

Toward an Understanding for Assessing 21st-century Skills:
Based on Literature and National Assessment Practice

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Abstract

While 21st century skills are getting increasing traction in both academia and the professional world, a big challenge today is that there has been no consensus on the unified conceptual framework to define and measure 21st century skills. This consensus is indispensable for understanding, teaching and assessing these skills. Additionally, few frameworks have detailed the standards or benchmarks for the assessment and evaluation of the learning process and the learning outcomes with regard to 21st century skills. This paper argues with supporting evidence that instituting a taxonomy is indispensable to meeting the urging needs of 21st century skill education. Also, it brings up a unique taxonomy, the Taxonomy for Assessing 21st Century Skills (TACS), which is a framework built on all the existing frameworks explicitly on 21st century skills thus far as identified via a systematic review. It is intended to cover the minimum conceptual components, including the minimum educational objectives and benchmarks that must be considered for a dialogue or action undertaken on 21st century skill education.

Key Words: policy issues in assessment, assessing learning, standard setting, 21st century skills

Introduction

Speaking of “21st-century skills,” what do we actually mean? The term “21st-century skills” appears to be a broad umbrella, and it is not surprising that there a lack of consensus on what 21st-century skills exactly are despite the fact that 21st-century skills are getting increasing traction in education systems globally (Nyamkhuu & Morohashi, 2019). As Care (2018) has precisely captured, “[t]here are more differences across ways of framing these [21st century skills] than there are in identifying the actual skills themselves” (p. 4). The Partnership for 21st Century Skills (P21, now known as the Partnership for 21st Century Learning) has broadly defined 21st-century skills as “the knowledge, skills, and expertise students should master to succeed in work and life in the 21st century” (Battelle for Kids, 2019, p. 3). It includes traditionally emphasized substantive knowledge. More narrowly, the KSAVE model from Assessment & Teaching of 21st Century Skills (ATC21S) considers ten skills beyond subjects. They are 1) creativity and innovation, 2) critical thinking, problem-solving and decision-making, 3) learning to learn or metacognition, 4) communication, 5) collaboration, 6) information literacy, 7) ICT literacy, 8) citizenship, 9) life and career, and 10) personal and social responsibility (Binkley et al., 2012).

This lack of consensus is problematic, for it is partly why contentions over how to frame and assess 21st-century skills keeps increasing, which, in turn, can impede relevant assessment practices’ further development and establishment in the formal education system. “There is no shortage of current definitions of 21st century skills and knowledge,” according to experts from RAND Corporation (Saavedra & Opfer, 2012a, p. 4). Darling-Hammond (2010) claimed that thinking in this regard kept polarized, which is unfortunate as the assessment field can embrace a powerful opportunity for 21st-century skill development. Setting forth a clear understanding “once and for all about what students should know,” as she asserted an interview according to an

Education Week report, is critical to settle down debates over what should be covered in the 21st-century education and the relevant assessment (Sawchuk, 2009). Importantly, since assessment is integral to other aspects of the education including pedagogy and curriculum (Care & Luo, 2016), the progress of the overall 21st-century skill education could lag behind today's societal demand if the relevant assessment system is not established enough in the first place. As evidenced by scholars at the Brookings Institution, challenges specific to assessment of 21st-century skills may be one reason why translating related policy demands into school- and classroom-level educational practice is facing difficulty (Vista, Kim, & Care, 2018, p. 2).

This study is expected to raise the awareness of the shortage of a consensus on assessing 21st-century skills, and what this consensus could be. Specifically, drawing upon information from both the research literature and the national documents with regard to 21st-century skill assessment, it is to identify the 21st century skills being currently being addressed and assessed, in response to the following two research questions: 1) What 21st-century skills have been recognized in the existing educational research literature? 2) What 21st-century skills are being assessed according to national documents about assessment across countries?

Considering the fact that a variety of understandings about the term "21st-century skills," I started my research with a loose definition of this term to guide the rest of this study. It is worth noting that many discussions on "21st-century skills" involve qualities like curiosity, creativity, and metacognition, which are not "skills" in its strict sense (Saavedra & Opfer, 2012b). Hence, although some existing conceptualizations or frameworks about "21st-century skills" could help frame this study, I will not take this advantage, for this study aims to seek patterns and common understandings from an essentially descriptive process to avoid the problem of going after one hype about "21st-century skills" and having bias against others. In addition, I chose to use the

term “21st-century skills” instead of “21st-century competencies” or other popular terms in this regard as it is currently the widely recognized term that have been used internationally and it complies with the term that is being used by powerful paradigm changers in this field such as RAND Corporation and the Brookings Institution.

