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21st-century digital skills instrument aimed at working professionals: Conceptual development and empirical validation

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ABSTRACT

Employees with high levels of 21st-century digital skills are beneficial for organizations characterized by rapid technological changes and complex knowledge bases. Although a number of instruments have been used to measure digital skills, they do not consider the broad range of 21st-century skills. Additionally, available measures are limited by their use of agreement scales and by their primary focus on students or citizens. This study aims to overcome these limitations by developing a set of reliable measures that focuses on the frequency of activities performed by working professionals to assess each core 21st-century digital skill. To this end, we conducted cognitive interviews, a survey pilot, and a full survey among a large sample of professionals working within the creative industries. The result is a theoretical, empirically validated instrument that measures six types of 21st-century digital skills: information, communication, collaboration, critical-thinking, creativity, and problem-solving skills.

1. Introduction

The industrial economy based on manufacturing has shifted to a service economy driven by information, knowledge, and creativity. Fundamental economic changes have reshaped workplaces and the nature of work (Soulé and Warrick, 2015). Technology has supported these changes, which include flatter management structures, task teams, and cross-organizational networking. Since employees' skills drive organizations' competitiveness and innovation capacity (Anderson, 2008), the rapid integration of new information communication technologies (ICTs) results in continuously evolving digital skills necessary for employment and participation in society. In an age where ICTs predominate, people need the capabilities to thrive in and beyond education (Littlejohn et al., 2012). The current workplace requires employees who can find, process and structure information; who can solve problems; who are creative innovators and who exhibit effective communication and cooperation abilities (Boyaci and Atalay, 2016). The initial approach to defining digital skills is shifting from a restricted technical orientation toward a wider perspective that considers the so-called content-related or higher-order skills (Claro et al., 2012). Students and workers are expected to possess these skills as they are considered key to workplace performance (Leahy and Dolan, 2010). In this study, we are interested in digital skills in the broader context posed by 21st-century skills that bring together ICT and content-related skills. Van Laar et al. (2017) conducted a systematic literature review to synthesize the relevant academic literature concerned with 21st-century digital skills. This review resulted in a comprehensive framework based on seven core skills: technical, information management, communication, collaboration, creativity, critical thinking, and problem solving. The current contribution focuses on the development of an instrument measuring these 21st century digital skills. All skills are fundamental for performing the necessary tasks in a broad range of occupations. Previous research

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shows that managers neither have skill requirements top of mind nor have a clear understanding of the role skill development plays in organizational management practices (Van Deursen and Van Dijk, 2014). However, measuring the level of employees' 21st-century digital skills is beneficial for organizations characterized by rapid technological changes and complex knowledge (Kamprath and Mietzner, 2015).

Conceptually, the instruments available are limited by conceptual ambiguity because various labels are used for the same skills, or the labels do not correspond to the skills being measured. Because of this ambiguity, technical abilities are often emphasized as opposed to the integration of the digital component in the whole range of 21st-century skills. On a methodological level, an important challenge is the use of self-reports that easily lead to individuals overrating their level of skills (e.g., Hargittai, 2005; Merritt et al., 2005; Talja, 2005). Furthermore, research tends to focus on citizens or students instead of on the skills required for working professionals (Van Laar et al., 2017). This study aims to overcome these limitations by developing a set of reliable measures that focus on the frequency of activities that working professionals perform to assess each core 21st-century digital skill. The following research question will be addressed:

Which set comprises the reliable measures for assessing the level of core 21st-century digital skills (information, communication, collaboration, critical thinking, creativity, and problem solving) among working professionals?

To answer this question, we reviewed the literature about existing skill measures, used as an input to develop an initial instrument. This instrument was improved following a three-fold approach: (1) cognitive interviews, (2) a pilot survey, and (3) a full survey. This approach is necessary to refine and test the validity of the latent skill constructs and corresponding items.

2. Initial instrument development

A plethora of concepts and frameworks are used to describe what is needed to benefit from digital tools and media. Consequently, research directions define it in various ways. Digital divide research, for example, has centred on the acquisition of the necessary digital skills for the general population to function well in an increasingly digital environment (e.g., Hargittai, 2010; Helsper and Eynon, 2013; Van Deursen and Van Dijk, 2010). Prominent in the new media literacy research is the assessment of critical media consumption and responsible media production, especially among youth (e.g., Buckingham 2007; Jenkins et al., 2006; Livingstone, 2004). Furthermore, a growing field of research is concerned with the teaching and learning practices to ensure students' mastery of 21st-century skills in the classroom as preparation for working life (e.g., Binkley et al., 2012, Dede, 2010; Siddiq et al., 2016). These research directions have in common that they acknowledge that both basic skills necessary to use digital tools and skills required to comprehend and use online content should be accounted for. However, existing instruments do not capture the full range of digital skills necessary. The most important reason for the lack of skill tests might be that the literature concerning these skills is not consistent in the terms used and in the underlying concepts applied (Van Deursen and Van Dijk, 2010). Moreover, research often seems technical-oriented toward present digital technologies, such as IT literacy, ICT literacy or computer literacy.

Recently, Van Laar and colleagues (2017) conducted a systematic literature review to synthesize relevant academic literature concerned with 21st-century digital skills. They concluded that 21st-century skills emphasize a broad spectrum of skills, yet do not integrate the digital aspect. Digital skills, on the other hand, often do not cover the broad spectrum of skills posed by 21st century skills. Besides, 21st-century skills refer to an extensive list of skills on conceptual level while digital skills often refer to a limited number of skills on operational level. Our goal is to develop an instrument of data collection for 21st-century digital skills that will adequately measure and reflect each skill's operational components. To accomplish this aim, we combined items from various existing scales and, in certain cases, added new items that are useful in the digital context. To develop the initial instrument, we elaborated on the framework of Van Laar et al.(2017) who provided conceptual definitions and key components for each 21st-century digital skill based on academic literature. See Table 1. In this study, we focus on the following core 21st-century skills: information, communication, collaboration, critical thinking, creativity, and problem solving. Since few studies have been conducted to date to add the digital component to 21st-century skills, we also used the offline 21st century skill measures found in the literature as a point of departure. We added a digital aspect to the skill items by, for example, mentioning the use of internet applications. The internet was explained as e-mail, web applications (e.g., Skype), and social media (e.g., Facebook, Twitter, and LinkedIn). Each item measured the frequency of various activities that are related to the 21st-century digital skills definition. A direct behavioral indicator of skills. The respondents were asked to respond to the statements using a five-point Likert scale: (1) never, (2) rarely, (3) sometimes, (4) often, and (5) (almost) always.

