



The Development and Validation of a 21st Century Skills Instrument: Measuring Secondary School Students' Skills

Alpaslan Sahin

Harmony Public Schools, USA

Mirim Kim

Myeongsun Yoon

Texas A&M University, USA

Abstract: Due to the rapid change in technology and information dissemination, the qualities and skills employers and colleges demand in the 21st century have changed. To help higher education institutions and workforce to identify and measure their prospective students and employees' skills respectively, we designed an instrument for secondary grade students to self-assess their 21st century skills. After successful piloting, validation of the final instrument was done with 282 high school students from a public high school in Texas. We utilized exploratory factor analysis and investigated construct validity for the instrument using principal axis factoring with Promax rotation and Kaiser normalization. We found that the original 48 items developed for the instrument were loading the four factors as theorized in our model. Finally, confirmatory factor analysis (CFA) models for four scales were separately investigated. Maximum likelihood estimation method was used for all analyses though Mplus8.2 (Muthén & Muthén, 1998-2017). We came up with 5 factors and 43 items. Researchers, K-12 educators, postsecondary educators, and employers may benefit from the development of this instrument.

Keywords: *21st century skills; Exploratory factor analysis; Instrument development; Principal axis factoring; Confirmatory factor analysis.*

Introduction

In today's world, with the evolution of every aspect of human life pioneered by technological and scientific advances, it is indispensable to have transformed the expectations and standards for the skills and competencies that individuals should possess for both work and daily life. The changes in standards and expectations are indeed a paradigm shift in skills needed for life—a shift that occurred in transitioning from the 20th century to the 21st century. Although the

late 20th century is not very long ago, differences in skills needed between then and now are profound, well known, and well documented. For example, collaboration was not a type of skill that was needed as critically in the 20th century but it has become an essential skill in the 21st century. When contemplating about the essential skills that are in the rise in the 21st century, it is important to analyze the way we understand some relevant constructs and how they have altered and/or transcended their original essence. For instance, cognition has evolved

thanks to research on neurosciences and cognitive and developmental psychology resulting in implications for teaching and student learning (Mintz, 2014). Cognition moved towards the forefronts of learning theories (e.g., Piaget, 1950) way before the turn of the new century, however, it was not until recently that it truly made it to the educational practice, after utilization of technological advances, educational technology, in particular (Saettler, 2004).

The shift also rendered educational goals and objective to be revisited and reformed because they could not stay static. Bloom's Taxonomy (Bloom, 1984) for educational goals, for example, which have been applied by many K-16 educators for decades, has been revised by cognitive psychologists, educational theorists and researchers, and assessment specialists. Rather than simple nouns of the original taxonomy, verbs and gerunds were added to the names of categories to underline the dynamism 21st century brought in (Anderson et al., 2001, Churches, 2008). Moreover, we live in a digital age in which technology is progressively ubiquitous. This is why many new educational terms have been introduced with the turn of the century such as "digital literacy." This necessitates reforms in what to

teach/learn, with what to teach/learn, when to teach/learn, how to teach/learn, how to assess learning, and so forth. Reformed-based teaching and standards movements are some policies have come to life as a response to these developments.

The key question is then: What are the "new" skillsets that are needed now or in the near future? Also, how do we define them? In defining 21st century skillsets, many parties should be involved in the process since the new set of skills is overarching and more sophisticated than they were in the last century (Dede, 2010). It is a collaborative task with involvement from educators, education experts, researchers, workforce leaders, and business partners to define and illustrate the skills, knowledge, expertise, and support systems that students need to succeed in work, life, and citizenship (Partnership for 21st Century Learning [P21], 2009; 2016). In very basic and commonly acceptable terms, 21st century skills refer to certain core skills and competencies such as collaboration, problem-solving, digital literacy, knowledge in key subjects such as mathematics and science, and social and leadership skills students nearing end of compulsory education need to succeed in work, life, and citizenship (Binkley et al., 2012; P21, 2016;

Rich, 2010). The next section describes frameworks that are used to define 21st century skills and how learning should look like within the framework.

