goal:</i> Formative assessments are used for the purpose of improving teaching and learning. They involve making students thinking visible as they progress through the course, giving them feedback about their thinking, and providing opportunities to revise.</p>
<p><i>Characteristics:</i></p> <ul style="list-style-type: none"> - Focus on 21st century skills and content - Make thinking visible by revealing the kinds of conceptual strategies a student uses to solve a problem. - Be structured so that educators can identify the background knowledge a student used to solve each problem in real time. - Be largely performance-based and authentic, calling upon students to use 21st century skills. - Generate data that can be used to directly inform instructional practices. - Aim to build capacity –both teachers' and students' - Be part of a comprehensive assessment continuum (i.e., must be ongoing) - Reflect an understanding of learning as multidimensional, integrated, and revealed in performance over time. 	<p><i>Characteristics:</i></p> <ul style="list-style-type: none"> - Outcomes are intended and clearly specified in advance. - Methods are deliberately planned - The evidence of learning is used by teachers and students - Collaboration of students and teachers on working toward learning goals - Adjustments occur during instruction
<p><i>Advantages:</i></p> <ul style="list-style-type: none"> - Enhance student achievement - Help students to become more aware of what and how they are learning. - Increase student motivation. 	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> - Formative assessment could be employed for all of the 21st century skills in all kinds of learning environments.

No significant differences can be found in the conceptualization of summative and formative assessment given by P21 and ATCS. Both frameworks seem to suggest that formative assessment is more aligned with the characteristics and nature of 21st century skills; however they recommend a combination of these two types of assessment so as to guarantee a more comprehensive approach.

A more detailed overview on the characteristics of large scale summative assessment instruments for 21st century skills can be found in the NAEP framework, although with a particular focus on technological literacy. This framework suggests that assessment should address *content areas* and *practices* that characterize the field as well as *contexts* that reflect societal issues and actual problems people are called upon to solve. The content and the context for the assessment should be informed by existing national and international

standards and research. The NAEP framework is also an example of how technologies can be used to support assessment of 21st century skills, which will be discussed in the next section.

As stated in P21 and ATCS, different instruments can be used to support formative and summative assessment. Standardized tests, essays, and student presentations at the end of a course or unit are typically regarded as summative assessment instruments; whereas portfolios, self-assessment, peer-assessment, examinations of work in processes, and systematic observations of learning are most commonly used as formative assessment instruments.

The study conducted by the European Union (Gordon et al, 2009) reveals that in most countries the assessment of key competences is typically carried out through standardized tests, teacher assessment and portfolio assessment. While standardized tests are still mainly focused on the assessment of competences related to core subjects (particularly mother tongue, mathematics, and science), teacher assessment and portfolio assessment are used across a more extensive range of key competences. Although in less extent, some countries make use of self and peer assessment, particularly in relation to the development of social competences.

Additionally, four different approaches to the assessment of key competences were identified by the above mentioned study: (a) assessment of cross curricular competences explicitly; (b) assessment of cross curricular competences implicitly; (c) assessment of subject-specific competences; (d) assessment of knowledge rather than competence. While the first two approaches show some progress in the assessment of 21st century skills, the other two reveal that the need to assess these competences is not yet fully acknowledged in many countries.

Discussion in the expert team

Assessing 21st century competences is a very complex and challenging task. As the frameworks assert, formative assessment procedures seem to be more aligned with the characteristics and nature of 21st century skills. However, the practical issues related to the introduction of formative assessment in schools are hardly mentioned by the frameworks. Are teachers prepared to conduct formative assessments? What does this type of assessment demand from teachers and students? What kinds of support do teachers and schools need to introduce formative assessment? The need for professional development and adequate support structures arise again as critical issues for implementing and assessing 21st century skills.

In addition, assessment types and instruments need to be aligned with the level of complexity of 21st century skills taught across primary, secondary and tertiary education. It can be argued that at the level of primary education having the opportunity to experience 21st century skills might be sufficient -which then could be assessed by the inspectorate-, while more elaborated procedures are needed for the assessment of 21st century skills in secondary and tertiary education.

Finally, an issue that gets little attention in the frameworks is the need for active student involvement in assessment. Students should be able to assess the quality of their own (self assessment) and each others' learning products and processes (peer- assessment).