2.1. Information management

Information management refers to the use of ICT to search, select, and organize information to make informed decisions about the most suitable information source for a given task. Key components include the ability to (1) define search terms, (2) access information from a variety of sources, (3) evaluate the reliability and usefulness of retrieved information, and (4) manage information to find it later. In total, 14 items were used to measure define, access, and evaluate (Van Deursen and Van Dijk, 2009). To measure the manage part of information management, we adapted three items from Majid et al. (2010) and three from Hwang et al. (2015), and we added one item ourselves.

Table 1
Framework with core 21st-century digital skills adopted from Van Laar et al. (2017).

21st-century digital skills dimensions	Conceptual definition with operational components
Technical	The skills to use (mobile) devices and applications to accomplish practical tasks and recognize specific online environments to navigate and maintain orientation. Key components: ICT knowledge, ICT usage, navigation
Information management	The skills to use ICT to efficiently search, select, organize information to make informed decisions about the most suitable sources of information for a given task. Key components: define, access, evaluate, manage
Communication	The skills to use ICT to transmit information to others, ensuring that the meaning is expressed effectively. Key components: transmitting information
Collaboration	The skills to use ICT to develop a social network and work in a team to exchange information, negotiate agreements, and make decisions with mutual respect for each other towards achieving a common goal. Key components: interactive communication, participation in discussions
Creativity	The skills to use ICT to generate new or previously unknown ideas, or treat familiar ideas in a new way and transform such ideas into a product, service or process that is recognized as novel within a particular domain. Key components: content creation
Critical thinking	The skills to use ICT to make informed judgements and choices about obtained information and communication using reflective reasoning and sufficient evidence to support the claims. Key components: clarification, assessment, justification, linking ideas, novelty
Problem solving	The skills to use ICT to cognitively process and understand a problem situation in combination with the active use of knowledge to find a solution to a problem. Key components: knowledge acquisition, knowledge application

2.2. Communication

Communication is about using ICT to transmit information to others, ensuring that the meaning is expressed effectively. This study focuses on transmitting information in broad terms: (1) appropriateness, (2) expressiveness, (3) online profiling, and (4) online networking. Appropriateness concerns having knowledge about the online medium for your message to make it suitable for the situation. Expressiveness concerns coming across clearly to make sure your behavior indicates the intended feelings or thoughts. Four items for appropriateness were derived from Schulze et al. (2017) and one item came from Wrench (2004). To measure expressiveness, we adapted five items from Bakke (2010).To measure online profiling, we used the social media exploitation levels of Sigala and Chalkiti (2015) as inspiration. In total, sixteen items were considered such as updating your personal profile, sharing information for discussions, and identifying experts in your field. As a result, positive reactions, recommendations, and new collaborations might emerge. Finally, online networking refers to an individual's ability to make connections for instrumental or expressive return (Lee and Chen, 2017). Online networking skills were adapted from three items from Lee and Chen (2017) and one item from Burleson and Samter (1990), and we added three items. In addition, we added eight items regarding using your online network to generate new business, increase brand awareness or achieve policy goals.

2.3. Collaboration

Collaboration concerns using ICT to develop a social network and work in teams to exchange information, negotiate agreements, and make decisions with mutual respect for each other toward achieving a common goal. Components are limited to interaction and sharing ideas. This study extends these components to (1) responsibilities, (2) planning, (3) interdependence, and (4) knowledge sharing. Responsibilities concern understanding your own and your collaborating partners' roles to support and complement the team. To create measures for responsibilities, we adapted four items from Archibald et al. (2014), and we added one item ourselves. Planning concerns monitoring team progress to accomplish tasks on time. The planning component was developed by adapting six items from Chiocchio et al. (2012) and one item from Van de Oudeweetering and Voogt (2017). Interdependence refers to reliance on interactions among professionals who are all dependent on the others to accomplish their tasks (Bronstein, 2003). To measure interdependence, we adapted four items from Bronstein (2003), and we added one item ourselves. Knowledge sharing refers to exchanging information to help team members perform tasks. To measure knowledge sharing, we adapted five items from Chiocchio et al. (2012).

2.4. Critical thinking

Critical thinking is defined as using ICT to make informed judgments and choices regarding obtained information and communication using reflective reasoning and sufficient evidence to support claims. Key components are the abilities to (1) clarify the subject, (2) assess the suitability of a source, (3) invoke arguments for claims, and (4) link and suggest new ideas for discussion. Clarification and assessment items were developed from six items from Sosu (2013) about critical openness and reflection. Critical openness reflects the tendency to be actively open to new ideas, to be critical in evaluating these ideas and to modify one's thinking in light of convincing evidence. Reflective skepticism conveys the tendency to learn from past experiences and question evidence. Justification was adapted from two items from the scoring criteria of Newman et al. (1995) and one item from Van de Oudeweetering

and Voogt (2017). Novelty was based on three items from Newman et al. (1995).

2.5. Creativity

Creativity is defined as using ICT to generate new or previously unknown ideas or to treat familiar ideas in a new way and transform such ideas into a product, service or process that is recognized as novel within a particular domain. This study elaborates on the key component content creation. Content creation is the ability to create new content or elaborate on previous content to produce creative expressions (Ferrari, 2013). To measure creativity, several existing scales were used, and we developed two items ourselves. Six items were adapted from Zhou and George (2001) concerning idea generalization and performing tasks creatively. Furthermore, we added two items regarding generating innovative ideas or applications for your field from Carmeli and Schaubroeck (2007), one item about looking for potential work methods from Janssen (2000), and one item about judging an idea's usefulness from Scott and Bruce (1994). Finally, we changed the four scoring criteria (fluency, flexibility, originality, and elaboration) from Torrance (1972) into six items. The items are defined as the abilities to (1) quickly invent multiple options, (2) consider various alternatives, (3) think of innovative ideas, and (4) work out ideas in more detail.

