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Identifying Critical 21st Century Skills for Workplace Success:

A Content Analysis of Job Advertisements

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Joseph Rios is currently an assistant professor at the University of Minnesota, Robert Pugh is now affiliated with Course Hero, and Adam Bacall is no longer employed at the Educational Testing Service. The authors would like to thank Diane Napolitano for her assistance with conceptualizing the data collection procedure, and Lin Zhang for his services as the project manager. Furthermore, we are in gratitude to Bobby Naemi for his assistance in providing expert feedback regarding 21st century skills. In addition, the authors would like to thank Harrison Kell, Diane Napolitano, and Don Powers from the Educational Testing Service for their useful feedback in preparing this manuscript.

Author contribution statement:
The first author conceived of the presented idea. All authors were involved in conceptualizing the data collection process, while the third author wrote the Python code for data extraction. The first three authors conducted data analyses and interpreted the findings. Although the majority of writing was done by the first author, authors two and three contributed to this work. All authors provided feedback on the draft and the first and second authors conducted critical revisions of the article throughout the review process. Final approval of the version to be published was made by all authors.

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Abstract

This paper extends the literature on 21st century learning skills needed for workplace success by providing an empirical examination of employers' direct communication to potential employees via job advertisements. Our descriptive analysis of 142,000 job advertisements provides two contributions. First, this is one of the first papers to empirically rank-order skill demand. In doing so, it is clear that oral and written communication, collaboration, and problem solving skills are in high demand by employers, with particular emphasis on the pairing of oral and written communication. Furthermore, it is apparent that many of the skills suggested in the literature as being critical for workplace success are in very low demand by employers, and some were not found to be mentioned at all (e.g., social responsibility). Second, this paper explicitly examined whether 21st skill demand varied by job characteristics, which was found to be the case with differences being noted for both education level and degree field requirements. Results were replicated with a sample of roughly 120,000 job advertisements collected one year from the initial data collection. Implications for developing educational standards around 21st century skill development are discussed.

Identifying Critical 21st Century Skills for Workplace Success: A Content Analysis of Job Advertisements

Given rapid social, scientific, and technological changes, the U.S. is continuing its shift from an industrial- to information-based economy. As such, in addition to technical and subject-matter expertise, the majority of jobs being created require an increasingly broad skill set to deal with the demands of technological advances and a globalized workforce (Hart Research Associates, 2015; Kirsch, Braun, Yamamoto, & Sum, 2007). Such skills have been called by many names across research and non-research contexts. In this paper, we will refer to them as 21st century skills, which we define as a combination of cognitive (e.g., non-routine problem solving, critical thinking, meta-cognition), interpersonal (i.e., social), and intrapersonal (i.e., emotional, self-regulatory) skills that are malleable (i.e., potentially responsive to intervention) and relatively stable over time in the absence of exogenous forces (e.g., intentional intervention, life events, changes in social roles; Duckworth & Yeager, 2015; Pellegrino & Hilton, 2012). Regardless of the terminology used, prior research has suggested that 21st century skills predict both academic and workplace success (e.g., Almlund, Duckworth, Heckman, & Kautz, 2011). Yet, employers have criticized that recent college graduates lack these skills when entering the workforce (e.g., Goodman, Sands, & Coley, 2015; Hart Research Associates, 2015). Therefore, to promote workforce preparedness and long-term success of the U.S. economy, it is clear that student development of 21st century skills is greatly needed. However, one question remains: what are the vital 21st century skills necessary for workplace success?

Approaches to Identifying Critical 21st Century Skills

There have been several attempts to review and organize frameworks around 21st century skills, drawing from perspectives in psychology, education, and other sub-disciplines within these fields (e.g., Kyllonen, 2012; Markle, Brenneman, Jackson, Burrus, & Robbins, 2013).

However, the existing research is mixed about how to conceptualize 21st century skills and the relative importance or rank-ordering of these skills (Duckworth & Yeager, 2015). This may be largely due to methodological differences in the three approaches to developing 21st century frameworks, which include relying on theorists, using job analysis data, and surveying employers. The theory-driven approach involves incorporating feedback from substantive experts and/or workforce specialists to determine learning outcomes of 21st century skills. However, we have found that theory-driven frameworks differ largely based on who is synthesizing the skills and for which population the skill development is being conceptualized for. As an example, life-long, self-directed learning encompasses the ability to continue developing personal attributes and gaining a deeper understanding of one's own workplace and work roles. Though this skill is commonly referenced among employers (Casner-Lotto & Barrington, 2006; Neubert, Mainert, Kretzschmar, & Greiff, 2015), it is less often highlighted as being of importance in frameworks focused on educational settings populated with children and adolescents in explicitly learning-centered environments. Consequently, when frameworks are developed by theorists, conceptual issues can limit the skills focused on by employers and educators, even within the same broad category of 21st century skills, making it difficult to understand how to value different skills because of the multitude of unique interpretations.