Theoretical Framework

Inculcating 21st century skills is not about teaching new skills, but in fact, breathing life and giving importance to the otherwise dormant skills that were not much in demand in the 20th century (Silva, 2009). The advent of technology automated the mundane and menial jobs, thus, resulting in the decrease amount of people required to put in effort for such work (Levy & Murnane, 2004). Even in existing jobs, there arise cases where there is no written solution and in such situations professionals have to improvise and adapt using their knowledge and experience to figure out a remedy (Dede, 2010). Most of the workforce is now looking for employees that can perform more than trivial tasks. They must be able to comprehend their role and realize its functioning (Silva, 2008). There are different arguments as to what skills constitute the 21st century skills and furthermore, in what manner should they be taught. There are many proponents for development of new standards, assessments, and curriculum that reflect the needs of the 21st century (Rotherham & Willingham,

2010). Also, basic skills and its application go hand in hand (Rotherham & Willingham, 2010; Silva, 2009).

Several researchers reviewed and synthesized different frameworks for 21st century skills (e.g., Dede, 2010; Mishra & Kereluik, 2011; Voogt & Roblin, 2012). The most common frameworks—found in the literature and also included in these different syntheses and in this study—were P21 (2009), enGauge (North Central Regional Educational Laboratory [NCREL] & Meriti Group, 2003), International Society for Technology in Education (2016), and Organisation for Economic Cooperation and Development (OECD; 2005). Although there is some inconsistency in the origin of different frameworks (i.e., goals, intentions) and the implications they extend (i.e., practice), it is fortunate to see greater alignment across different frameworks in terms of what overarching skillsets are and why they are important (Dede, 2010; Voogt & Roblin, 2012). The underlying skillsets common across all these different frameworks can be grouped into four main categories: (a) *learning and innovation skills* (Ongardwanich, Kanjanawasee, & Tuipae, 2014; Saavedra & Opfer, 2012; Lombardi, 2007; Pacific Policy Research Center

[PPRC], 2010), (b) *life and career skills* (Bell, 2010; Ongardwanich, Kanjanawasee, & Tuipae, 2014; P21, 2016), (c) *interdisciplinary themes* (literacy; Association of American Colleges and Universities, 2007; NCREL & Meriti Group, 2003; OECD, 2005; Schneider, 1997), and (d) *information, media, and technology skills* (Ongardwanich, Kanjanawasee, & Tuipae, 2014; PPRC, 2010; P21, 2016). These categories are explained below and are used as the framework for the 21st Century Skills Instrument (21CSI) developed in this study. The 21CSI instrument developed in this study draws on these four overarching constructs each of which has up to four sub-constructs.

Learning and innovation skills are critical to be creative and a lifetime learner as they may be also called as “survival skills” (Savendra & Opher, 2012, p. 8). The new living standards, world of work, and contemporary citizenship constantly demand higher levels of thinking, communication, and collaboration. In this new era, individuals are expected to develop and create new ideas and to respond to new and diverse perspectives (*creativity and innovation*; P21, 2016). *Critical thinking and problem solving* are now considered the new basics of learning (Anderson et al., 2001;

Lombardi, 2007). Effective and interactive *communication* and *collaboration* skills are also crucial as learning is fundamentally a social activity in many ways (Dron & Anderson, 2014; Trilling & Fadel, 2009). Thus, individuals should be able to articulate ideas effectively using different communication means and work in harmony and productively in groups (Pacific Policy Research Center [PPRC], 2010).

Life and career skills basically refer to social and emotional competencies needed to navigate through the complex life and work environments (P21, 2016). Being able to work effectively even in ambiguous environments and to adapt to a variety of context and situations (*flexibility and adaptability*), understanding and embracing cultural and social difference (*social and cross cultural skills*), transcending mastery skills and self-monitoring (*initiative and self-direction*), and working with the interest of the larger community in mind and inspiring others by example (*leadership and responsibility*) are all important constructs related to *life and career skills* (Bell, 2010; PPRC, 2010; P21, 2016).