2.6. Problem solving

Problem solving is defined as using ICT to cognitively process and understand a problem situation in combination with the active use of knowledge to find a solution. This study elaborates on the components knowledge acquisition and application. In line with these two components, knowledge must be first be acquired regarding a new problem situation, and subsequently, this novel information must be applied when solving a complex problem (Greiff et al., 2014). Problem-solving skills are required to deal effectively with complex non-routine situations in different domains (Funke et al., 2018). In total, we adapted eight items from the problem-solving confidence scale of Heppner and Petersen (1982) and two from Van de Oudeweetering and Voogt (2017).

2.7. Cognitive interviews

The first step to improve our survey design involved cognitive interviewing. Cognitive interviews are a common method for improving instrument design by assessing respondents' understanding of questionnaire items (Knafl et al., 2007). Cognitive interviews serve an exploratory function by explaining people's responses. Furthermore, cognitive interviews help to identify which items may be possible to omit or represent an incomplete or misleading view (Desimone and Le Floch, 2004). In line with this technique, respondents were encouraged to talk through their thought process as they answered the developed survey questions. In total, nine participants from the authors' network were asked to complete the initial survey and express their thoughts. Respondents received an incentive of 10 Euros for their participation.

The interview results helped us evaluate whether the items proposed measured the skill constructs we intended. We checked whether all respondents understood the question, found the question relevant, and were able to formulate an answer on the provided scales. Items that were perceived as problematic were adjusted or removed. Appendix A displays all skills as adjusted after conducting the cognitive interviews. Based on the interviews, an introductory sentence to distinguish searching information online from managing digital information was included. Moreover, the meaning of meta-data appeared unclear and was specified. Finally, the item 'do you have difficulties assessing whether you have sufficient information to complete your task' was removed because it is context specific. For communication, the item 'do you up-date your online profile' was removed because it could be seen as fraudulent when you devote time to that task at work. In addition, the item 'do you update your online work portfolio' was altered to 'do you update your online work portfolio when your work situation changes' because it only makes sense to update your work portfolio when you have something relevant to add. For critical thinking, an introductory sentence was included to explain that the next statements were about online discussions. As a result, the reduced number of words per item may eliminate redundancy. For problem solving, we removed the item 'does the internet help you analyze unknown situations' because it appeared too abstract. Moreover, the item 'do you solve problems using the internet by investing sufficient time and energy' was altered because the amount of time you invest in problem solving depends on the problem's complexity. Overall, participants made suggestions to specify words, shorten items, undo the reverse-coding, and randomize items.

3. Pilot survey results

To further improve our survey, we conducted an online pilot survey among professionals working within the creative industries. The small-scale pilot survey was used to identify the problematic items and to improve the content coverage of the constructs. Potential respondents from our own network were approached via e-mail. The pilot was completed by 58 respondents from the population of interest in October 2017, sufficient for a pilot study where the purpose is preliminary survey or scale development (Johanson and Brooks, 2010). Respondents received an incentive of 10 Euros for their participation.

Respondents represented the following branches: (1) visual art/photography, (2) performing arts, (3) museums, (4) radio/television, (5) film, (6) books/magazines, (7) journalism, (8) publishing/media, (9) fashion/textile, (10) architecture, (11) industrial design, (12) graphic design, (13) advertising/marketing, (14) games, and (15) new media/software. The division of branches is based on a mapping document of the creative industries in the Netherlands (Raes and Hofstede, 2005).

3.1. Exploratory factor analysis (EFA)

We used exploratory factor analysis in SPSS (IBM Statistics) for each 21st century digital skill. The aim was to explore the reliability of the constructed skill scales and to identify items that have caused problems. We based the factor solutions on the percentage of variance accounted for by the factors and on the cohesiveness of the items within the identified skill factors. We used varimax rotation because we knew from previous research that internet skills are related. Therefore, we expected ambiguity in positioning some of the items, which might cause them to load on more than one factor. Factor loadings of 0.30 were considered significant for inclusion in a factor. Item loadings above 0.30 are acceptable in an exploratory factor analysis (Costello and Osborne, 2005). For most skills, the operational components as identified in the literature were reflected in the fixed number of factors extracted. For creativity and problem solving, the factor solutions were based on the number of factors with eigenvalues that exceeded 1.0. The key operational components often resulted in separate constructs and, therefore, items were added if less than five items loaded together on one factor. A factor with fewer than three items is generally weak and unstable; five items or more strongly loading items are desirable and indicate a solid factor (Costello and Osborne, 2005). Furthermore, the EFA results show that the negatively formulated items often turned out to be outliers and were therefore adjusted or removed. Appendix B displays the items as adjusted after pilot testing.

3.1.1. Information management

For information management, four items loaded together and represented define and access. For the full test, we added an item from Van Deursen and Van Dijk (2009). For evaluate, six items clustered together. The items ‘look further than the top three results’ and ‘estimate the future value of information before you save it’ did not appear to load on access or manage but on evaluate. After carefully considering the content, we decided that it is appropriate to label them as evaluate. To manage, we identified three items that loaded together, and therefore, one item from Majid et al. (2010) and one item from us was added.

3.1.2. Communication

For communication, appropriateness and expressiveness were combined, and we identified seven items that loaded together. The item ‘do you not know what behavior is appropriate in a particular situation on the internet’ was adjusted. We removed the reverse-coding because it seems reasonable to assume that this is the reason for being an outlier. Online profiling resulted in two factors, content sharing and contact building, with five items each loading together. The item ‘do you find internet contacts who can inform you about your field’ from networking was added to contact building. For content sharing, we altered ‘does someone else share a message you posted’ to ‘do you share a message from someone else on internet’. In addition, we altered ‘receiving feedback’ into ‘giving feedback’. Networking resulted in ten items. The item ‘do you respond to online messages from your network’ from online profiling loaded on networking but was removed based on its content.

3.1.3. Collaboration

For collaboration, responsibilities resulted in four items. The item ‘use the internet to discuss strategies to achieve a common goal’ from planning was added to responsibilities. Although this was not in line with our expectations, we decided that its content corresponds to the factor. Furthermore, we added one item in line with the items loaded together. Planning resulted in three items. Two items loaded on multiple factors, and therefore, we specified them toward planning. For interdependence, four items clustered together. We added one item from Bronstein (2003). Knowledge sharing resulted in four items. The item ‘do you have difficulties sharing work-related knowledge with each other via the internet’ was added after removing the reverse-coding.

