21st century competencies in the Chinese science curriculum

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Abstract

Many organizations and countries have tried to describe goals for education in terms of competencies for the 21st century. Various frameworks for 21st century competencies appeared in literature. In 2016, China published Core Competencies for Student Development Proposal calling for open comments. This proposal may serve as a guideline for education reform in the 21st century. Scientific literacy has been one of the goals of science education in China since the eighth curriculum reform in the year 2001. However, the current National Science Curriculum does not have an explicit description of '21st century competencies'. For the benefit of future education reform, it is important to determine how competencies are represented in the current curriculum. The analysis of Chinese curriculum also serves as an example of implying the analysis framework for 21st century competencies. In this chapter, we first articulate 21st century competencies by comparing and summarising eight selected frameworks. Then we deductively analyse the Chinese National Primary Science Curriculum through the revised framework describing the Assessment and Teaching of 21st Century Skills (ATC21S). We found that '21st century competencies' is an internationalised concept addressing the demands of the current century, even though the selection of these competencies has been influenced by individual cultures. According to our analysis, the 21st century competencies are included in Chinese National Science Curriculum, but not systematically. Most 21st century competencies are mentioned as abstract concepts rather than being described in detail. Moreover, the distribution of different competencies is not equal. How to integrate 21st century competencies systemically into a science curriculum is an unsettled issue. In this integration China can learn from Nordic countries, such as Finland, which have emphasised a long time the importance of education.

Key words: 21st century, competencies, science curriculum, primary, China

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Introduction

The discussion of 21st Century Competencies (hereafter referred to as 21st CC) has been an important topic in educational policy all over the world. Discussion on 21st CC is based on questions about which knowledge and skills should be taught or which competencies the next generation should learn at school (Reimers & Chung, 2016). With a considerable amount of literature published on this topic, a globalised educational reform tendency has emerged. Many supranational organizations, such as the Organisation for Economic Co-operation and Development (OECD) and the European Union (EU), were the first to publish documents outlining educational goals for the 21st century using frameworks. Meanwhile, international companies such as the Intel Corporation and Microsoft have collaborated with educators and educational institutions to develop frameworks for teaching or assessing 21st CC (e.g. Assessment & Teaching of 21st century skills, ATC21S). Countries around the world have developed their own frameworks for 21st CC (e.g. Singapore, the United States, Finland and China). But various terms and definitions for 21st CC appear in different literature. In this chapter 21st CC are defined as an integration of knowledge, skills, attitudes and values that young people are required to have in the 21st century (Ananiadou, & Claro, 2009; European Union, 2007; Voogt & Roblin, 2010; Pellegrino &Hilton, 2012).

The goal of education has been changed from knowledge-centred to competencies-focussed. As EU declared, education plays a key role in ensuring that citizens acquire the key competencies needed to live in our changing world (EU, 2007). The goals for science education have evolved as well over the past decades, changing from the teaching of subject knowledge to nurturing transferable knowledge, skills and attitudes (Heiman & Slomianko, 1987; Pellegrino & Hilton, 2012). We may ask which the key competencies are and do the competencies relate to science education in school. Comparing frameworks for 21st CC at national and supranational level can be helpful to answer the question. Moreover, analysis of a national science curriculum as an example

can make the research more concrete and find whether emphasis difference of competencies exists in terms of national context.