These and other practical issues related to the introduction of new types of assessment require careful consideration while defining national and local strategies to support the implementation and assessment of 21st century skills.

Recommendations from the expert team

- § The types of support schools need to implement formative and summative assessments aligned with 21st century skills should be identified. Based on these needs, clear strategies for the provision of support should be developed.
- § Build on previous assessment practices. Earlier innovative forms of assessment developed at schools should be acknowledged and considered as a starting point for the introduction of new assessment types. "Good practices" should be shared and disseminated within and beyond the school.
- § There is a need to align assessment formats for 21st century skills to the level of complexity which is expected at primary, secondary and tertiary education.
- § Student involvement in assessment should be emphasized through the introduction of self and peer assessment procedures.
- § Exemplary assessment instruments and guidelines could be designed, illustrating multiple forms of formative and summative assessment of 21st century skills.

ICT and assessment

Overview of the frameworks

The potential contributions of technology to support the development of new forms of assessment and to meet some of the challenges raised by the assessment of 21st century skills are acknowledged by P21, ATCS and NAEP. Across these frameworks it is suggested that technology can make the delivery of assessment more effective and efficient, by increasing the speed with which results become available, and reducing costs and time required to score and to provide feedback. Additionally, ATCS suggests that technology can also be used to improve assessment practices by:

- (a) *Changing the business of assessment*, i.e., the core processes that define the enterprise such as developing tests, delivering tests, scoring constructed responses on screen, etc.
- (b) *Changing the substance of assessment*, i.e., using technology to change the nature of what is tested or learned. From this perspective, it is argued that technology could be used to expand and enrich assessment tools by including more authentic tasks. Furthermore, technology could also be used to assess new constructs that have either been difficult to assess or which have emerged as part of the information age.

Whether in a more superficial way (by making traditional forms of assessment more efficient) or in a more profound way (by changing the nature of what and how is being assessed), technology holds the promise of contributing to the development of new assessment forms and instruments. However, ATCS warns that the use of technology to improve traditional assessment of core subjects should not be confused with the assessment of 21st century skills. According to this framework, 21st century skills assessments will not just use technology to support assessment functions, but will focus on measuring the application of 21st century skills while using technology. A concrete initiative regarding the assessment of computer and information literacy skills is the IEA International Computer and Information Literacy Study (2010 – 2014)¹¹, which aims to assess student achievement in computer and information literacy through authentic and computer-based assessment at an international level. (See Appendix 3 for examples of technology supported assessment of 21st century skills).

Finally, ATCS differentiates between two new forms of assessment that can be supported by technology: concurrent and transformative assessment. *Concurrent assessment* refers to on-demand assessments that can be available instantaneously. The immediate feedback provided can inform high level processes as well as more straightforward procedures. *Transformative assessment* refers to assessments that do not only provide an indication of past performance, but also of the ways individuals and teams can tackle broader problems and situate their work relative to that of other team members and other teams, both within and beyond the school walls.

Discussion in the expert team

There is no doubt that technology brings new possibilities for the assessment of 21st century skills. However, as the ATCS already asserts, the use of technology does not necessarily guarantee the assessment of 21st century skills. Furthermore, not all 21st century skills need to be assessed through technology-based instruments. The nature and context of what needs to be assessed should determine the choice of whether technology based assessment is the best solution or not.

Implementation issues related to the use of technology-based assessment should also be carefully considered. Equal access to required hardware, software and internet facilities should be guaranteed across schools.

Recommendations from the expert team

- § Exemplary technology-based assessment instruments should be developed, in order to illustrate how technology could be used to support the assessment of 21st century skills. Previous research and innovative projects in this area should be considered as a starting point.

¹¹ www.iea.nl

§ If technology based assessments are going to be implemented, then schools should be provided with all the required facilities needed for this type of assessments (i.e., hardware, software and internet connection).