3.1.4. Critical thinking

For critical thinking, six items clustered together on the factor labelled reflection. Two items loaded on justification. The item ‘do you consider various arguments and opinions’ loaded on both reflection and justification and, therefore, we altered this item to justification. Furthermore, two items loaded on novelty. As a result, we added two items to justification and three items to novelty from Newman et al. (1995).

3.1.5. Creativity

For creativity, eleven items clustered together. To improve the quality, ‘do you use the internet to become a creative role model’ was altered into ‘do you present yourself as a creative role model on the internet’. Furthermore, the item ‘do you search out new work procedures or techniques via the internet’ was adapted from Janssen (2000).

3.1.6. Problem solving

All items clustered together on problem solving. To finalize the scale, the item ‘do you find the solution via the internet even though initially no solution is immediately apparent’ was added (Heppner and Petersen, 1982).

4. Full survey results

4.1. Sample and procedure

The final step in instrument development was to conduct a full online survey among professionals working within creative

Table 2
Sample characteristics.

	N	%
Gender		
Male	507	55.9
Female	400	44.1
Age		
18–30	289	31.9
31–45	344	37.9
46–60	221	24.4
60+	52	5.7
Missing	1	0.1
Education		
Medium	183	20.2
High	724	79.8
Branch organization		
Advertising/marketing	110	12.1
New media/software	93	10.3
Radio/television	86	9.5
Performing art	76	8.4
Architecture	74	8.2
Graphic design	68	7.5
Museum	57	6.3
Gaming	55	6.1
Industrial design	50	5.5
Visual art/photography	47	5.2
Journalism	46	5.1
Publishing/media	46	5.1
Film	43	4.7
Fashion/textile design	34	3.7
Books/magazines	22	2.4
Function level		
Junior	139	15.3
Mid-Level	288	31.8
Senior	480	52.9

industries in the Netherlands. The data was collected from October to December 2017. The sample included people who are directly involved in the creative work process (e.g., designers, engineers and project managers). To obtain a sample of the creative industries in the Netherlands, we used two online panels. The panels used screenings questions to ensure respondents were working within creative industries. Members received a small incentive for their participation. Additionally, we approached respondents by sending them an e-mail invitation. The potential respondents were screened using LinkedIn or the company's website. Respondents received an incentive of 10 Euros if they completed the online survey. The final sample contains 907 completed surveys. See Table 2.

4.2. Confirmatory factor analysis (CFA)

CFA was used to test the model fit of the factor structures found with the EFA. Goodness of fit can be determined with the following indices (Byrne, 2010): chi-square test (χ^2), root-mean-square errors of approximation (RMSEA $\leq$ 0.05), the comparative fit index (CFI $\geq$ 0.90), and the Tucker–Lewis index (TLI $\geq$ 0.90). The initial model based on the previous step did not result in a fitted model. The model was tailored in an iterative process. To obtain model fit as well as sufficient discriminant and convergent validity, we needed to merge the separate skill components under collaboration and those under critical thinking. Furthermore, we needed to remove the definition and access components of information management. The final model including all factor structures has a good fit: $\chi^2(1665) = 3922.18$, $\chi 2/df = 2.36$; RMSEA = 0.036; CFI = 0.93; TLI = 0.93.

4.3. Scale characteristics

To test whether the scales that resulted from the CFA show high reliability and good fit, we conducted a reliability analysis. All scales have good to high alpha values, ranging from 0.72 to 0.94. See Table 3. Furthermore, information management obtained the highest mean score (M = 4.11, SD = 0.75). Only communication sharing (M = 2.63, SD = 0.88) and communication building (M = 2.86, SD = 0.88) scored below 3.

4.4. Convergent and discriminant validity

To understand whether the factors show convergent and discriminant validity, Composite Reliability (CR), Average Variance Extracted (AVE), and Maximum Shared Variance (MSV) were performed (Gaskin, 2011). CR and AVE are used to assess the reliability

Table 3
Scale characteristics.

Skills scale	Mean	SD	Variance	α
Information evaluation	3.68	0.72	0.51	0.72
Information management	4.11	0.75	0.56	0.74
Communication expressiveness	3.86	0.60	0.36	0.80
Communication sharing	2.63	0.88	0.77	0.77
Communication building	2.86	0.88	0.77	0.83
Communication networking	3.05	0.81	0.66	0.92
Collaboration	3.39	0.76	0.58	0.94
Critical thinking	3.44	0.66	0.44	0.94
Creativity	3.33	0.71	0.50	0.88
Problem solving	3.53	0.60	0.37	0.92

of the constructs. The acceptance value of CR is 0.70 (Hair et al., 1998) and it is found that all constructs have a high degree of internal consistency. Another reliability measure, AVE, reflects the overall amount of variance in the items accounted for by the latent construct. According to Fornell and Larcker (1981), an acceptable level of AVE is 0.50 or above for a construct. The constructs demonstrate sufficient convergent validity, except for information evaluation. In this instance, the AVE is below 0.50. To demonstrate the discriminant validity of the constructs, AVE for each construct should be greater than the level of MSV. Table 4 shows that all of the constructs demonstrate sufficient discriminant validity.

4.5. Proposed 21st-century digital skills instrument

The final instrument with the estimate values per skill is displayed in Table 5. Items that were removed are marked with an asterisk in Appendix B.

5. Discussion

5.1. Main findings

Work environments are increasingly knowledge driven and technology-rich, work problems are becoming more complex, and people often work in multidisciplinary teams (Griffin et al., 2012; Littlejohn et al., 2012). Just a few examples of developments in the labour markets that have been changing the skill demands of many jobs. This study proposes a thoroughly tested instrument for measuring 21st-century digital skills. 21st-Century skills generally refer to a wider range of competences on conceptual level (Griffin et al., 2012), whereas ICT related skills are often described as a separate skill within these frameworks. To the contrary, studies that attempt to measure digital skills often fail to cover the wider range of skills proposed by 21st-century skills frameworks. Only a few approaches provide an integration of digital and 21st-century skills. As these integrated 21st century digital skills can be considered the key to employment opportunities and innovation, the proposed instrument is a valuable contribution to existing (digital) skill measurements.