A national curriculum is a plan that guides educational practice in one country (Schmidt, Raizen, Britton, Bianchi, & Wolfe, 1997). The curriculum directs teachers to instruct students according to the needs of the society and the learners (Oliva, 1997). At the beginning of 2000, learning 21st CC was proposed in many countries' curricula as an educational goal (Reimers & Chung, 2016). China published its National Primary Science Curriculum in 2001, a document that shows great interest in scientific literacy and converts a knowledge-centred approach to a competence-centred approach (Wang, 2016). At the beginning of 2016, the Chinese Society of Education released a document called the 'Core Competencies for Student Development Proposal' on behalf of the Ministry of Education (Wang, Zhu, Jiang, Wei, Zhou, & Liu, 2016), calling for comments from educators, teachers and researchers. Once this feedback has been taken into account, the revised proposal will be officially published and will serve as a guide for future educational reform (Lin, 2016). How to implement 21st CC in school curricula and how to teach these competencies through learning activities are some of the most important and challenging issues since the framing of the 21st CC proposition (Korhonen & Lavonen, 2016). No 21st CC have been systematically integrated into the Chinese National Curriculum. However, since China intends to use 21st CC as a guide for educational reform in the near future, it is necessary to know how these competencies are understood in the documents for the current curriculum and how they are characterised for certain school subjects.

This chapter will answer the following question: How are 21st century competencies characterised in the current Chinese science curriculum documents? To answer the question, we will first present and summarise selected 21st CC frameworks developed by different organizations at national and international levels. Then we will present a tentative framework for the analysis of

21st CC. Finally, we will focus on an analysis of the Chinese National Primary Science Curriculum in the context of 21st CC.

Comparative Analysis of Selected 21st Century Competencies Frameworks

In this section, we analyse different descriptions of 21st CC by reviewing eight selected frameworks. The frameworks have been purposely chosen to cover different 'culture' contexts following the comparative view proposed by Bray and Thomas (1995) (see Table 1). The comparative analysis consists of six aspects. The first, 'Intention', is divided into six categories based on a taxonomy of curriculum ideologies, as follows: *Academic rationalism* stresses the learning of academic disciplines to enhance learners' intellectual capabilities and cognitive skills; *social and economic efficiency* envisages education as a means for developing the human capital needed in a society (e.g. 'competencies should be valued, applied in relation to measurable benefits for both economic and social purposes'); *social reconstructionism* views the importance of education in bringing about social reform and improvement (e.g. 'the focus was largely on addressing the ecological impact of ever increasing unrestricted development'); *orthodoxy* sees the function of education as inducting learners into a particular religious or political orthodoxy (e.g. 'cultivating socialist builders and successors'); *progressivism* centres on learners by providing opportunities for enhancing their personal and intellectual development (e.g. 'particular support to fulfil their educational potential'); *cognitive pluralism* refers to multiple intelligences, competencies and attitudes (e.g. 'building on diverse individual competencies, the differing needs of learners should be met') (Adamson, Bray & Morris, 2014). The six categories can be summarised as society-demand-centred and learner-need-centred.

The remaining five categories are as follows: 2) the 'Target group' is analysed by educational level, such as school education or lifelong learning, and the intended region, for example local or global; 3) 'Terminology and connotation' gives the descriptions and understanding of the concept 'competency' in different frameworks; 4) 'Basis for categorization' shows the starting point and

how competencies are grouped by different organisations and countries; 5) General competencies are transferable instead of discipline-specific; 6) 'Competencies linked with traditional school subjects' are abilities typically nurtured through core topics in school, such as mathematics, science, literature (mother tongue) and foreign languages, which are based on subject knowledge. The analysis follows content analysis principles.

Table 1 Selection of the Frameworks

Level	Eastern context	Western context	Global context
Country	Core Competencies for Student Development Proposal (China)	National Core Curriculum for Basic Education 2014(Finland)	
Cross-country		Key Competences for Lifelong Learning (European Union)	
International			Learning: the Treasure within (UNESCO), Toward Universal Learning: What Every Child Should Learn (UNESCO), The Definition and Selection of Key Competencies (OECD), The Programme for International Student Assessment Frameworks (OECD), ATC21S (An international project group)

Intentions are internationalised with small emphasis differences

Most frameworks show the intentions on academic rationalism and social reconstructionism. Society-demand-centred intention is the principle driver of 21st CC frameworks as a whole, but small emphasis differences exist. For example, UNESCO's emphasis is on social reconstructionism, whereas the European Union counts on education's social and economic efficiency (see Examples below). The development needs of individuals are taken into consideration as well, an internationalised tendency today, as learner-centred educational philosophy is a modern idea

consistent with the popular development of cognitive psychology. However, most descriptions of the value of promoting 21st CC are from the perspective of society's demands rather than from the perspective of individual development. The example below quoted from European Union's document show that individual development is seen as a way of 'adapting' to the society changes.