Instead, I will rely on the original meaning of “skills” from the learning sciences and the dictionary. As presented in the widely received *Human Learning* book from Ormrod (2012), the term “skill” is treated nearly interchangeable with *procedural knowledge*. Specifically, *learning* is “a *long-term* change in mental representations or associations as a result of experience” (p. 4), and one of the two types of knowledge that exist in the long-term memory is *procedural knowledge*, which is about “knowing how to do things” (p. 223). In addition, the dictionary Merriam-Webster defines the “skill” broadly as “the ability to use one's knowledge effectively and readily in execution or performance” (Skill [Def.1a], n.d.). Considering the information from both the learning science and the dictionary, this study will refer to “21st-century skills” as any knowledge, understandings, performances or competencies that are essential long-term manifestations for making things happen.

Methodology

Design

Aiming to gather a rather comprehensive coverage of different understandings from both the research and the national practice about 21st-century skill assessment, I will employ a descriptive design for this study. First, a systematic review of the educational research literature will be undertaken to answer the first research question about what 21st-century skills have been acknowledged by the research literature. Then, an overview will be completed about national assessment practices on the 21st-century skills, using a Brookings’s data source that covers

countries across the globe to answer the second question about what 21st-century skills are being assessed according to national documents about assessments. The first step is expected to bring up an initial understanding of 21st-century skills based on the research literature, and the second step is to investigate the assessment practices themselves.

As mentioned earlier, “21st-century skills” in this study is referred to as procedural knowledge that exists over the long term with regard to the know-how of *doing*. Relying on this conceptual perception, I treat “21st-century skills” as interchangeable with other terms about the “skill” in relevant documents in the 21st century. They include transversal skills, soft skills, life skills, intangible skills, noncognitive skills, social-emotional skills, citizenship skills, skills for sustainable development, metacognitive skills, nonacademic skills, nontraditional skills, and unconventional skills that are not traditionally assessed in the formal education system.

Step 1: Systematically Review the Research Literature on 21st-Century Skills

A systematic review “collate[s] all empirical evidence that fits pre-specified eligibility criteria” (Liberati et al., 2009, p. 2). I will go through the following procedures to complete this step: Formulating the inclusion criteria and searching strategies, locating studies, screening and selecting studies, assessing quality of the selected studies, coding skill-related information, and synthesizing the coded information (Card, 2012; Littell, Corcoran, & Pillai, 2008).

Considering the inclusion criteria for studies to be selected, I find it important to lean on studies that have reviewed or cited more than one existing framework explicitly for understanding 21st-century skills. They are the ones that have considered reviewing other frameworks, made an effort to build on the existing research work, and usually ended up being more established than the ones that build or cite one single framework without consideration of others, or simply illustrate skills without a framework. Hence, the original inclusion criteria will

lead to the selection of studies that have covered more than one framework for understanding 21st-century skills, specified as follows:

- 1) having been released in English from 2000 up to 2017 (since 2000 is the beginning of the 21st century and 2017 is the year right before 2018, in which this study was initiated);
- 2) having been released as academic peer-reviewed journal papers or reports that were indexed in research databases;
- 3) having explicitly identified more than one framework, model or system that helps understand 21st-century skills in the learning context.

To locate and select relevant studies that meet the inclusion criteria, I will target a total of six research databases will be covered by the literature search: Academic Search Premier, ERIC, PsycINFO, PsycARTICLES, Teacher Reference Center, and Professional Development Collection. These databases are known for their wide coverage of educational research literature, and I feel certain that all the important works will be covered if I target these databases.

A wide array of key words will be used for the search of the eligible studies given the broad definition of “21st-century skills” for this study, including synonyms or interchangeable terms that are frequently used in the literature. They will consist of “21st century,” “twenty first century,” “transversal,” “soft,” “life,” “intangible,” “noncognitive,” “social-emotional,” “citizenship,” “sustainable development,” “nonacademic,” “nontraditional,” “unconventional,” “skill,” “competency,” “ability,” “aptitude,” “education,” “learning,” as well as “framework,” “taxonomy,” “classification,” and “concept.” Once all the relevant studies in these databases are located, screened and selected, their reference lists will be checked in search for additional sources that meet the inclusion criteria.