Based on a critical evaluation of existing instruments, a set of measures for information, communication, collaboration, critical-thinking, creativity, and problem-solving 21st-century digital skills was developed. We aimed to avoid common response formats such as self-evaluation (how good are you at) or agreement (how much do you agree) scales. In most existing skill measurements, people are presented with a list of skills and are asked to evaluate how well they perform those skills. Measurements typically gather data based on people's own perceptions or estimations of their digital skills (Kuhlemeier and Hemker, 2007). Self-report survey data has significant validity problems (Hargittai, 2005; Merritt et al., 2005; Talja, 2005). Merritt et al. (2005), for example, checked the validity of self-reports concerning computer skills and found that these were rated higher than actual skills. Interpretations of skills

Table 4
Convergent and discriminant validity.

Scale	CR	AVE	MSV
Information evaluation	0.72	0.46	0.10
Information management	0.75	0.50	0.04
Communication expressiveness	0.80	0.57	0.19
Communication sharing	0.78	0.53	0.43
Communication building	0.84	0.63	0.57
Communication networking	0.92	0.60	0.57
Collaboration	0.94	0.58	0.16
Critical thinking	0.94	0.55	0.16
Creativity	0.89	0.56	0.27
Problem solving	0.89	0.59	0.19

Table 5
Proposed items to measure 21st-century digital skills (factor loadings in between brackets).

Skill	Item	M	SD
	At work, how often…		
Information management	Do you save useful digital files directly to the right folder (0.751)	4.24	0.80
	Are you consistent in the naming of digital files (0.709)	4.03	0.93
	Do you organize digital files via a hierarchical folder structure (0.666)	4.08	1.02
Information evaluation	Do you check the reliability of a website (0.725)	3.59	0.98
	Do you check the information found on a different website (0.676)	3.49	0.89
	Do you check if the information found is up to date (0.639)	3.95	0.82
Communication expressiveness	Do you get what you want from interactions on the internet (0.775)	3.74	0.72
	Are you via the internet effective in accomplishing what you want (0.757)	3.90	0.71
	Do you know how to use the internet to express ideas clearly (0.729)	3.94	0.71
Communication sharing	Do you post new messages on the internet (0.774)	3.11	1.04
	Do you post a blog/article on the internet (0.720)	2.30	1.09
	Do you share information on the internet to start a discussion (0.697)	2.49	1.04
Communication building	Do new collaborations emerge by approaching online contacts (0.845)	2.82	0.97
	Do you establish online contacts to collaborate with (0.837)	3.06	1.02
	Do you find experts on the internet to start a project with (0.695)	2.71	1.04
Communication networking	Do you spend time and effort in online networking with people from your field (0.860)	3.05	1.01
	Do you use your online network to benefit from it (0.848)	3.09	1.00
	Do you use your online network to generate business (0.813)	2.90	1.08
	Do you build online relationships with people from your field (0.784)	3.29	0.95
	Does the internet help you approach new professional contacts (0.757)	3.32	0.88
	Do you use your online network to increase brand awareness (0.757)	3.16	1.10
	Do you start a conversation with other professionals via the internet (0.738)	2.85	1.05
	Do you use your online network to achieve policy goals (0.632)	2.77	0.99
Collaboration	Do you share important information with your team via the internet (0.832)	3.64	0.95
	Do you use the internet to share information that supports the work of others (0.826)	3.49	0.96
	Do you use the internet to share resources that help the team perform tasks (0.823)	3.44	0.99
	Do you use the internet to provide each other with information that progresses work (0.817)	3.65	0.95
	Does the internet help you get support from co-workers (0.802)	3.30	0.94
	Do you communicate via the internet with co-workers from other disciplines (0.738)	3.47	0.96
	Do you share work-related knowledge with each other via the internet (0.736)	3.45	0.91
	Do you use the internet to give feedback to co-workers (0.723)	3.19	1.06
	Does the internet help you carry out tasks according to the planning (0.714)	3.41	1.07
	Do you use the internet to discuss your role and contributions with team members (0.692)	3.02	1.08
	Does the internet help you use other professionals' expertise (0.605)	3.26	0.86
Critical thinking	Do you give substantiated arguments or reasoning (0.785)	3.63	0.90
	Do you give proof or examples of arguments you give (0.785)	3.37	0.87
	Do you give a justification for your point of view (0.777)	3.50	0.89
	Are you able to put the discussion into a new perspective (0.765)	3.29	0.84
	Do you ask questions to understand other people's viewpoint (0.756)	3.56	0.93
	Do you consider various arguments to formulate your own point of view (0.756)	3.60	0.83
	Do you connect viewpoints to give a new turn to the discussion (0.754)	3.29	0.88
	Do you suggest new related points (0.748)	3.20	0.86
	Do you filter the most important points from discussions (0.733)	3.64	0.87
	Do you generate new input from a discussion (0.708)	3.32	0.81
	Are you open for ideas that challenge some of your held beliefs (0.681)	3.59	0.84
	Do you use the internet to justify your choices (0.634)	3.30	0.86
Creativity	Do you give a creative turn to existing processes using the internet (0.849)	3.20	0.87
	Do you use the internet to generate innovative ideas for your field (0.814)	3.38	0.87
	Do you show originality in your work using the internet (0.772)	3.24	0.93
	Do you use the internet to execute your tasks creatively (0.704)	3.40	0.85
	Do you follow trends on the internet to generate original ideas (0.679)	3.51	0.90
	Do you use the internet to evaluate the usability of your ideas (0.670)	3.22	0.92
Problem solving	Does the internet help you find the best way to solve the problem (0.817)	3.58	0.73
	Do you solve the problem using the internet (0.811)	3.48	0.81
	Do you come up with solutions to the problem via the internet (0.800)	3.59	0.77
	Does the internet help you find ways to solve problems (0.792)	3.74	0.72
	Are you confronted with a problem that you are sure you can solve using the internet (0.767)	3.40	0.82
	Do you make a decision using the internet that makes you feel happy afterwards (0.765)	3.57	0.73
	Do you find the solution via the internet even though initially no solution is immediately apparent (0.706)	3.32	0.76
	Does the actual outcome you achieved via the internet match what you expected (0.676)	3.57	0.70

*The items were asked in Dutch on a 5-point Likert scale: 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = (almost) always.

not only are perspective and context dependent but also depend upon with whom they compare themselves (Talja, 2005). As such, we used frequency scales (how often), ranging from 'never' to '(almost) always', instead of agreement scales to account for respondents' behavior. Findings from previous research show that some of the created frequency items are better suited as a proxy for actual digital skills measures than agreement scales (Van Deursen et al., 2012). Therefore, the items of our instrument measured the frequency of various skill-related activities that are related to the 21st-century skills definition.