Examples:

> …education has a fundamental role to play in personal and social development. The Commission does not see education as a miracle cure or a magic formula opening the door to a world in which all ideals will be attained, but as one of the principal means available to foster a deeper and more harmonious form of human development and thereby to reduce poverty, exclusion, ignorance, oppression and war. (Delors, 1996, p.11)

> Education in its dual role, both social and economic, has a key role to play in ensuring that Europe's citizens acquire the key competences needed to enable them to adapt flexibly to such changes (European Union, 2007, p. 3).

Different core terminologies are used but share similar connotations

Although various terminologies are used to describe 21st CC and there are different ways of categorising these competencies, they all have similar connotations. 'Competency' is generally accepted as an integration of knowledge, skills, attitudes and values (Ananiadou, & Claro, 2009; European Union, 2007; Voogt &Roblin, 2010; Pellegrino& Hilton, 2012). 'Key competencies' are the necessary general abilities needed for citizens to participate fully in contexts in the new century (Ananiadou & Claro, 2009). The history of developing 21st CC could explain why there are different terminologies with similar connotations. Competencies for the 21st century were first proposed by UNESCO and developed by the OECD and the EU (Lin, 2016). These organizations with their well-developed frameworks and theories have significantly influenced the development of frameworks at the country levels (Halász & Michel, 2011; Meyer & Benavot, 2013; Lin, 2016). For example, the generation of the Chinese framework included analysis of international frameworks of 21st CC and learning from other organizations or countries (Lin, 2016). The connotation consistency

of the concept demonstrates an international agreement on the connotations of 21st CC. However, different terminology may cause confusion and lead to ambiguity and thus hinder the implementation of competence in educational practice (Binkley, Erstad, Herman, Raizen, Ripley, Miller-Ricci & Rumble, 2012; Voogt & Roblin, 2012).

Moreover, each internationally mentioned competence has the same meaning without cultural differences, such as critical thinking, creative thinking, problem-solving and innovative working (Binkley et al., 2012; Voogt & Roblin, 2010; Pellegrino &Hilton, 2012). Traditionally, it has been argued that even if western countries and China use the same terminology for creativity, they interpret the concept differently (Lubert, 1998; Fryer & Fryer-Bolingbroke, 2011). But with the advance of globalisation, the connotations of each internationalised key competency in China are no longer cultural-dependent (Niu, 2006; Reimers & Chung, 2016), even if specific emphases and selections of certain competencies are culture-related.

Selection of competencies indicates similarities and cultural differences

Lifelong learning or sustainable development and demands of modern society are the typical basis for categorization of the competencies. Competencies are selected based on the categorizations. Learning to learn, critical thinking, creativity, problem solving, Information and Communication Technology skills, communication and collaboration competencies are the highly mentioned general competencies in all frameworks. Competencies in learning traditional school subjects, such as science, are without cultural differences. Most frameworks require the competencies in literature, mathematics, and foreign language. All frameworks mention the importance of studying science.

The difference in selection of competencies for 21st century teaching and learning in each framework is influenced by the cultural context. A specific competency required in a certain framework may be a cultural hallmark. But the coverage of the competencies indicates cultural dependency. ‘It is important to recognise that many Europeans live in bilingual or multilingual

families and communities, and that the official language of the country in which they live may not be their mother tongue' (European Union, 2007, p. 5); thus learning foreign languages is one of the core aims in European documents. The Chinese framework includes nine 'core competencies', involving 25 subcategories. The framework not only includes all the internationalised general competencies (except communication) with internationalised meaning, but also includes Chinese culture-related competencies, such as cultural heritage and political identity (Chinese Society of Education, 2016). This selection combines internationalised and culture-related competencies and indicates the values of traditional culture in Chinese education as well as its internationalised nature.