The final pool of the selected studies will emerge after three screenings of the literature. In the first screening, I will retain any source in the research databases and any of their relevant reference sources that explicitly addressed 21st-century education. In the second, only the sources from the first screening that have identified at least one 21st-century skill framework will be selected. Considering the limited time and capacity for this research project, I will focus on highly recognized frameworks, which are the ones at least reviewed or cited by other researchers. Also, this volume of work is expected to reach the saturation, in which more research studies in this field are not going to be helpful in identifying any new codes or themes. Therefore, the last screening will keep only the sources that have explicitly reviewed more than one framework about 21st-century skills for further consideration. It is these studies kept in the final pool as well as the primary studies they reviewed or cited for conceptualizing 21st-century skills will be analyzed.

Step 2: Overview 21st-Century Skills Assessment Practice in National Documents

This study will take advantage of the recent database from the Brookings Institution (2016). The database already systematically mapped out the efforts to foster the skills beyond literacy and numeracy across 153 countries in the world given their presence in national documents. In terms of the selection criteria for this phase of the research, only the national documents 1) that this Brookings database has provided clear citations (either an accessible link or a full document name), and 2) that have addressed the field practice to assess or measure 21st-century skills will be selected for this research, following the coding and analysis schemes mentioned earlier.

Coding and Analysis

To appropriately configure the information from selected research studies and national documents, the thematic synthesis method will be used, and NVivo 12 is the software I will use for the coding and analysis of text data. The coding and analysis in essence consist of two major steps to generate descriptive themes and to provide sufficient answers to the research questions (J. Thomas, O'Mara-Eves, Harden, & Newman, 2017, p. 193).

First, I will identify codes across the included sources. This procedure essentially translates relevant information in a common set of descriptive codes for further analysis. I will utilize the open coding approach to develop codes while coding line by line, mainly because the research questions are open-ended in nature and the open coding scheme keeps options fully open to allow new understandings to merge (Sutcliffe, Oliver, & Richardson, 2017, p. 137). This procedure will be inductive, as I will merely rely on the definitions of “21st-century skills” in lieu of existing theories when generating the codes.

Second, I will generate descriptive themes by organizing the codes developed from the first step. The axial coding approach will be adopted in this procedure to associate codes that are

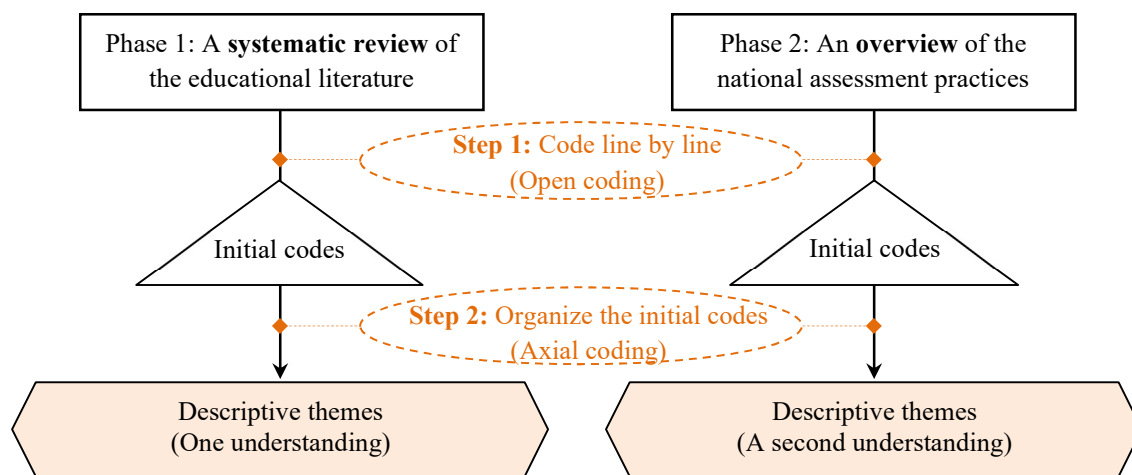


Figure 1. The systematic approach of this research process.

conceptually similar with one another (James Thomas & Harden, 2008) via both inductive and deductive reasoning. It includes collapsing multiple codes into one to avoid redundancy and adding additional levels of coding to clarify generic relationships among codes when needed (Corbin & Strauss, 2014). Figure 1 depicts this research process.