Interdisciplinary themes transcend the traditional core subject areas (i.e., reading,

social sciences, math, and science) and emphasize the contemporary literacy elements such as *civic literacy*, *environmental literacy*, and *global awareness*. There is the need for students to be able to participate in the civic society by understanding and actively contributing to civic decisions (*civic literacy*; OECD, 2005). Environmental issues, whether caused by human or occurred naturally, present significant problems to humanity and nature. It is very important for students to understand and discuss environmental issues and propose and evaluate a variety of solutions to these problems (*environmental literacy*; Schneider, 1997). In addition, in today's world, students should be able to work with and exchange knowledge exchange with people from diverse background. However, achieving this goal in the most successful way relies on having a global awareness, which requires knowing, respecting, and understanding different cultures, religions, lifestyles, ideologies, and political contexts (*global awareness*; NCREL & Meriti Group, 2003).

Information, media, and technology skills are used by effective citizens and workers to determine the extent of information needed and access it, evaluate sources of information

critically and use them effectively, and understand social, political, and economic issues surrounding the use of information (PPRC, 2010).

It should be noted that besides the four constructs there are specified above, all the frameworks include in some form or other for the students to possess basic and holistic forms of literacy which includes but not limited to science, mathematics, arts, languages, and social sciences.

Purpose of the Research

Our goal of this study is to develop and validate an instrument designed to measure secondary school students' self-assessment of 21st century skills they may have developed during K-12 school years. Although several indicators and ways of measuring students 21st century skills were offered and developed (see Griffin & Care, 2015; Ongardwanich, Kanjanawasee, & Tupae, 2014; Soh, Osman, & Arsad, 2012; Trilling & Fadel, 2009), there is a scarcity of instruments that delve into students' perceptions about their own skills and that are comprehensive enough to cover all aspects of the 21st century skills framework introduced above. Moreover, there have been various attempts in order to measure the advanced

skills required in the modern era (CRESST, CWRA, River City, IBD, Key Stages 3 ICT Literary Assessment, NAEP). However, we are in a situation where we do not need more tests but better assessments (Silva, 2008). There is a need, not only for 21st century skills, but a viable measurement to assess them on a large scale. The tests listed may be intensive in their approach, but they have drawbacks in the form of expense, logistics and administration.

In addition, existing instruments either deal with only some subdomains of this framework (e.g., digital literacy; see Calvani, Cartelli, Fini, & Ranieri, 2009) or are limited to certain contexts (e.g., Osman, Soh, & Arsad, 2010). In response to this need in the field, the present study details the steps used to develop and validate an instrument to measure students' self-perceptions on their acquisition of 21st century skills. The 21CSI instrument developed in this study will provide a more convenient and sufficient way of evaluating secondary grade students' 21st century skills by asking them how they see what they learned during their secondary years.

Methods

Participants

Participating school was an urban public charter high school in west Texas where majority of students are Hispanics in west Texas. The participating school was representing the city demographics and majority of its students were Hispanics. First, we distributed parent consent forms to students who are younger than 18 years old. Out of 400 students, 321 returned the parent consent forms. We sent the instrument to 321 9-12 grade. Of those, 282 (88%) of them completed the survey. The study participants were 44% male, 82% Hispanic, 5% black, 11% white, and 3% Asian. Their grade demographics were 30% 9th, 24% 10th, 24% 11th, and 22% 12th grade students.

Development of the Instrument

The cross-sectional survey method was used to identify 21st century skills elements for secondary grade students. Through an extensive review of the related literature and focus group discussions, we came up with the constructs that best represent what secondary grade students need to learn and can learn through their high school education in this era. The focus group crew included math and science educators, science and STEM university professors. Each group read the

literature chosen for the study and reviewed the instruments related to the focus of the study. Then, they discussed their groups of skills with each other groups and agreed on constructs and subconstructs after 2 two-hour meetings. Finally, they came together discuss their item sentences. This took two half-day study sessions. All of these study groups yielded four factors, 11 sub-factors, and 37 items.

Then, we sent the instrument to three nationally known researchers (George Washington University, Texas A&M University, and University of Texas-Austin) with expertise on 21st century skills and STEM education for content validity (Lawshe, 1975). Three experts were asked to provide comments and suggestions for each construct and items on its content and category. We also sent the instrument to a linguistic expert (Duquesne University) for language validity. We were provided comments and feedbacks regarding the appropriateness of each item for both native and international secondary grade students' language level. Upon receiving all those great inputs, the research group met one more time to go over the comments and suggestions to re-write the items. For instance, one expert worried about too much affirmative questions

included in the instrument. Another one suggested including several negative format type questions would increase the reliability of the survey. Our language expert recommended us to have multiple shorter items instead of one long item.