6. RECOMMENDATIONS

21st century competences & assessment

- § 21st century competences can be defined in terms of knowledge, skills, attitudes, values and ethics (KSAVE¹²), and should be realized through core subjects. An operational definition of each competence will help to determine what students are expected to achieve and what the focus of assessment should be.
- § The need for different types of new literacies - information literacy, ICT skills and technological literacy - in the knowledge society must be acknowledged. These new literacies should be embedded within and across the other 21st century skills and core subjects.
- § Core subjects, 21st century competences and interdisciplinary themes need to be identified, starting from what is already being taught at schools. Links between these need to be explained so as to depict how the “new” skills are integrated into the curriculum.
- § Interdisciplinary themes should allow linking school’s core subjects with what is going on in society, while at the same time contributing to the acquisition of 21st century skills. These themes should be regarded as dynamic and in continuous change, since they must reflect contemporary societal issues.
- § A national framework with a clear definition of 21st century skills and the strategies to support and regulate its implementation and assessment should be developed. The emphasis of 21st century skills across educational levels and the assessment targets for each skill should be explicitly described in this national framework.
- § The role of non formal and informal education contexts in supporting the acquisition of 21st century skills should be acknowledged and taken into account. Strategies to link what is learnt *in* and *outside* the school should be developed.

Implementation of 21st century competences

- § *Create awareness about the importance of 21st century skills.* Encourage a public debate about the importance of 21st century skills, stimulating the participation of different stakeholders.
- § *Create ownership* by involving teachers throughout the implementation of 21st century skills, starting from the discussion of its importance, to the definition of its role and place in the curriculum and its assessment.

¹² KSAVE is a framework developed by the ACTS to provide measurable descriptions of each skill in terms of knowledge, abilities (skills), attitudes, values and ethics.

- § *Build on what is already there.* Initiatives for the implementation of 21st century skills should build on previous research and schools' work. Earlier innovative educational projects developed at schools should be acknowledged and regarded as a starting point for the development of new initiatives. "Good practices" should be shared and disseminated within and beyond the school.
- § *Start with a small scale implementation.* Encourage small scale projects at the schools so as to build awareness and a growing understanding of how to integrate 21st century skills across subjects. These projects would also allow teachers to gain a better understanding of the educational gains and challenges associated with the implementation of 21st century skills. Through follow up studies, the factors for success and failure in these small scale projects could be identified in order to inform the development of new initiatives.
- § *Encourage collaboration and networking.* Collaboration and knowledge sharing between schools, between schools and researchers or experts, and between schools and other organizations from the public and private sector should be emphasized. For this purpose, the creation of partnerships and networks should be encouraged.
- § *Develop exemplary strategies.* Propose multiple ways to approach the implementation of 21st century skills, giving schools flexibility to decide how to proceed. School adaptation of national guidelines should be encouraged. Exemplary (technology-based) assessment instruments and guidelines could be designed, illustrating multiple forms of formative and summative assessment of 21st century skills.
- § Technology should be regarded as a powerful learning resource that can support the acquisition of 21st century skills. ICT facilities ought to be made available in quantity and in quality at schools to guarantee the opportunities for technology use in the classrooms.