To ensure the reliability of the coding, I will bring on board another coder to complete the coding of 10% of the studies randomly selected from the retained studies. The inter-coder reliability (Lombard, Snyder-Duch, & Bracken, 2010) will be assessed by calculating Cohen's kappa that shows how consistent the codes generated by this coder are with the codes I will have generated. Doing so will make sure the coded data are reproducible by different coders following the coding scheme of this study in theory, and that the findings from this data are grounded on substantiated methods.

Taken as a whole, the methodology of this study is exploratory in nature. Throughout this systematic research process, I will only rely on the definitions of "21st-century skills" established earlier for this study to proceed the coding and analysis of information. In this way, with few fixed initial concepts, this study is intended to provide comprehensive information to answer the open-ended research questions respectively based on descriptive data derived from both the research literature and the national documents about the assessment practice.

Preliminary Results and Discussion

As of today, I have completed the coding and the analysis of the data. In the next phase, as addressed earlier in the Methodology section, I will bring another coder to code 10% of the studies randomly sampled from the retained pool of studies to be coded, and calculate Cohen's Kappa to ensure the reliability of the data (Lombard et al., 2010). At this stage, a total of 21

sources were retained in the final pool and 45 primary sources were extracted from them for the coding and analysis.

To start with, 471 sources in 2000-2017 were identified from the six research databases. In the first screening of this literature, 397 sources were removed for they were either duplicates or did not explicitly address 21st-century education, left with 74 potentially relevant sources. In the second screening, 173 sources were identified via reference lists of the 74 sources, 158 sources were removed for their full text cannot be located or for they did not identify any 21st-century skill framework, and four sources were removed for they were duplicates. This second screening selected out 89 sources for the final screening, in which 68 sources were removed for they did not identify more than one 21st-century skill framework, and 45 primary sources were extracted from the retained 21 sources.

In the coding and analysis of the 21 retained sources, an impressive pattern emerged from the largely repetitive descriptive codes. 297 codes were generated in the open coding procedure (Sutcliffe, Oliver, & Richardson, 2017) that developed codes when coding the documents line by line. Then, they were reorganized into 34 themes in the axial coding (James Thomas & Harden, 2008), which combined similar codes into one, reduced redundant codes, and reorganized the final codes to find patterns. The 34 themes, despite the fact that they were largely interconnected with each other, exhibited seven different value-laden emphases when ordered along a circular frame. As shown in Figure 1, though the demarcation between emphases were evidently mandatory, the seven emphases happened to correspond to seven interrelated factors that are essential to an individual's living, thinking and working individually or with others. They are 1) Physical well-being (Themes 1-2), 2) Foundational literacies and skills (Themes 3-11), 3) Individual productivity (Themes 12-18), 4) Relation with others (Themes 19-23), 5) Social-

emotional well-being (Themes 24-27), 6) Ethics, morals and citizenship (Themes 28-31), and 7) Continuous learning (Themes 32-34). For each of the seven emphases, the key themes that surfaced were specified as follows in Table 1.