After addressing the recommendations, the final instrument constructed included 48 items for self-assessment of secondary grade students' 21st century skills in four domains: The first section of the survey, *learning and innovation skills* (LIS), is comprised of five sections: creativity and innovation (3 questions), critical thinking and problem solving (5 questions), communication (4 questions), initiative and self-direction (4 questions), and leadership and responsibility (3 questions). The second main construct is *life and career skills* (LCS) with three sections—flexibility and adaptability (4 questions), social and cross-cultural skills (4 questions), and collaboration (4 questions). The third construct, *interdisciplinary themes* (IT), has three sections: global awareness (3 questions), civic literacy (3 questions), and environmental literacy (4 questions). The fourth construct is *information, media, and technology skills* (IMTS) with seven items. All questions ask participants' beliefs about how confident they are on the statements

given under each sub-construct (e.g., “*I can analyze and evaluate alternative points of view*”). The responses to these 48 questions in total are on a 7-point Likert-scale (7=Very Confident to 1=Not Confident at All).

Data Analysis

Confirmatory factor analysis (CFA) models for four scales were separately investigated. Maximum likelihood estimation method was used for all analyses through *Mplus8.2* (Muthén & Muthén, 1998-2017).

Results

First, we ran a PCA with scree plot without any rotations to determine the number of new and reduced factors that will come out. We extracted 6 factors which had eigenvalues greater than 1. These 6 factors account for 68% of the variance cumulatively. According to the Kaiser-Guttman rule, factors with Eigenvalues greater than 1 should be accepted.

To cross check, we also examined the scree plot (see Figure 1). According to the scree plot, it shows the sharp descent of the Eigenvalues of factor 1 to factor 4, and a leveling off from factor 5 onwards suggesting that four factors should be rotated in the survey items. The results of the factor

extraction and rotation indicated that four factors explain 63.53% cumulatively of the total variance in the data. Then, we re-did the PCA with direct oblimin rotation with 4 factors.

Because we found correlations greater than .32, we used one of the oblique rotations—Promax with Kaiser normalization as part of our exploratory factor analysis (EFA) with principal axis factoring as common factor analysis to uncover the latent constructing underlying the variables. We successfully achieved a simple structure (Brown, 2009) that explained all the original 48 items with four factors that was proposed in the study.