REFERENCES

- Ananiadou, K. & Claro, M. (2009). *21st Century Skills and competences for New Millennium learners in OECD countries*. Organization for Economic Cooperation and Development. EDU Working paper no. 41. Retrieved from [http://www.oalis.oecd.org/oalis/2009doc.nsf/linkto/edu-wkp\(2009\)20](http://www.oalis.oecd.org/oalis/2009doc.nsf/linkto/edu-wkp(2009)20)
- American Association of School Librarians & Association for Educational Communications and Technology. (1998). *Information power: Building partnerships for learning*. Chicago, IL: American Library Association.
- Anderson, R. (2008). Implications of the information and knowledge society for education. In J. Voogt, & G. Knezek, (Eds.), *International handbook of information technology in primary and secondary education* (pp. 5-22). New York: Springer.
- Ben-Peretz, M. (1990). *The teacher-curriculum encounter. Freeing teachers from the tyranny of texts*. Albany, NY: Princeton University Press.
- Bransford, J.D., Brown, A.L., & Cocking, R.R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school* (expanded ed.). Washington, DC: National Academy Press.
- Committee on Technological Literacy. (2002). *Technically speaking. Why all Americans need to know more about technology*. Washington: National Academy Press.
- Dede, C. (in press). Technological supports for acquiring 21st century skills. In E. Baker, B. McGaw, & P. Peterson (Eds.), *International Encyclopedia of Education, 3rd Edition*. Oxford, England: Elsevier.
- Dede, C. (2010). Comparing Frameworks for 21st Century Skills. In J. Bellanca & R. Brandt, Eds, *21st Century Skills*, pp. 51-76. Bloomington, IN: Solution Tree Press.
- Europese Commissie. (2002). *eEurope 2005: An information society for all*. Brussel: Europese Commissie.
- Fisch, K., & McLeod, S. (2009). *Did You Know? 3.0 – 2009 Edition*. Gevonden op 15-5- 2009 op www.youtube.com/watch?v=PHmwZ96_Gos
- Fullan, M. (2001). *The new meaning of educational change* (3rd Edition). New York: Teachers College Press.
- Gordon, J., Halsz, G., Krawczyk, M., Leney, T. et al. (2009). *Key competences in Europe. Opening doors for lifelong learners across the school curriculum and teacher education*. Warsaw, Center for Social and Economic Research on behalf of CASE Network. Retrieved from http://ec.europa.eu/education/more-information/moreinformation139_en.htm
- Law, N., Pelgrum, W.J., & Plomp, T. (2008). *Pedagogy and ICT use in schools around the world. Findings from the IEA SITES 2006 study*. CERC Studies in comparative education. Hong Kong: Comparative Education Research Centre, The University of Hong Kong, and Dordrecht: Springer.

- Levy, F., & Mundane, R.J. (2004). *The new division of labor. How computers are changing the way we work*. Princeton University Press and the Russell Sage Foundation.
- Levy, F., & Mundane, R.J. (2006). *How computerized work and globalization shape human skill demands*. MIT, Department of Urban Studies and Planning & Harvard University, Graduate School of Education, May 31.
- Lieberman, A., & Pointer Mace, D. (2008). Teacher learning. The key to educational reform. *Journal of Teacher Education*, 59(3), 226-234.
- Mioduser, D., Nachmias, R., & Forkosh-Baruch, A. (2008). New literacies for the knowledge society. In J. Voogt, & G. Knezek, (Eds.), *International handbook of information technology in primary and secondary education* (pp. 23 -42). New York: Springer.
- OECD. (2004). Lifelong learning. *Observer*. February, 1–8. Gevonden op 30 juni 2005 op <http://www.oecd.org/dataoecd/17/11/29478789.pdf>
- Reich, R. (1992). *The work of nations. Preparing ourselves for the 21st -century capitalism*. New York: Vintage Books.
- Travers, K.J., & Westbury, I. (1989). *The IEA study of mathematics I: Analysis of mathematics curricula*. Oxford: Pergamon Press.
- Trier, U. (2002). Twelve countries contributing to DeSeCo: A summary report. In D. Rychen, L. Salganik, & M. McLaughlin (Eds.), *Definition and selection of key competences. Contributions to the second DeSeCo symposium* (pp. 27-59). Geneva, Switzerland, 11-13 February.
- Van den Akker, J. (2003). Curriculum perspectives: An introduction. In J. van den Akker, W. Kuiper, & U. Hameyer (Eds.), *Curriculum landscapes and trends* (pp. 1-10). Dordrecht, the Netherlands: Kluwer.
- Voogt, J.M., & Odenthal L.E. (1997). *Emergent practices geportretteerd. Conceptueel raamwerk*. Enschede: Universiteit Twente.
- Voogt, J. (2003). Consequences of ICT for aims, contents, processes and environments of learning. In J. van den Akker, W. Kuiper, & U. Hameyer (Eds.), *Curriculum landscapes and trends* (pp. 217-236).
- Voogt, J., & Pelgrum H. (2005). ICT and curriculum change. *Human Technology; an Interdisciplinary Journal on Humans in ICT Environments*, 1(2), 157-175.
- Voogt, J. (2008). IT and curriculum processes: Dilemmas and challenges. In J. Voogt, & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 117-132). New York: Springer.