To test the validity and reliability of our instrument, we used a three-fold approach. First, cognitive interviews were conducted to improve the clarity of the proposed skill items. Second, a pilot survey was conducted to explore the factor structure. Finally, a full survey was conducted to measure the consistency of the skill factors in a sample of professionals working within the creative industries. Our main contribution is that we developed a set of reliable measures for assessing 21st-century digital skills among working professionals, presented in Table 5.

5.2. Limitations and future studies

We used creative industries to validate our instrument. Creative industries are major industries in the 21st century, a time in which knowledge generation through creativity and innovation is emphasized (Florida, 2002). Future studies may test whether the instrument also applies to other industries. Creative industries is a highly educated sector which may clarify the high mean values. Similar studies on other samples would prove useful in comparing and extending our findings. For example, the necessity of particular skills could differ between industries.

The original review of core 21st century digital skills also considered technical skills. In the current contribution, these skills were not included because creative industries are at the forefront of adopting and applying new technological devices (Müller et al., 2009). More specifically, this study only sampled people who are directly involved in the creative work process. Supporting staff such as office managers, financial leads, and interns were not included. The focus is on content-related or higher-order skills since these are considered the most important. Nevertheless, for other industries such as manufacturing or retail, exploring the level of basic digital skills could be valuable. Future studies could easily measure basic digital skills by using available instruments. For example, Van Deursen and Van Dijk (2009) provide examples of basic operational skills. Additionally, contextual skills, such as ethical or cultural awareness, were not considered but do require research attention. Because of the number of skills, we had to make a choice; therefore, we focused on the core skills considered fundamental for performing necessary tasks at work.

The disadvantage of frequency scales is that you ask respondents whether they have engaged in an activity. The answer scales are commonly used in empirical research on Internet uses (Van Deursen et al., 2016). Here, we aim to overcome this limitation by including in each item a skill component within these activities. Items related to specific platforms or activities were avoided. In our instrument, for example, we did not ask respondents "how often do you use Photoshop?" using a frequency scale ranging from 1 'never' to 6 'several times per day'. Alternatively, the focus is on the skill component by asking how often 'do you check the reliability of a website' or 'do you get what you want from interactions on the internet'. However, ideally, the measurement of 21st-century digital skills should provide the possibility to actually use Internet applications. Observational studies or performance tests prove to be very suitable to provide a realistic view of people's digital skills but their cost and time are a strong limitation for large-scale data gathering. Future research is encouraged to develop a performance test for each 21st-century digital skill.

The use of internet applications was mentioned in each skill item to capture the digital aspect. This choice was made because creative industries contain many key branches. A limitation is that the items could be perceived as too general because we do not mention digital programs specific to each branch. However, because we do explain the broader meaning of the internet, the items are applicable to organizations outside creative industries, which is an advantage. With constant changes in ICTs, certain measures may become outdated while others rise in prominence and importance (Hargittai and Hsieh, 2012).

With regards to the final instrument, we needed to remove the define/access components of information management. This result could be caused by the translation of the items. Future research is encouraged to test additional items. Furthermore, information evaluation had low convergent validity; therefore, it should be improved in future studies.

6. Conclusion

We proposed an instrument to measure information, communication, collaboration, critical thinking, creativity, and problem solving 21st-century digital skills, aimed at working professionals. The developed instrument would not only be useful to assess the level of 21st-century digital skills for working professionals but also to measure the impact of the individual labor situation or organizational policies on the level of 21st century digital skills. Measurements are needed to monitor skill levels and to identify the causes of potential skill insufficiencies. 21st-Century digital skills are essential for productive employees, but ways to engage employees to ensure they can acquire these skills are also fundamental.

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Appendix A. Items per skill after the cognitive interviews

Information management

Define

1. …formulate a problem statement before starting a search stream
2. …have difficulties to come up with search terms
3. …combine multiple search terms in one search action
4. …think it is easy to choose appropriate search results (Items 1-4 adapted from Van Deursen and Van Dijk, 2009)

Access

1. …specify the search action to limit the number of search results
2. …change the search terms based on the obtained search results
3. …use Booleans to limit the number of search results (e.g., AND, OR, " ")
4. …look further than the top three search results
5. …does the choice of a search result not yield what you expected (Items 1-5 adapted from Van Deursen and Van Dijk, 2009)

Evaluate

1. …check the information found on a different website
2. …check if the information found is up to date
3. …check the reliability of a website
4. …turn to multiple sources when searching for information (Items 1-4 adapted from Van Deursen and Van Dijk, 2009)

Manage

1. …order digital information for easy retrieval
2. …are you not able to find the digital file with the necessary information
3. …add metadata (extra information) to your digital files (Items 1-3 adapted from Majid et al., 2010)
4. …lose time searching digital information
5. …estimate the future value of information before you save it
6. …remove outdated information (Items 4-6 adapted from Hwang et al., 2015)
7. …save useful digital files directly to the right folder

Communication

Appropriateness

1. …not know what behavior is appropriate in a particular situation on the internet (Adapted from Wrench, 2004)
2. …not share something online because it could hurt others
3. …pay as much attention to the way you type things as to what you type
4. …make a comment on the internet that hurts someone unintentionally
5. …make sure your comments on the internet are appropriate to the situation (Items 2-5 adapted from Schulze et al., 2017)

Expressiveness

1. …know how to use the internet to express ideas clearly
2. …are you via the internet effective in accomplishing what you want
3. …get what you want from interactions on the internet
4. …are your comments on the internet misunderstood
5. …can you easily express your opinion via the internet (Items 1-5 adapted from Bakke, 2010)

Online profiling

1. …share information on the internet to start a discussion
2. …update your online profile when your work situation changes
3. …find experts on the internet to start a project with (Items 1-3 adapted from Sigala and Chalkiti, 2015)
4. …post a new message on the internet
5. …respond to online messages from your network