To avoid the limitations associated with purely theory-driven frameworks, researchers have relied on information obtained from job analyses (e.g., Burrus, Jackson, Xi, & Steinberg, 2013). A job analysis is the process of collecting data to understand the skills necessary to perform a particular job. One of the most extensive job analysis databases is the Occupational Information Network (O*NET) developed by the U.S. government to assist students, job seekers, businesses, and workforce development specialists in understanding the skills needed to perform

specific jobs in the current economy. Although an intriguing approach, job analyses are limited because they generally: (a) are based on very small sample sizes, (b) possess a high degree of subjectivity in identifying skills, and (c) are unable to directly observe certain skills.

Additionally, researchers have directly asked employers about the 21st century skills needed for their companies (e.g., Hart Research Associates, 2015). Although this strategy provides more direct communication when compared to theoretical and job analysis approaches, a reliance on survey data may be problematic for two reasons. First, the individual answering the survey may not possess adequate knowledge about the variety of skills required for a wide range of employees within a particular organization as they may not be thoroughly connected to employees on the ground. As an example, survey participants can include CEOs, presidents, and executives, while managers and low-level employees are less often asked what skills they feel are of most importance (e.g., Hart Research Associates, 2015). Second, survey responses largely occur outside of the hiring context, and as such the skills identified within a survey may not be accurate enough in comparison to the specific skills required for actual job positions. Employers responding to a survey in abstract may find it easy to state that ideal candidates must possess communication skills, problem solving skills, creativity, and a host of other skills simultaneously. However, the realities of a specific job position are such that certain skills will be more valued than others in practice.

An Alternative Approach

As existing methods to identifying critical 21st century skills have largely failed to incorporate direct communication between employers and job candidates, an alternative approach is needed. One such approach is conducting a content analysis of online job advertisements, which is advantageous in three ways. First, a job advertisement requires

employers to stipulate, in their own words, the skills that they need from their workers. As these advertisements can often be short in length, employers have limited space to include a comprehensive inventory of skills required for the job, and instead are more likely to mention highly desirable skills that they worry may not be common in the applicant pool (Burning Glass Technologies, 2015). Furthermore, explicitly linking the key desired skills to specific positions represents a more accurate reading of what employers are looking for in applicants across a variety of jobs. Second, by examining a large number of advertisements, a real-world examination of labor market demands on 21st century skills can be obtained for diverse job characteristics, such as field, minimum education requirement, etc. Such information may add to previous suggestions/findings around differential skill demand by job type. Third, analyzing advertisements taken from the Internet will provide a representative sample of positions in the economy as 80% to 90% of all job openings requiring a college degree are now posted online (Carnevale, Jayasundera, & Repnikov, 2014).

Study Objective

The objective of this study is to conduct an empirical investigation of 21st century skills that are critical for students' transition from higher education (i.e., jobs requiring a college degree) to the workforce by web scraping and conducting content analyses of online job advertisements. Focusing specifically on 21st century skills needed for college graduates is of particular importance as 99% of the 10.6 million jobs created after the Great Recession[1] have required some form of postsecondary education (Carnevale, Jayasundera, & Gulish, 2016). The following research questions are addressed:

1. What are the most in-demand 21st century skills identified in job postings requiring a college degree?

2. How do these skills differ by education level and degree field?

Findings from this study have the potential to assist in signaling the need for building highly in-demand skills – assuming that they are both learnable and malleable – into education and training systems.

Method

To address our study objective, we first conducted a literature review of 21st century skills to compile a list of terms (i.e., critical 21st century skills) to be searched for in job advertisements. Upon developing this list, we next had to extract job advertisements from the Internet, code independent variables, and identify the 21st century skills that were requested by employers from our precompiled list. Below, we describe these processes in greater detail.