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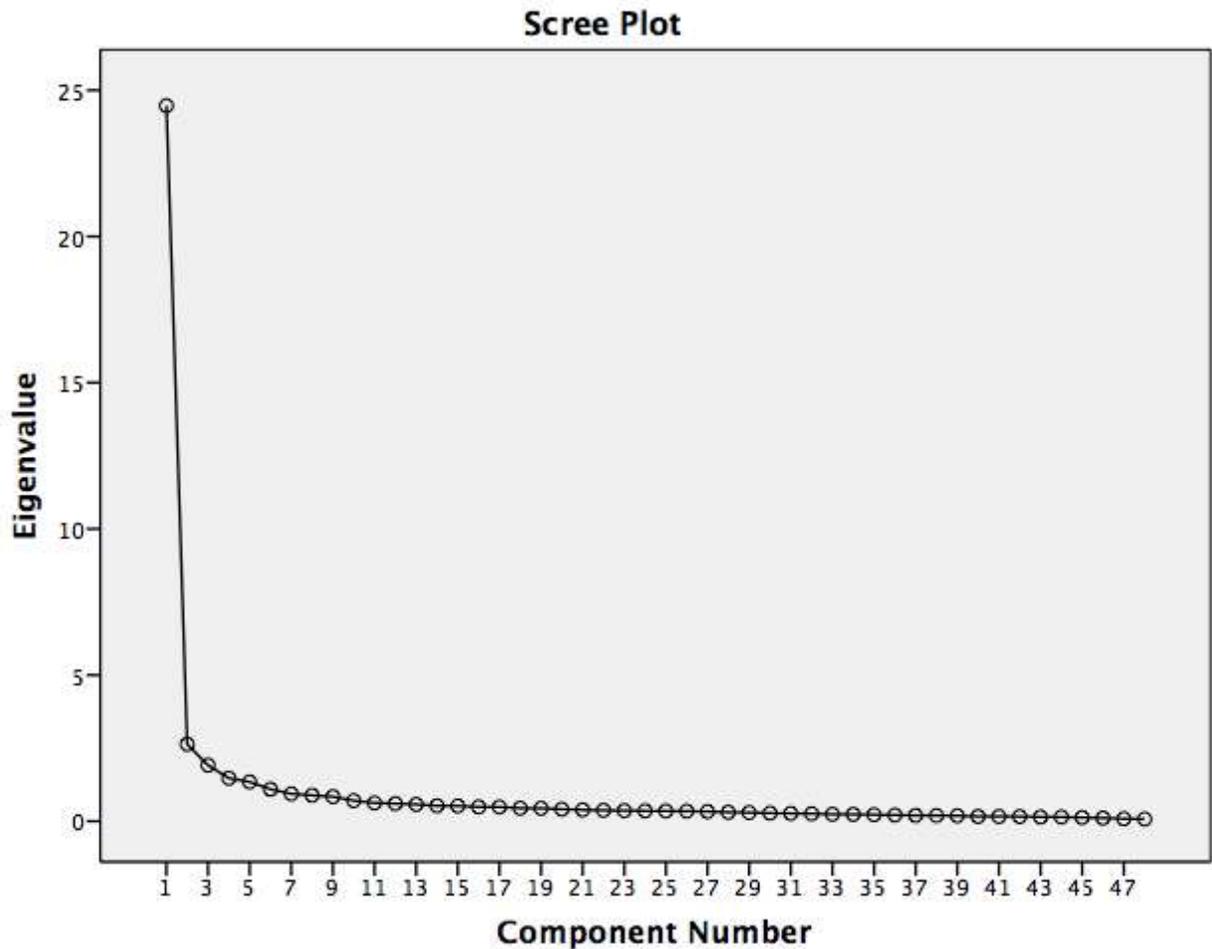


Figure 1. Scree plot of eigenvalues.

A scale of learning and innovation skills (LIS) is constructed with five subscales: (1) Creativity and innovation; (2) Critical thinking and problem solving; (3) Communication; (4) Initiative and self-

direction; (5) Leadership and responsibility. A single factor model that is 19 items loaded on the single factor was fitted to the data (see Table 1).

Table 2

Global Fit Indices for CFA Models

	Chi2	CFI	RMSEA	SRMR
Learning and Innovation Skills (19)				
Single factor	399.487 (152)	.928	.076	.041
Life and Career Skills (10)				
2-factor	116.166 (34)	.972	.093	.037
Modified 2-factor*	84.057 (33)	.974	.074	.028
Interdisciplinary Themes (7)				
Single factor	27.007 (14)	.991	.058	.016
Information, Media, and Technology Skills (7)				
Single factor	65.623 (14)	.959	.116	.031
Modified single factor*	35.681(13)	.980	.085	.023

Note. * A residual correlation was freed based on the modification indices

The original item set of Life and career skills (LCS) scale had 15 items under four subscales: (1) Flexibility and adaptability; (2) Social and cross-cultural skills; (3) Collaboration; (4) Global awareness. However, some of items were dropped from the final set of items based on the EFA result, because three items (i.e., FA2, SSCS2, and SSCS3) had cross-loadings on more than two other factors not relevant to the LCS factor, and two items (i.e., GA2 and GA3) had a cross-loading over .30. A 2-factor model representing 'Life and career skills-a and 'Life and career skills-b' factors was tested. Seven items loaded on the LCS-a factor and

three items loaded on the LCS-b factor. Due to the low fit of RMSEA (.093), we freed a residual correlation between FA4 (*Dealing positively with setbacks and criticism*) and COL4 (*Valuing individual contributions of others for collaborative work*) based on the modification indices. The global fit for the modified 2-factor model was fair (CFI = .974, RMSEA = .074, SRMR = .028, in Table 2). A factor correlation between two factors was .938, and the freed residual correlation was .347.