Difficulties in integrating 21st CC into aims for learning traditional school subjects

The description of competencies for the 21st century is not a new idea, but their current descriptions show a fresh tendency in the aims for education that extends goals for learning traditional school subjects (Pellegrino & Hilton, 2012; Voogt & Roblin, 2010). Under the internationalised tendency of teaching 21st CC, Chinese education scholars, on instructions from policy-makers, have proposed competencies such as collaboration, as well as personal, social and global responsibilities (Lin, 2016). These competencies are needed more than ever in the new century, with its modern and complex social context and its internationalised and future-driven meanings. Understanding of global responsibility is important for sustainable development and life and protection of the environment. However, the relationship between general 21st CC and the traditional study of school subjects is obscure in all the frameworks. The reasons may be two-fold. Firstly, all frameworks introduced in Table 1 focus on the big picture and on goals for education without suggesting any practical approach. Few suggestions are given on how to integrate these competencies into the school subjects or realize the objectives. Secondly, research in this field is lacking, making it difficult for framework designers to develop operational approaches (Pellegrino

&Hilton, 2012) and presenting a challenge to traditional school education and the educational system.

Clarifying the relationship between 21st CC and aims for traditional school subjects is helpful for curriculum design, teaching and learning. Some countries have tried to integrate these aims into their curricula. In the United States, the National Research Council uses transferable and transversal competencies to describe 21st CC and the learning of traditional school subjects (Pellegrino & Hilton, 2012). So does Finland's new National Curriculum make the connection with 21st CC and aims of school subjects (Finnish National Board of Education, 2016; Vahtivuori-Hänninen, Halinen, Niemi, Lavonen, Lipponen, & Multisilta, 2014). China recently proposed frameworks for 21st CC education in order to restructure the educational system further after the curriculum reform of the 1990s (Wang, 2016; Reimers & Chung, 2016). It is useful to understand the situation of 21st CC in the current curriculum, which will benefit the next round of curriculum revision. As the last version of the Chinese National Curriculum shows internationalised and modern tendencies, we argue that abilities belonging to 21st CC have in fact been added into the curriculum. Therefore, in the second part of this chapter we analyse 21st CC in the Chinese National Science Curriculum.

Analysis of 21st century competencies in the Chinese National Science Curriculum

Our analysis followed the deductive content analysis process using the revised ATC21S framework as shown in Table 2 (Mayring, 2015; Schwarz, 2015). The ATC21S framework is a concept structure created by Cisco, Intel and Microsoft (Binkley et al., 2010). We chose the framework for three reasons. Firstly, the list of 21st CC from ATC21S is based on 12 relevant frameworks drawn up by countries and organizations and is sufficiently broad and comprehensive (Binkley et al., 2012). All the competencies illustrated in ATC21S are consistent with our research results of the frameworks in the first part of this chapter. Secondly, this is an assessment-driven framework for schools, and offers operational definitions of competencies. They are helpful for us

to develop definitions of the codes. Thirdly, competence categories of ATC21S are generally people's competencies-orientated instead of orientated towards specialists in certain disciplines. Although in ATC21S competence is called a skill, knowledge, skills, attitudes, values and ethics are all integrated into the framework (Binkley et al., 2012). The ATC21S framework has been carefully examined by the authors, who agreed to use it for analysis.