6. …establish online contacts to collaborate with
7. …post a blog/article on the internet

Online profiling outcomes

1. …are you recommended by others via the internet
2. …receive feedback on a shared blog/article
3. …receive positive comments on your online profile
4. …does someone else share a message you have posted
5. …does a message that you have posted result in an online discussion
6. …are you approached via your online profile
7. …receive positive comments or 'likes'
8. …do new collaborations emerge by approaching online contacts

Networking

1. …have difficulties starting a conversation with other professionals via the internet (Adapted from Burleson and Samter, 1990)
2. …build online relationships with people from your field
3. …use your online network to benefit from it
4. …spend time and effort in online networking with people from your field (Items 2-4 adapted from Lee and Chen, 2017)
5. …does the internet help you approach new professional contacts
6. …use the internet to maintain contacts with people from your field
7. …find the internet contacts who can inform you about your field

At work, how often do you use your online network to…

1. …generate business
2. …gain new ideas
3. …obtain information
4. …gain knowledge
5. …influence opinions
6. …increase brand awareness
7. …stimulate innovation
8. …realize policy goals

Collaboration

Responsibilities

1. …use the internet to determine how other people's skills contribute to yours
2. …use the internet to actively participate in meetings
3. …use the internet to identify the competences of team members
4. …use the internet to share your contributions with the team (Items 1-4 adapted from Archibald et al., 2014)
5. …use the internet to communicate the different roles of team members

Planning

1. …use the internet to discuss strategies to achieve a common goal (Adapted from Van de Oudeweetering and Voogt, 2017)
2. …use the internet to make adjustments to the planning
3. …does the internet help you monitor the progress of the team
4. …does the internet help you carry out your tasks on time
5. …does the internet help you make sure team members complete their tasks on time
6. …use the internet to exchange information about 'who does what'
7. …use the internet to discuss deadlines with each other (Items 2 -7 adapted from Chiocchio et al., 2012)

Interdependence

1. … does the internet help you use other professionals' expertise s
2. …use the internet to give feedback to co-workers
3. …use the internet to support others in their professional role
4. …does the internet help you get support from co-workers (Items 1-4 adapted from Bronstein, 2003)

5. …are you via the internet informed about each other's progress

Knowledge sharing

1. …use the internet to provide each other with information that progresses the work
2. …use the internet to provide each other with information that supports the work of others^^^
3. …use the internet to share resources that help the team to perform tasks
4. …have difficulties sharing work-related knowledge with each other via the internet
5. …share important information with your team via the internet (Items 1-5 adapted from Chiocchio et al., 2012)

Critical thinking

Reflection

1. …filter the most important points from discussions
2. …think it is easier to understand other people's viewpoints via the internet
3. …use the internet to justify your choices
4. …use the internet to learn from other people's experiences
5. …look critically at what you do on the internet
6. …are you open for ideas that challenge some of your held beliefs (Items 1-6 adapted from Sosu, 2013)

Justification

1. …ask questions to understand other people's viewpoint (Adapted fromVan de Oudeweetering and Voogt, 2017)
2. …give substantiated arguments or reasoning
3. …consider the various arguments and opinions (Items 2-3 adapted from Newman et al., 1995)

Novelty

1. …find it difficult to look at the bigger picture
2. …suggest ideas
3. …suggest new related points (Items 1-3 adapted from Newman et al., 1995)

Creativity

1. …are you the first person to come up with an idea
2. …are you the one who quickly thinks about multiple possibilities
3. …consider various alternatives at the same time
4. …get compliments for your original ideas
5. …are you the one who comes up with original ideas
6. …work out ideas in more detail (Items 1-6 adapted from Torrance, 1972)
7. …look on the internet for potential work methods (Adapted from Janssen, 2000)
8. …use the internet to evaluate the usability of your ideas (Adapted from Scott and Bruce, 1994)
9. …use the internet to generate innovative ideas for your field
10. …give a creative turn to existing processes using the internet (Items 9-10 adapted fromCarmeli and Schaubroeck, 2007)
11. …come up with creative ideas via the internet
12. …come up with original solutions to problems using the internet
13. …use the internet to execute your tasks creatively
14. …show originality in your work using the internet
15. …suggest ideas found on the internet to improve existing products/services
16. …use the internet to be a creative role model (Items 11-16 adapted from Zhou and George, 2001)
17. …follow trends on the internet to generate original ideas
18. …use the internet to show your work creatively to others

Problem solving

1. …does the internet help you find ways to solve problems
2. …does the internet help you find the best way to solve the problem (Items 1-2 adapted from Van de Oudeweetering and Voogt, 2017)
3. …becomes the problem quickly clear via the internet
4. …come up with solutions to the problem via the internet

5. …make a decision using the internet that makes you feel happy afterwards
6. …are you sure that you solved the problem via the internet
7. …solve the problem using the internet
8. …does the actual outcome you achieved via the internet matches what you expected
9. …are you confronted with a problem that you are sure you can solve using the internet (Items 3-9 adapted from Heppner and Petersen, 1982)

Appendix B. Items per skill after the pilot test

Information management

Define/access

1. …change the search terms based on the obtained search results* (λ = 0.787)
2. …specify the search action to limit the number of search results* (e.g., date, type) (λ = 0.700)
3. …combine multiple search terms in one search action* (λ = 0.659)
4. …use Booleans to limit the number of search results* (e.g., AND, OR, " ") (λ = 0.314)
5. …think it is easy to come up with appropriate search terms* (Adapted from Van Deursen and Van Dijk, 2009)

Evaluate

1. …check the reliability of a website (λ = 0.732)
2. …check if the information found is up to date (λ = 0.710)
3. …look further than the top three search results* (λ = 0.686)
4. …check the information found at a different website (λ = 0.603)
5. …turn to multiple sources when searching for information* (λ = 0.447)
6. …estimate the future value of information before you save it* (λ = 0.413)

Manage

1. …save digital files directly to the right folder* (λ = 0.756)
2. …add metadata (extra information) to your digital files (λ = 0.727)
3. …order digital files for easy retrieval* (λ = 0.660)
4. …organize digital files via a hierarchical folder structure (Adapted from Majid et al., 2010)
5. …are you consistent in the naming of digital files*