APPENDIX 1 Guiding questions for the expert meeting discussion

Arguments for the need of 21st century skills

1. Which foundations guide the discussion about 21st century learning in the different models?
 - a. How do we value these foundations?
 - b. How are these foundations connected?
 - c. Are any foundations missing in the debate?
2. Who 'owns' these foundations (policy, professional practice, research, the business community, parents)
3. Is there a conflict of interest between individual needs and societal needs?

21st century skills/Competencies

4. What are similarities and differences between the competencies that citizens/ students need to have in the 21st century according to the different models?
 - a. What do WE consider core competencies and why?
 - b. How are 21st century skills related to the 'traditional' subjects?
5. Which 21st century competencies should be learned where?
 - a. School (formal education)
 - b. World of Business (at the workplace)
 - c. Home & peers (informal learning)
6. Are ICT competencies different from the others and should they accordingly have a different treatment in policy terms?

Implementation issues

7. What do the models say about the relationship between 21st century competencies and existing curricula?
 - a. Should 21st century skills be integrated into subject-based curricula?
 - b. How to develop standards/target for 21st century competencies for different educational levels (primary, secondary, tertiary)?
8. How to cope with the need for 21st century competencies at the one hand and the 'basic skills' movement (e.g. No Child Left Behind in the US) on the other hand
9. How do the models differ on the factors they consider key for successful implementation of 21st century skills policies?
 - a. High-quality and relevant teacher training?
 - b. Curriculum integration?
 - c. Clear and rigorous assessment?
 - d. Up to date technology?
 - e. Educational leadership at the school level?
10. What processes/ strategies need to be in place at the policy level to implement 21st century learning in education?
11. How can we involve teachers in the overall debate and in the design of teacher training programmes in particular?

12. What are opportunities and risks of public-private partnerships in the uptake of 21st century learning?

Assessment

13. Which different functions of assessment are distinguished in the different models
 - a. Accountability
 - b. Selection
 - c. Certification
 - d. Formative/diagnostic
 - e. Prediction
14. Who is responsible for these different functions of assessment? And what does that imply for the development of a system of assessment?
15. How can the different functions of assessment be addressed for assessing 21st century competencies:
16. What types of assessment are appropriate for the monitoring and evaluation of 21st century skills and competencies?
17. What needs to be in place to develop assessment practices for 21st century competencies
 - a. Policy
 - b. Practice
 - c. Technology

Connections

18. What are the main similarities and differences between the models (essential points)?
 - a. Foundations
 - b. 21st century competencies
 - c. Role of technology
 - d. Implementation issues
 - e. Assessment
19. What are the 'blind spots'?
20. What next steps are needed to realize 21st century learning in schools?
21. What are roles for research, policy, world of business, practitioners in this regard?

APPENDIX 2 Examples of technology use for the implementation of 21st century skills

WISE: Web-based Integrated Science Environment

Website: <http://wise.berkeley.edu/pages/intro/wiseFlashIntro.php>

Level: Middle and high school students

Content Areas: Science, Mathematics, and Social Sciences

Related 21st Century Skills: Problem solving, communication, collaboration, self-direction

The Web-based Inquiry Science Environment (WISE) is a free online science learning environment supported by the National Science Foundation. Students engage in inquiry projects about contemporary issues, learning about and responding to them through designing, debating, and critiquing solutions. Students do most WISE activities on a computer, using a web browser. Special WISE software guides students through evidence and information pages that provide content, "notes", "hints", and discussion tools that encourage students to reflect and collaborate.

The River City Project

Website: <http://muve.gse.harvard.edu/rivercityproject/index.html>

Level: Middle school students

Content Areas: Science

Related 21st Century Skills: Problem solving, collaboration, self-direction, ICT skills

River city is a technology-based middle school science curriculum that supports students as they learn the principles and concepts of science; acquire the reasoning and procedural skills of scientists; devise and carry out investigations that test their ideas; and understand why such investigations are uniquely powerful.

The technological structure that delivers the curriculum is a Multi User Virtual Environment (MUVE). Students take on the identity of an avatar (i.e. a virtual persona in the world), and communicate with other avatars via text chat and virtual gestures. Students can find "hints" by clicking on different artifacts in the virtual world and use digital tools such as a virtual microscope. As they move through the environment, students follow multiple threads that potentially lead to very different hypotheses and experiments. This helps refute the common belief that there is one right answer to any science experiment.