Table 2 Analysis framework for 21st century competencies in primary science curriculum based on the revised ATC21S framework

Category	Subcategory
Ways of thinking	Creative thinking and generating of innovations
	Critical thinking, problem-solving, decision-making
	Learning to learn, metacognition
Ways of working	Communication
	Collaboration (team-work)
Tools for working	Information literacy (research on sources, evidence, biases, etc.)
	ICT literacy
Living in the world	Citizenship, personal, local and global
	Life and career
	Personal, social and global responsibility

The analysis framework includes four categories and 10 subcategories. *Ways of thinking* consists of creative thinking and generating of innovations; critical thinking, problem-solving, decision-making; and learning to learn or metacognition. *Creative thinking and generating of innovations* is imaginative, inventive and involves the generation of new ideas (Fisher, 1991; Cropley, 2011) and the production of relevant and effective novelty. *Critical thinking* involves the evaluation, analysis, synthesis, and interpretation of something to provide a judgement and provides the 'why' and 'how' of choosing one idea (Villalba, 2011; Mason, 2008). *Problem-solving* is 'general term applied to the process whereby the person overcomes obstacles and moves from a start state to a goal state' (Ward, 2011, p.254). In the start state one recognise or formulate the problem then generate alternatives or ideas or possible solutions to the problem and finally choose and combine ideas in order to find best solution and finally implement the solution (Fisher, 1991). *Decision-making* is a process in problem-solving where one identify and choose alternatives based

on the values and preferences of the decision-maker. *Learning to learn* is the ability to pursue and persist in learning, to organise one's own learning, including through effective management of time and information, both individually and in groups (Hoskins & Fredriksson, 2008; European Union, 2007). Metacognition is the 'knowledge and cognition about cognitive phenomena' (Jaušovec, 2011, p.107). *Ways of working* includes communication and collaboration. *Communication* means the act or process of using words, sounds, signs, or behaviours to express or exchange information or to express your ideas, thoughts, feelings, etc., to someone else with respect (Webster online Dictionary). Collaboration is 'the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own (John-Steiner, 2011, p.222)'. *Tools for working* includes information literacy and ICT literacy. *Information literacy* means the ability to recognise, locate and use information needed for a certain context efficiently and effectively (Eisenberg, Lowe & Spitzer, 2004). For example, PISA science framework emphasises these type of competences: identifying scientific issues (scientific information), in explaining scientific phenomena (use knowledge or information for explaining) and in drawing evidence-based (information available) conclusions (OECD, 2013). *ICT literacy* is defined as the ability to recognise, locate and use information needed for a certain context efficiently and effectively using ICT. Living in the world involves citizenship at both global and local level; life and career; and personal, social and global responsibility. *Citizenship* means knowledge, skills and open minds to participate in civic activities. *Life and career* is a set of different competencies intended for living in a changeable world. This competency views from a job or career adaptation perspective. *Personal, social and global responsibility* is the tolerance and respect for people of other backgrounds, races, ethnicities, and lifestyles; expanded cultural and global awareness and sensitivity; personal identification (Musil, 2009). This competency is from the view of culture awareness.

Each coding unit includes one idea (See examples below). To increase validity and reliability, three authors worked together in the analysis process. The first author read the text several times and translated it into English. The first two authors then participated in a pilot analysis. Based on the pilot coding of the Chinese curriculum, three authors further discussed and revised the categories and coding rules. Thereafter, the first author went through the text and analysed it twice. If there were any confusing coding units, the three authors discussed them. The Chinese curriculum has four parts in total: preface, general aims for science education, content area of science, and practical suggestions for classroom practice. Preface declares the task of science education at primary level. The general aims for science education outlines the aims of science education from knowledge, skills, attitudes and society aspects. Practical suggestions are empirical suggestions for teaching and assessment. Since the practical suggestions are unrelated to the educational goals, we decided after discussion to omit that part from the analysis. Then we calculated the frequency and percentage of units in each subcategory, because they can reflect the competency emphasis in the curriculum.