Literature review. A literature review of 21st century skill frameworks was conducted in Google Scholar. The search terms used were: *Non-cognitive skills*, *21st Century Skills*, *Workplace Skills*, and *Applied Skills*. Articles or reports providing a framework of critical skills (i.e., more than one skill) for workplace success within the past 20 years were kept, while articles focusing on only one skill were excluded. Upon identifying literature via Google Scholar that met the inclusion criterion, multiple rounds of cross-referencing were conducted until no further literature was identified. This literature search was completed between February and August 2017. In total, 16 articles of relevance were included, and content analyses of these articles were conducted to identify reoccurring skills proposed by distinct researchers. As shown in Table 1, we identified 15 distinct 21st century skills that were referenced in three or more articles. The skills mentioned in 50% or more of the articles reviewed were: Collaboration (n = 13); Problem Solving (n = 11); Communication Skills (n = 10); Critical Thinking (n = 9); Oral Communication (n = 8); Written Communication (n = 8); Ethics (n = 8); and Cultural Sensitivity (n = 8). As it

was expected that individuals writing job advertisements may use inconsistent terminology in describing the same skills (e.g., adaptability was often referred to as flexibility, responsiveness, or versatility), synonym lists were generated from the Psycinfo and Merriam-Webster thesauri, where possible, and finalized through group consensus. Feedback on the accuracy of the synonym list was made by a hiring resource specialist involved with developing job advertisements for a large corporation. The reoccurring skills and their respective synonyms were used as terms to be searched for in the job advertisements.

Web scraping job advertisements. Job advertisements were extracted from two major online websites, *careerbuilder.com* (one of the largest job aggregation websites on the Internet) and *collegerecruiter.com* (a job aggregation website geared towards recent graduates searching for entry-level jobs), between February and April 2017, using a web scraping application built using Python's *Scrapy library*[2]. The raw HTML of each post was parsed in order to identify the following fields: "job title", "description", "location", and "company name", and the posts were de-duplicated based on job description. The unique descriptions were processed to allow for independent variable and skill identification as follows: (a) all text were lowercased, (b) descriptions were split into sentences, and (c) extraneous punctuation (e.g. asterisks and dashed lines, used for formatting), sequences of multiple spaces, and control characters such as newlines and tabs, were removed.

Independent variables. Before identifying 21st century skills, information was extracted from the processed descriptions where available for: (a) education level, and (b) degree field/major.

Education level. Education level was defined as the lowest degree requirement by an employer. These were grouped into four categories: "associate's degree", "bachelor's degree",

"graduate degree" ("master's", "doctoral", or "professional" degree), and "not stated". This variable was identified via a combination of regular expression pattern matching and hand-coded heuristics.

Degree field. This variable was defined as the subject of degree specialization preferred by the employer. Examples include "accounting", "computer science", "graphic design", etc. Extracting the degree field involved: (a) compiling a lexicon of possible college majors from two online college information resources (www.shmoop.com and www.jvis.com), and (b) using regular expression pattern-matching to identify the specification of a degree requirement mentioning one of the majors in the lexicon. Majors were then grouped into the following degree fields: (a) science, technology, engineering, and mathematics (STEM), (b) social sciences, (c) education, (d) business, (e) arts and humanities, and (f) other.

21st century skill identification. To identify which skills were mentioned in a job advertisement, case-insensitive keyword matching was used. In order to minimize the potential problem of term ambiguity (e.g. a skill term, such as "service-oriented," is used in the post to express an aspect of the company instead of a desired trait of the prospective applicant), all keyword matches were filtered using a set of hand-coded heuristics based on a review of randomly-sampled data (approximately 300 job posts were sampled per skill). For instance, a match of the term 'responsive' in a post was ignored if it co-occurred with language describing web applications (e.g. "optimizing responsive site code"). While the disambiguation method described above makes an attempt to avoid false positives, its performance is not perfect. In order to quantify the false positive (Type 1 error) rate of our skill-matching method, annotations were performed on a subset of matched data. Any skill or synonyms of skills that were found to identify false positives at a rate above 5% were dropped from all further analyses. As an

example, although *leadership* was identified to be an important 21st century skill by three of 16 frameworks, we were unable to distinguish heuristics that would maintain Type I error below 18%. Consequently, this skill was removed from our study, though, no other skills were dropped based on this criterion.