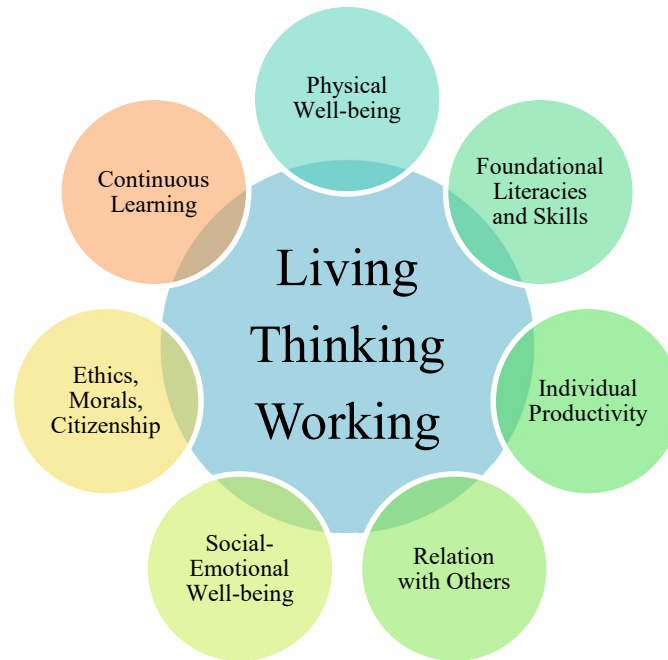


Figure 2. An initial structure for understanding 21st-century skills in the literature (preliminary).

Physical Well-being

This emphasis represents thematic ideas regarding the physical health and physical capabilities of an individual. It consists of two themes, namely health and wellness awareness, and health literacy. It concerns understandings such as health as a condition of the life quality, attitudes towards body, and the knowledge about the medium weights of different products.

Foundational Literacies and Skills

Foundational to an individual's further development to survive and thrive in a society today, this emphasis about foundations stresses basic knowledge and skills that are fundamental at the beginning phase of an individual's life and career. It emphasizes basic literacies and low-level skills, including language literacy, numeracy and quantitative literacy, spatial literacy,

Table 1

Themes Covered by the Seven Emphases

| Emphasis | Theme | No. | Example(s) of the descriptors for the theme |
|------------------------------------|--|---------------------------------|---|
| Physical well-being | Health and wellness awareness | 1 | Understanding of health as a condition of the quality of life, attitude to body |
| | Health Literacy | 2 | Health, physical skills (medium weighting) |
| Foundational literacies and skills | Language literacy | 3 | Language proficiency |
| | Numeracy and quantitative literacy | 4 | Basic numeracy, mathematics |
| | Spatial literacy | 5 | Mapping, think spatially |
| | Environmental literacy | 6 | Environmental awareness, environment-related competencies |
| | Visual literacy | 7 | Aesthetic sensibility |
| | Digital literacy | 8 | Information, media and technology skills |
| | Financial, economic, business and entrepreneurial literacy | 9 | Financial planning, economic analysis, management, leadership |
| | Skills to integrate information across disciplinary boundaries | 10 | Cross-disciplinary synthesis |
| Others | 11 | Technical and vocational skills | |
| Individual productivity | Skills to access resources | 12 | Access to resources |
| | Skills to interactively use tools | 13 | Using language, knowledge and information, technology interactively |
| | Skills to effectively use tools | 14 | Using models and simulations to explore complex systems and issues; using ICT tools, communicative media and presentations |
| | Skills to manage and apply information | 15 | Analyzing, planning, prioritizing, making decisions, managing for results |
| | Skills to solve problems (from research and information proficiency) | 16 | Acting autonomously, observing, questioning, hypothesizing, associating, synthesizing, experimenting, identifying trends, forecasting possibilities, formulating responses, defending ideas, making conclusions, presenting information |
| | Skills to solve problems (from innovation) | 17 | Initiative, imagination, creativity, curiosity, motivation, critical thinking, creative thinking, inventive thinking |
| | Intra-personal skills | 18 | Self-reflection, metacognition, learning to learn |

Table 1 Continued

| Emphasis | Theme | No. | Example(s) of the descriptors for the theme |
|--------------------------------|---|------------|--|
| Relation with others | Context awareness | 19 | Acting within the big picture, contextual learning skills, organizational skills, conflict management and resolution |
| | Communication | 20 | Assertion, interacting with heterogeneous groups, social skills, social and cross-cultural skills |
| | Collaboration | 21 | Cooperation, teamwork, collective problem resolution |
| | Entrepreneurship | 22 | Leadership, risk-taking, relationship skills, networking |
| | Others | 23 | Adaptability, flexibility |
| Social-emotional well-being | Self-awareness | 24 | Self-efficacy, self-confidence, sense of personal agency and belief |
| | Self-management | 25 | Self-direction, self-regulation, emotion management/intelligence |
| | Social awareness | 26 | Empathy, responsibility, relating to others, engagement |
| | Social competence | 27 | Articulating tasks, building peer relationship |
| Ethics, morals and citizenship | Ethics | 28 | Work ethic, code of behavior, integrity, ethical reasoning and action |
| | Morals | 29 | Moral reasoning, moral discernment |
| | Citizenship (local, global, digital) | 30 | Membership and action as a citizen on multiple levels, global citizenship, local citizenship, awareness and concern about traditions and progress on a global scale, service, accountability |
| | Civic literacy | 31 | Civic knowledge and engagement |
| | Respect for diversity | 32 | Awareness, understanding and appreciation of diversity and inclusion; openness to new ideas |
| Continuous learning | Foundational skills for lifelong learning | 33 | Initiative, curiosity, self-reflection |
| | Self-driven learning | 34 | Commitment to learning as a life-long process |