Examples (The examples have been translated from the original Chinese into English by the first author. Page numbers are the number in original Chinese curriculum)

> Cultivating student's creative thinking skills (p.3). – Creative thinking
> Positive to different opinions and understand ideas of others (p.8) – Critical thinking
> Develop student ability in analysing problems and solving problems (p.4). – Problem-solving
> Guide student to summarise and reflect on what they have learned (p.4). – Metacognition
> Make student learn to regulate study by themselves and study individually (p.4). – Learning to learn
> Actively participate in communication and discussion (p.8). – Communication
> Learn to collaborate with others (p.3) – Collaboration
> Stress learning by doing and cultivate students' ability in collecting and processing information about science (p.6) – Information literacy
> Improve the ability to facilitate the development of society and economy (p.2). – Citizenship
> Respect other persons' emotion and attitudes in inquiry activities (p.8). – Personal, social and global responsibilities

Distribution of 21st century competencies in the science curriculum

A total of 108 units relate to 21st century competencies in the Chinese science curriculum (see Table 3). Descriptions of 21st CC mostly use the 'competence word' directly, such as 'creative' and 'collaborate' (see examples above). Few detailed descriptions (using words with meanings related to 21st CC) can be found. This indicates that goals for 21st CC are not fully integrated into the science curriculum, but the organizers may have implicit ideas about these competencies or they may have a latent 'belief' that general competencies can be taught through science. According to the curriculum structure, most of the 21st CC units (98%) are represented in the preface (31.5%) and the aims section (66.7%), whereas only two units appear in the content goals section (see Table 3). This may imply that most of the 21st CC are mentioned as large, wide-ranging goals instead of being systematically integrated into the science content. Without clarifying the relation between traditional school science education and 21st CC cultivation, the curriculum may confuse and 21st CC may be ignored in practice. Thus, in the implementation of the Core Competencies for Student Development Proposal in classrooms, China needs to implement the 21st CC to the subject specific curriculum units in order to make the subject teaching aims and objectives consistent with the 21st CC descriptions.

Table 3 Distribution of 21st century competencies

Structure	Frequency and percentage of units
Preface	34 (31.5%)
General aims for science education	72 (66.7%)
Content Area of science	2 (1.9%)
Total	108

Distribution of categories of 21st century competencies in the science curriculum

The results show significant differences among 21st CC categories in the curriculum (see Table 4). 'Ways of thinking' has the majority of units (N=72). The number of units in the 'Ways of working' category was the second largest. 'Tools for working' is the least represented in the

curriculum. Almost 37% of the units are found in ‘critical thinking, problem-solving, decision-making’. Around 15% of the units belong to ‘creativity and innovation’. Most of the 21st CC units found in the category ‘Ways of thinking’ may relate to the Chinese education tradition and the policies published in the past several years. Chinese education prefers improving children’s thinking skills. The Entrance Examination for Higher Education is a good example of one of the intensive thinking skills examinations. Since the 1990s, China has realised that creativity and innovation in science and technology are sources of power for a country’s development. Many policies encouraging creativity and innovation in science and technology have been published. With the policy innovation, education has been changing from examination-centred and emphasis on memorisation to critical thinking skills and being creativity centred (Wang et al., 2016). ‘Learning to learn’ in the curriculum is consistent with the goal of primary level education in China as well, which aims at the cultivation of good habits for lifelong learning. Since lifelong learning relates to ‘learning to learn’, we coded lifelong learning in this category. In the Chinese curriculum ‘lifelong learning’ as a term has been mentioned several times. These results also show a natural and typical consideration in education, namely that thinking skills and science education are connected. Additionally, changing the ways of teaching guided by new aims may be one of the approaches to achieving educational goals in the new century.

About 11% of the units are located in ‘communication’ and 13% in ‘collaboration’ (see Table 4). The emphasis on communication and collaboration underlined in the curriculum is not unique. As mentioned before, China has been changing its pedagogy for years. Together with its famous inquiry-based teaching and learning, teamwork and communication have been encouraged as well (Wang, 2016). China also has a tradition of valuing collaboration. Interestingly, communication is not explicitly mentioned as a 21st CC in the Core Competencies for Student Development Proposal. But this does not mean that this competence is not important. At least in the

science curriculum, it is explicitly stressed several times, which demonstrates the importance given to it and shows the consideration of new teaching approaches.