Communication

Appropriateness/expressiveness

1. …make sure your comments on the internet are appropriate to the situation* (λ = 0.652)
2. …make a comment on the internet that hurts someone unintentionally* (λ = 0.630)
3. …know how to use the internet to express ideas clearly (λ = 0.629)
4. …pay as much attention to the way you type things as to what you type* (λ = 0.499)
5. …get what you want from interactions on the internet (λ = 0.484)
6. …are you via the internet effective in accomplishing what you want (λ = 0.478)
7. …know what behavior is appropriate in a particular situation on the internet* (λ = 0.374)

Content sharing

1. …post a blog/article on the internet (λ = 0.743)
2. …give feedback on a shared blog/article* (λ = 0.693)
3. …post a new message on the internet (λ = 0.646)
4. …share information on the internet to start a discussion (λ = 0.531)
5. …share a message from someone else on the internet* (λ = 0.511)

Contact building

1. …find experts on the internet to start a project with (λ = 0.746)
2. …establish online contacts to collaborate with (λ = 0.657)
3. …do new collaborations emerge by approaching online contacts (λ = 0.654)

4. …find the internet contacts who can inform you about your field* (λ = 0.574)
5. …are you approached via your online profile* (λ = 0.565)

Networking

1. …spend time and effort in online networking with people from your field (λ = 0.810)
2. …build online relationships with people from your field (λ = 0.763)
3. …use your online network to increase brand awareness (λ = 0.731)
4. …use the internet to maintain contacts with people from your field* (λ = 0.708)
5. …does the internet help you approach new professional contacts (λ = 0.687)
6. …use your online network to generate business (λ = 0.662)
7. …use your online network to benefit from it (λ = 0.658)
8. …use your online network to influence opinions* (λ = 0.611)
9. …use your online network to achieve policy goals (λ = 0.586)
10. …start a conversation with other professionals via the internet (λ = 0.420)

Collaboration

Responsibilities

1. …use the internet to identify the competences of team members* (λ = 0.836)
2. …use the internet to determine how other people's skills contribute to yours* (λ = 0.824)
3. …use the internet to discuss strategies to achieve a common goal* (λ = 0.654)
4. …use the internet to communicate the different roles of team members* (λ = 0.615)
5. …use the internet to discuss your role and contributions with team members

Planning

1. …does the internet help you monitor the progress of the team* (λ = 0.653)
2. …use the internet to make adjustments to the planning* (λ = 0.572)
3. …does the internet help you make sure team members complete their tasks on time* (λ = 0.516)
4. …does the internet help you carry out tasks according to the planning
5. …use internet to plan who is responsible for what* (Items 4-5 adapted from Chiocchio et al., 2012)

Interdependence

1. …use the internet to give feedback to co-workers (λ = 0.723)
2. … does the internet help you use other professionals' expertise (λ = 0.722)
3. …are you via the internet informed about each other's progress* (λ = 0.685)
4. …does the internet help you get support from co-workers (λ = 0.669)
5. …communicate via the internet with co-workers from other disciplines (Adapted from Bronstein, 2003)

Knowledge sharing

1. …use the internet to provide each other with information that progresses the work (λ = 0.875)
2. …share important information with your team via the internet (λ = 0.851)
3. …use the internet to share resources that help the team to perform tasks (λ = 0.793)
4. …use the internet to share information that supports the work of others (λ = 0.758)
5. …share work-related knowledge with each other via the internet (Adapted from Chiocchio et al., 2012)

Critical thinking

Reflection

1. …use the internet to learn from other people's experiences* (λ = 0.803)
2. …use the internet to justify your choices (λ = 0.769)
3. …filter the most important points from discussions (λ = 0.745)
4. …think it is easier to understand other people's viewpoints via the internet* (λ = 0.618)
5. …are you open for ideas that challenge some of your held beliefs (λ = 0.524)
6. …look critically at what you do on the internet* (λ = 0.411)

Justification

1. …ask questions to understand other people's viewpoint (λ = 0.891)
2. …give substantiated arguments or reasoning (λ = 0.713)
3. …consider various arguments to formulate your own point of view
4. …give proof or examples of arguments you give
5. …give a justification for your point of view (Items 3-5 adapted from Newman et al., 1995)

Novelty

1. …suggest new related points (λ = 0.905)
2. …suggest new ideas* (λ = 0.834)
3. …connect viewpoints to give a new turn to the discussion
4. …generate new input from a discussion
5. …are you able to put the discussion into a new perspective (Items 3-5 adapted from Newman et al., 1995)

Creativity

1. …use the internet to generate innovative ideas for your field (λ = 0.835)
2. …show originality in your work using the internet (λ = 0.813)
3. …follow trends on the internet to generate original ideas (λ = 0.803)
4. …come up with creative ideas via the internet* (λ = 0.774)
5. …use the internet to execute your tasks creatively (λ = 0.751)
6. …give a creative turn to existing processes using the internet (λ = 0.727)
7. …use the internet to show your work creatively to others* (λ = 0.702)
8. …use the internet to evaluate the usability of your ideas (λ = 0.632)
9. …are you the one who quickly thinks about multiple possibilities* (λ = 0.523)
10. …come up with ideas via the internet to improve existing products/services* (λ = 0.319)
11. …present yourself on the internet as a creative role model* (λ = 0.315)
12. …search out new work procedures or techniques via the internet (Adapted from Janssen, 2000)

Problem solving

1. …come up with solutions to the problem via the internet (λ = 0.909)
2. …does the internet help you find the best way to solve the problem (λ = 0.887)
3. …solve the problem using the internet (λ = 0.870)
4. …are you sure that you solved the problem via the internet* (λ = 0.854)
5. …does the internet help you find ways to solve problems (λ = 0.851)
6. …make a decision using the internet that makes you feel happy afterwards (λ = 0.834)
7. …are you confronted with a problem that you are sure you can solve using the internet (λ = 0.812)
8. …becomes the problem quickly clear via the internet* (λ = 0.808)
9. …does the actual outcome you achieved via the internet matches what you expected (λ = 0.632)
10. …find the solution via the internet even though initially no solution is immediately apparent (Adapted from Heppner and Petersen, 1982)

*Items that are excluded based on CFA results of the full survey are marked with an asterisk (*).

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