Interdisciplinary themes (IT) and Information, media, and technology skills

(IMTS) scales are constructed by seven items, respectively. A single factor model was tested for both constructs, and the IT single factor model was fitted to the data well (CFI = .991, RMSEA = .058, SRMR = .016, in Table 1).

On the other hand, the IMTS single factor model showed the low fit of RMSEA. Modification index suggested a residual correlation between IMTS2 (*Using various*

media forms) and IMTS7 (*Effectively utilizing technology in variety of ways as they relate to life*), and the freed residual correlation was .339. The global fit of the modified single factor model was better (CFI = .980, RMSEA = .085, SRMR = .23, in Table 1).

Finally, each item was assessed for its internal consistency. All factors had high Cronbach alpha reliability (Table 2).

Table 2

21CSS Instrument Cronbach Alpha Reliability Scores

# of items	Factors	Internal Consistency
19	Learning and innovation skills	.954
7	Life and career skills-a	.924
3	Life and career skills-b	.797
7	Interdisciplinary themes	.934
7	Information, media, and technology skills	.921

Discussion and Conclusions

Due to rapid change in technology and information dissemination systems, the qualities and skills employers and colleges demand in the 21st century have changed. To help higher education institutions and workforce teams to identify and measure their prospective students' and employees' skills respectively, we designed and tested a

21st century skills instrument at a local high school in Texas. We found that the finalized 43 items for the instrument successfully measured the high school students' core skills with 5 factors and 11 skills.

With the evolution of every aspect of human life pioneered by technological and scientific advances, it has become indispensable to have changed and improved expectations and

standards for the skills and competencies that individuals should possess for both work and daily life (Dede, 2010; P21, 2016; National Center on Education and the Economy, 2007). As a response to this transformation in skills and competencies, in this study, we developed and validated the 21CSI designed to measure secondary school core students' 21st century skills. Although, our study/instrument is similar to what Ongardwanich, Kanjanawasee, and Tuipae has developed in 2014, our instrument measures several more skills with less items including Global citizenship, Civic, and Environmental literacy. Also, our instrument is designed to measure high school students' self-assessment of their 21st century skills development after each year.

Our goal was to develop an instrument that was an easy-to-use/administer and cost-effective way of surveying students about their skills. Another aim was to work on an instrument that was comprehensive enough to cover all aspects of the 21-CSs framework introduced above. There have been various attempts to measure the advanced skills required in the modern era (e.g., CRESST, Key Stages 3 ICT Literary Assessment, NAEP; Ongardwanich, Kanjanawasee, & Tuipae, 2015; Soh, Osman, & Arsad, 2012).

Although some of these were either subject specific or focus only a few of several dimension of 21-CSs (Greiff & Kyllonen, 2016; Griffin & Care, 2015), only few of them have developed an instrument that was close to what we wanted to accomplish (e.g., Ongardwanich, Kanjanawasee, & Tuipae, 2015; Soh, Osman, & Arsad, 2012). The advantage of the current 21CSI instrument is that we accomplished to measure 11 research-recommended 21st century skills all at once.

Limitations and Future Research

One of the limitations of this research is about its sample size. The sample size we had was not enough to measure five factor CFA model. Future study with bigger sample size might have better fit of the 5-factor CFA model, then factor relationships can be examined. Another limitation and improvement area would be about its language. Although we consulted with a linguistic expert about its language and length, the language of the instrument may need more attention to simplify its language.

Future steps may include translation or trans-adaptation of this instrument to native languages of students from an international audience since 21-CSs are considered

universal. Future studies may also include to explore predictive value of this measure on students' future career choices. Cross validation of this instrument with other methods of measuring these skills is also needed.