Table 4 Distribution of categories of 21st Century competencies in the science curriculum

Category	Frequency and percentage of unit appearance	Subcategory	Frequency and percentage of unit appearance
Ways of thinking	72 (66.7%)	Creative thinking and generating of innovations	17 (15.7%)
		Critical thinking, problem-solving, decision-making	40 (37.0%)
		Learning to learn, metacognition	15 (13.9%)
Ways of working	26 (24.1%)	Communication	12 (11.1%)
		Collaboration	14 (13.0%)
Tools for working	1 (0.9%)	Information literacy	1 (0.9%)
		ICT literacy	0 (0.0%)
Living in the world	9 (8.3%)	Citizenship, global and local	8 (7.4%)
		Life and career	0 (0.0%)
		Personal, social and global responsibility	1 (0.9%)

'Tools for working' is the least often mentioned. Surprisingly, only one unit is in 'information literacy' and none is in 'ICT literacy'. However, in practice ICT has been introduced in Chinese classrooms for years, and computer science has been one of the basic courses in primary schools. One probable reason for the lack of units in ICT is that 'tools for working' are taught in other separate subjects, such as computer science. Moreover, national curriculum emphases on concepts and competencies students should acquire, rather the basic methods (tools) students learn to use. The absence of information literacy in this analysis may be connected with the coding method. In this research competencies directly related to science were not been included. Identifying scientific issues, in explaining scientific phenomena and in drawing evidence-based conclusions are competencies coded into PISA science framework. Thus, the absence of information literacy does not indicate its neglect in the curriculum.

The number of 'Living in the world' units is 8.3%. The percentage 7.4% in 'Citizenship' fits well with a characteristic of Chinese education, that is, an emphasis on social reconstructionism. However, 'Personal, social and global responsibility', which focuses on cultural awareness, is much

less than ‘citizenship’. One reason for this is the nature of the subject. Since science is a more international and culture-free subject, it is possible that cultural awareness is less often mentioned in connection with it. The lack of ‘Life and career’ is understandable as well. The curriculum analysed is for primary school students, who are not studying for careers. Meanwhile, in Chinese educational culture, it is lack of career guidance to teach with the idea of preparing students for a job or a career. Learning purposefully for careers has not been encouraged.

Cultural paradox of teaching 21st century competencies in the science curriculum

Critical thinking is the most favoured in the curriculum as shown in Table 4. This is consistent with the goals of education in China as formulated in the reforms of the 1990s. Chinese culture, such as the teachings of Confucius, also belongs among China’s educational values. As shown in the Core Competencies for Student Development Proposal, both culture and science are highlighted. However, the tradition of teaching culture may impede education in scientific thinking. Confucius highly valued the role of teachers and officials, whose authority cannot be challenged. In contrast, the ‘culture’ of science is to be critical and to value approaches of scientific inquiry or facts instead of idealised persons. Teaching ‘critical thinking’ seems to be in conflict with Chinese tradition, especially when both Chinese tradition and science are taught at the same time in primary schools. It is meaningful that Chinese education has been reforming to teach students to be more critical, and education has turned from teacher-centred to student-centred. However, it is more important to balance tradition and science in teaching primary school. Not only are tradition and science not opposed to each other, but they also may be integrated. However, it will be harder for primary school students to understand this. Thus, how to achieve a balance of these seemingly opposite competencies in school teaching, especially at the primary levels, needs deeper thought.