APPENDIX 3 Examples of technology use for the assessment of 21st century skills

E-scape: Assessment of learner performance through e-portfolio

Website: <http://www.gold.ac.uk/teru/projectinfo/projecttitle,5882,en.php>

Level: High school students

Content Areas: Science, design & technology, geography

Related 21st Century Skills: Creativity, decision making, metacognition, critical thinking, ICT skills

E-scape uses emerging digital technologies to enable learners to build an on-line portfolio of their performance, demonstrating their capability as it emerges. Learners undertake engaging activities that inspire them to create their work both as individuals and in teams. The e-scape portfolio is assembled automatically and dynamically, i.e. 'on the fly' as work is undertaken. This provides considerable insights into the learner's ongoing analytic, creative and decision making thought processes, revealing their true subject capability.

The e-scape project has progressed through three phases: Phase 1 (2004-2005) was a 'proof the concept' in which the possibilities of web-portfolios to capture live 'performance' were explored. In phase 2 (2005-2007) a prototype system for portfolio assessment was built. In phase 3 (2007-9) transferability and scalability issues are addressed.

Virtual Assessment Project

Website: <http://virtualassessment.org/about/about.html>

Level: Middle school students (Grades 6 and 7)

Content Areas: Science

Related 21st Century Skills: Problem solving, ICT skills

The goal of The Virtual Assessments Project is to develop and study the feasibility of using immersive technologies to assess middle school students' science inquiry learning. Phase 1 and 2 focus on (a) the purposes of the assessment; (b) the nature of knowing, and (c) the structures for observing and organizing knowledge. In Phase 3, assessment designers focus on the student model (what skills are being assessed), the evidence model (what behaviors/performances elicit the knowledge and skills being assessed), and the task model (situates that elicit the behaviors/evidence). These aspects of the design are inter-related. In the compilation phase, tasks are created. The purpose is to develop models for schema-based task authoring and developing protocols for fitting and estimation of psychometric models. Phase 4 of the delivery architecture, focuses on the presentation and scoring of the task.

Initiatives under development

NAEP Technological Literacy Assessment

Website: <http://www.edgateway.net/cs/naepsci/print/docs/470>

Level: Grades 4, 8 and 12 (United States)

Content Areas: Technological Literacy

Related 21st Century Skills: Technological Literacy

The National Assessment of Educational Progress (NAEP) will conduct in 2012 a Technological Literacy assessment. The assessment will include tasks and items samples from the domain of technological literacy achievement identified by the intersection of three major areas of technological literacy (i.e., Technology and society; design and systems; Information and communication technology) and technological practices (i.e., Understanding technological principles; developing solutions and achieving goals; communicating and collaborating). The assessment will be administered by computer and will be composed of sets of long scenarios, short scenarios, and discrete items. Students will be asked to perform a variety of actions using a diverse set of tools in the process of solving problems and meeting goals within rich, complex scenarios that reflect realistic situations.

ICILS: International Computer and Information Literacy Study

Website: <http://www.iea.nl/icils.html>

Level: Grade 8

Content Areas: Information Literacy

Related 21st Century Skills: Information Literacy

The IEA International Computer and Information Literacy Study (ICILS) will examine the outcomes of student computer and information literacy (CIL) education across countries. The assessment of Computer and Information Literacy will be authentic and computer-based. It will incorporate multiple-choice and constructed response items based on realistic stimulus material; software simulations of generic applications so that students are required to complete an action in response to an instruction; and authentic tasks that require students to modify and create information products using “live” computer software applications. Together with this assessment, a computer-based questionnaire will be developed so as to enable students to answer questions about computer use. In addition, on-line teacher and school questionnaires will ask about computer use, computing resources, and relevant policies and practices.

EXPERT TEAM

Prof. Dr. M.J. Cox, King's College London, London, UK

Prof. Dr. R. Schulz-Zander, Technische Universität Dortmund, Germany

Prof. Dr. T. Plomp, University of Twente, The Netherlands

Prof. Dr. J. van Braak, University of Ghent, Belgium

Drs. N. Vestering, Kennisnet