Implications

This instrument may help both researchers and practitioners. Researchers may use this to extend and expand research efforts in investigating students' 21-CSs and factors affecting these skills. Particularly interesting area of investigation would be linking 21-CSs to academic achievement such as

mathematics performance or science performance. Longitudinal studies would be also interesting to see how 21-CSs help students succeed in college and in life after college. 21CSI may also help schools and schools district to ensure that all students receive the most empowering forms of learning that can get them to be college-ready. Higher education may also benefit from this form of investigative lenses onto whether their students have the skills needed to find a good job and succeed in life after-college (Association of American Colleges and Universities, 2007).

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APPENDIX

21st Century Skills Instrument (21CSI)

43 items

Please state your level of confidence in performing/fulfilling the following tasks.

(1=Not confident at all, 3=Somewhat confident, 5=Confident, 7=Very confident)

A. Learning and Innovation Skills (19)

1. Creativity and Innovation

- 1.1. Developing new and innovative ideas.

- 1.2. Responding to new and diverse perspectives.
 - 1.3. Working on information from a variety of perspectives when developing ideas.
 - 2. Critical Thinking and Problem Solving**
 - 2.1. Reasoning effectively in making complex decisions.
 - 2.2. Asking relevant questions during the problem-solving process.
 - 2.3. Solving complex problems.
 - 2.4. Analyzing and evaluating alternative points of view.
 - 2.5. Providing feedback on decisions and processes.
 - 3. Communication**
 - 3.1. Articulating thoughts and ideas using written communication skills.
 - 3.2. Articulating thoughts and ideas orally and nonverbally (e.g., gestures) in a **SMALL** group environment.
 - 3.3. Articulating thoughts and ideas orally and nonverbally (e.g., gestures) in a **LARGE** group environment.
 - 3.4. Listening effectively to interpret meaning.
 - 4. Initiative and Self-Direction**
 - 4.1. Going beyond basic mastery skills to gain new expertise.
 - 4.2. Going beyond basic curricula to expand my own learning.
 - 4.3. Defining and prioritizing tasks without direct oversight.
 - 4.4. Completing tasks without any supervision.
 - 5. Leadership and Responsibility**
 - 5.1. Working with the interest of the larger community in mind.
 - 5.2. Inspiring others by example.
 - 5.3. Capitalizing on the strengths of others to achieve a common goal.
- B. Life and Career Skills-a (3)**
- 1. Flexibility and Adaptability**
 - 1.1. Assuming and fitting in different roles, schedules, and contexts.
 - 1.2. Performing tasks successfully without praises or other external rewards.
 - 1.3. Dealing positively with setbacks and criticism.

C. Life and Career Skills-b (7)**2. Social and Cross-Cultural Skills**

- 1.1. Understanding and embracing cultural and social differences.
- 1.2. Conducting myself in a respectful and professional manner.

3. Collaboration

- 2.1. Working effectively and respectfully with people from diverse backgrounds.
- 2.2. Including others' perspectives when making decisions.
- 2.3. Assuming shared responsibility for collaborative work.
- 2.4. Valuing individual contributions (of others) for collaborative work.

4. Global Awareness

- 3.1. Understanding the thinking of people from different backgrounds (e.g., cultures, religions, ideologies, and life styles).

D. Interdisciplinary Themes (7)**1. Civic Literacy**

- 1.1. Making sense of governmental processes locally or globally.
- 1.2. Understanding the local or global implications of civic decisions.
- 1.3. Participating in civic life (e.g., by influencing decision-making).

2. Environmental Literacy

- 2.1. Understanding complex environmental issues.
- 2.2. Evaluating proposed environmental plans.
- 2.3. Assessing the risks of proposed environmental plans.
- 2.4. Understanding how individual decisions affect the environment at local or global scales.

E. Information, Media, and Technology Skills (7)

- 1.1. Understanding ethical issues surrounding the production of information on the media.
- 1.2. Using various media forms.

- 1.3. Critiquing the inclusion or exclusion of opinions or factual information on the media.
- 1.4. Effectively creating and delivering media products.
- 1.5. Recognizing when and to what extent information is needed.
- 1.6. Evaluating and use the needed information effectively.
- 1.7. Effectively utilizing technology in variety of ways as they relate to life (e.g., web tools, games, and software).

Author name: Alpaslan Sahin, Ph.D.

University, Country: Harmony Public Schools, US

Email sahin.alpaslan38@gmail.com

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