Concluding remarks

In this chapter we have made an effort to explore how 21st CC are characterised in the Chinese science curriculum. In order to obtain a broader understanding of 21st CC, we chose eight frameworks, both international and local, for a detailed analysis of their main contents. Our analysis revealed that 21st CC are mostly discussed at a very general level without concrete descriptions for integrating them into educational contexts. The frameworks used different terminologies in characterising these competencies, but they also had qualities in common such as knowledge, skills, attitudes and values. All the frameworks emphasised some renewed competencies for the 21st century; for example critical and creative thinking were included in all of them and can be seen as culture-invariant competencies for 21st century education all over the world. We also found some culture-dependent competencies, such as cultural heritage and language. Based on the comparing results, we revised ACT21S framework for deductive content analysis.

This chapter used Chinese science curriculum for primary schools as an example to show how 21st CC characterized in a science curriculum at national level. In order to identify the main characteristics related to 21st CC in the curriculum, we deductively analysed the Chinese National Primary Science Curriculum using the revised ACT21S framework. According to our results, most units of 21st CC were represented in the preface and aims sections of the curriculum, whereas only two units (1.9%) appeared in the section devoted to content areas. The analysis of unit distribution in terms of curriculum structure indicates that elements of 21st CC are included in the Chinese science curriculum, but are not added in a systematic way.

The distribution of categories of 21st CC indicates the culture-dependence and subject-relevance of 21st CC sitting in national curriculum. Most of the 21st CC units found in ‘Ways of thinking’ were related to Chinese educational tradition and the reform policies published in the past several years. Approximately 11% of the units were located in ‘Communication’ and 13% in ‘Collaboration’. This trend is related to educational reform in China as well, in which teacher-centred instruction is being replaced with student-centred learning. The consequences of this reform

for science education have been to encourage inquiry-based teaching and learning, which demands collaboration and communication. The number of units in 'Living in the world' is quite low (8.3%). The idea of 'Citizenship' fits well with the characteristics of Chinese education, which emphasise reconstructionism. 'Personal, social and global responsibility', which focuses on cultural awareness, is less represented in the curriculum than 'Citizenship'. One reason for this is the nature of the subject of science with its preference for objective and culture-invariant content. The absence of 'Life and career' might be related to the age of the students, who are in primary school, and to ignorance of a career education tradition in China. However, none unit was found in 'ICT literacy'. The absence of ICT in the curriculum is not consistent with the Chinese educational context, as ICT is in fact highly respected in China. This may imply that ICT is seen as a tool for teaching rather than as an integrated goal in education. As a whole, 21st CC are not integrated systematically into the Chinese curriculum. A future challenge for Chinese education is to develop a new national curriculum consistent with the Core Competencies for Student Development Proposal and find the right balance for all the competencies mentioned in the curriculum. Moreover, teachers need more guidance on how to integrate 21st CC from the science curriculum into teaching and learning in primary school.

European countries have experience in incorporating 21st CC into national curricula and other documents (European Commission, 2012), even if they face challenges in designing strategic approaches of implementing 21st CC in schools as well. European countries are steps before China and China can learn from them. Nordic countries, including Finland, Norway, and Sweden jointly worked on a project named Key Competence Network on School Education (KeyCoNet) to identify and analyse the implementation of key competences in primary school education. Moreover, Finland has published its National Core Curriculum for Basic Education 2014. Each subject mentioned in this curriculum is guided by 'transversal competence' (equals to 21st CC in this chapter) (Finnish National Board of Education, 2016; Vahtivuori-Hänninen, Halinen, Niemi,

Lavonen, Lipponen, & Multisilta, 2014). This implies the significance of research on Finnish curriculum and enhancing the communication and collaboration of Chinese and Finnish educational systems. According to the comparative research on primary science curriculum based on PISA science framework, culture-invariant features have been found, for example, aims for competencies, attitudes and learning context are strengthened and encouraged in both curricula (Wang, Lavonen & Tirri, 2017). The similar goals and culture-invariant features of science education and tendency of integrating 21st CC into school subjects teaching in Finland and China built the basis of education communication. The culture-dependent features multiple the perspectives and learning content of the educational communication between two countries.

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