environmental literacy, visual literacy, digital literacy, and so on.

Individual Productivity

Grounded on the common concerns about how an individual can be successful, this emphasis about individual productivity underscores the heuristic knowledge, skills, competencies or any understandings that embrace the image of an independent, self-sustained individual. It involves knowledge and skills to access resources, to use tools, manage and apply information, solve problems and learn more about self-development by reflecting on how himself or herself learn and act.

Relation with Others

In an increasingly interconnected world, no man is an island, and the society prospers based on cohesion and collaboration. This emphasis about relation with others is marked with the emerging importance of interaction with others in varied societal settings for team collaboration and collective problem resolution. It entails knowledge and skills with regard to context awareness, communication, collaboration, entrepreneurship, adaptability and flexibility.

Social-emotional Well-being

Psychological and mental health is equally important for an individual's continuous growth and decision-making. This emphasis about social-emotional well-being unveils the rapidly raising attention to understandings of one's own capabilities, and knowledge and skills for self-control and management of one's relationship with itself and with the society. It is comprised of self-awareness, self-management, social awareness, and social competence.

Ethics, Morals and Citizenship

Ethics and morals are important to ensure the social balance against unfairness and inequity. Also, against the backdrop of the internationalization, the knowledge, skills and

attitudes about one's own and others' value and belief systems are essential to avoid infringement of the societal harmony. This emphasis about ethics, morals and citizenship signifies the amplified voice calling for more responsible reasoning and action, grounded on respect for diversity and civic procedures.

Continuous Learning

How to support individuals' continuous learning after they finish formal education is an emerging topic. This emphasis about continuous learning contains foundational skills and self-driven learning for lifelong learning. Different from the understanding in the widely-known *Key Competences for Lifelong Learning* (Sahin, Akbasli, & Yelken, 2010) that includes knowledge and skills essential to school success in the lifelong learning competences, this emphasis here accentuates a sense about commitment and stamina for self-motivated growth.

Overall, the seven emphases exhibited the broad spectrum of the skills covered in the current academic dialogue about "21st-century skills." It is worth noting that these emphases were built on the different sources that rarely cover all of the seven. Some researchers have pointed out that, most often, people were addressing higher-order skills when talking about "21st-century skills" (Saavedra & Opfer, 2012a). Meanwhile, in this study, most of the descriptors were found related to knowledge and skills necessary for one's overall success in career or workforce, which aligns with a claim that represents many—these skills are the ones "needed to be able to live in and contribute to our current (and future) society" (J. Voogt, Erstad, Dede, & Mishra, 2013). Interestingly, the emerged emphases appear to reflect a combined understanding from Maslow's hierarchy of needs from the low-level physiological needs to the high-level needs for self-actualization (Maslow, 1987) and Anderson and Krathwohl's Taxonomy that identifies four knowledge types from factual or conceptual knowledge that needs memorization to

procedural and metacognitive knowledge that requires higher-order thinking (Anderson & Krathwohl, 2001).

This finding demonstrated, for the first time from a theory-based approach to my awareness, that “21st-century skills” has become a large umbrella in which researchers and advocates tuck different types of skills or knowledge to integrate their ideal in an educational paradigm shift or reform. It supports Dede’s claim that the term “21st-century skills” is an “attention-getting misnomer” (2007), and that people using this term may mean different things (2009), based on a comparison of major organizations’ frameworks on what students are expected to know in the 21st century. It also partly aligns with the observation from Voogt and Roblin (2012)—many of the knowledge and skills addressed under this term “21st-century skills,” such as problem-solving and critical thinking, is nothing new in the 21st century.

However, this wide spectrum suggested the high expectations and ideals of a better education that meets the needs of individuals and the society in the new era. The rapidly increasing number of terms under the “21st-century skills” umbrella implied the ascending urge to change the status quo of the educational institutions we have largely inherited from the human society’s relatively traditional past. This urge about change itself is not surprising, for, after all, the educational institutions have kept evolving since Day One of their establishment over arguments about highly controversial or sensitive topics. These topics and relevant efforts include what should be assessed and taught in schools (see, for example, Common Core Standards Initiative) and how to admit students given their performance in assessments of one or multiple forms (see, for example, different universities’ GRE score acceptance policy).

What makes this situation particular is its stress of the “21st-century” theme, which is largely contextualized in the digital tools and new media in the information age, as well as the

ensuing cross-region, cross-cultural communication facilitated by the progress in the tools or platforms (Voogt et al., 2013). These elements in the new era are profoundly shifting people's perspectives regarding ways to live, think and work. To embrace this theme, new challenges must be addressed in the novel methods in assessing the digital competencies. This finding aligns with the fact that many studies involved in this research singled the ICT skills or digital literacy out as a unique component of the 21st-century skills (Ravitz, 2014; Saavedra & Opfer, 2012a).

A sensitivity analysis is exhibited in Table 2. It shows the contribution of each of the 21 review studies to this structure for an initial understanding of the skills being discussed under "21st-century skills." The majority of the selected studies on 21st-century skills covered Foundational Literacies and Skills, Individual Productivity, Relation with Others, Social-emotional Well-being, and Ethics, Morals and Citizenship. Comparatively speaking, a relatively small number of studies addressed the skills with the emphasis of Physical Well-being and Continuous Learning. Findings from the sensitivity analysis has important implications about the values underpinning the varied array of frameworks for 21st-century education. They suggest that strong research interests in this area about 21st-century skills were surrounding skills critical to individual and teamwork successes. While the skills for social-emotional well-being were catching attention, the skills that support an individual's physical health and lifelong learning were not discussed very often.

My results at the current stage are preliminary ones. They still need the confirmation from the next stage that assesses the inter-coder reliability to ensure the consistency of the data and analysis. Findings from this paper are not expected to be generalizable to the overall research dialogue about 21st-century skills.

Table 2

Contribution of Each Review Study to the Initial Structure (Preliminary)

| # | Source | Physical well-being | Foundational literacies and skills | Individual productivity | Relation with others | Social-emotional well-being | Ethics, morals and citizenship | Continuous learning |
|----|--------------------------------|---------------------|------------------------------------|-------------------------|----------------------|-----------------------------|--------------------------------|---------------------|
| 1 | Balistreri (2012) | X | X | X | X | X | X | X |
| 2 | Binkley et al. (2012) | X | | | X | X | X | |
| 3 | Care et al. (2018) | X | | X | X | X | X | |
| 4 | Davis (2016) | X | | | | X | X | |
| 5 | Dede (2007) | X | | | | X | X | |
| 6 | Dede (2009) | X | X | | X | X | X | |
| 7 | Ee (2014) | | X | X | X | X | X | |
| 8 | Fink & Geller (2016) | | X | X | X | X | X | X |
| 9 | Gokool-Ramdoo & Rumjaun (2017) | X | X | X | X | X | X | X |
| 10 | Gordon et al. (2009) | X | X | X | X | X | X | X |
| 11 | Greenstein (2012) | | X | X | X | X | X | X |
| 12 | Hillman (2012) | X | X | X | X | | X | X |
| 13 | Kereluik et al. (2013) | | X | X | X | X | X | |
| 14 | Mishra & Kereluik (2011) | X | X | X | X | X | X | |
| 15 | Omohundro (2015) | | X | X | X | | X | |
| 16 | Ravitz (2014) | | X | X | X | X | X | |
| 17 | Saavedra & Opfer (2012a) | | X | X | X | | X | |
| 18 | Saavedra & Opfer (2012b) | | | X | X | X | | |
| 19 | Uduigwome (2012) | X | X | X | X | X | X | X |
| 20 | Voogt & Roblin (2012) | | X | X | X | X | X | |
| 21 | Voogt et al. (2013) | | X | X | X | X | X | |

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Appendix I. Flowchart of the systematic review of the research literature on 21st-century skill frameworks