Results[3]

A total of 203,272 unique job advertisements (86% from careerbuilder.com and 14% from collegerecruiter.com) were collected and analyzed. The five occupational fields most represented in the sample included: (a) business, management, and administration (22.4%), (b) information technology (15.4%), (c) finance (12.5%), (d) health science (11.1%), and (e) science, technology, engineering, and mathematics (10.9%). In terms of minimum education requirement, 67% of the job advertisements collected explicitly required some form of a college degree (14% Associate's, 70% Bachelor's and 16% graduate degree). As the objective of this study was to examine 21st century skills requested for college degree holders, only those jobs explicitly requiring some form of a college degree were kept for further analysis, which led to a final sample size of 141,941 job advertisements. Of those, 28% specified a degree field, and the top five most requested fields were business (25%), accounting (14%), engineering (13%), computer science (11%), and nursing (6%). Full-time employment was specified for nearly 100% of the job advertisements that specified employment type. Figure 1 provides the proportion of job advertisements based on the interaction of degree level and field.

21st Century Skill Demand

All jobs. Of the roughly 142,000 job advertisements analyzed, 70% requested at least one 21st century skill included in our study, and of these advertisements, the average number of unique skills appearing in a single post was 1.69 (*Mdn* = 1, *SD* = 1.62, max = 12). Figure 1

presents the frequencies of occurrence by skill and education level. The most highly requested skill across all advertisements was oral communication (28%) followed closely by written communication (23%), collaboration (22%) and problem solving (19%). Aside from these skills, only social intelligence (12%) and self-direction (10%) were found to appear in 10% or more of the advertisements in our sample. Furthermore, skills, such as professionalism, creativity, adaptability, service orientation, continual learning, and cultural sensitivity, were listed in less than 5% of all advertisements (Figure 2). It should be noted that general communication (not specifying either oral or written communication) alone was the fifth most in-demand skill (14%), suggesting that had employers been more specific the observed percentages of oral and written communication would have been higher. As 73% of job postings (n = 103,242) mentioned more than one 21st century skill, the most popular skill co-occurrences were examined. Results demonstrated that across all job postings, the top five most requested skill co-occurrences were: (a) oral and written communication (28%), (b) oral communication and problem solving (10%), (c) oral communication and collaboration (10%), (d) written communication and problem solving (9%), and (e) written communication and collaboration (9%).

By education level. Clear differences were noted for some skills by minimum education level requirements. As an example, oral communication was found to be in greater demand for jobs requiring an associate's degree (22%) when compared to those requiring a bachelor's (16%) or graduate (15%) degree. In addition, collaborative skill demand was observed to progressively increase as the minimal degree requirement increased. Specifically, in proportion to the total number of advertisements at each education level, jobs requiring a doctoral degree demanded collaborative skills by 5% more than those requiring an associate's degree. However, the largest skill request difference by education level was observed for social intelligence. Although there

were no differences between bachelor's or graduate degree jobs (i.e., both requested social intelligence in about 6% of advertisements), jobs requiring an associate's degree demanded this skill at twice the rate than jobs requiring a higher degree. Beyond these skills, small differences were noted by education level (Figure 3). In terms of skill co-occurrence, the proportion of jobs that requested more than one 21st century skill and required an associate's, bachelor's, or graduate degree was 70%, 77%, and 68%, respectively. Similar to the results across all job posts, the most in-demand paired skills were oral and written communication for jobs requiring a bachelor's (28%) and graduate degree (29%); however, associate degree-level jobs emphasized the combination of oral communication skills with social intelligence (27%).

By degree field. In addition to education level, differences were noted by degree field for two of the top four skills observed for all job postings (Figure 4). Specifically, both oral (16%-17%) and written (14%-17%) communication were found to be listed nearly equally for jobs requesting a degree in the STEM (n = 18,318), social sciences (n = 2,241), education (n = 1,765), and business (n = 18,318) fields. However, larger differences were noted between degree fields for collaborative and problem solving skills. For instance, the former skill was found at a rate that was 50% higher for jobs requiring a social science degree (18%) when compared to those requiring a business degree (12%; the demand was 33% higher for jobs requiring education and social science degrees). In addition, large differences were noted for problem solving, particularly when comparing STEM and social science fields. That is, jobs requiring a STEM field (14%) requested problem solving skills at a rate that was 75% higher than social science jobs (8%; Figure 4). In regard to skill co-occurrence, across business, STEM, social science, and education degree fields, the top-most requested skill co-occurrence was oral and written communication. However, the second most in-demand joint skill for business (11%) and STEM

(12%) fields was oral communication and problem solving, while in the social science (14%) and education (11%) fields it was written communication and collaboration. Taken together, the results suggest that 21st century skill demand is differential by degree field for some skills.

Discussion

This paper extends the literature on 21st century learning skills needed for workplace success by providing an empirical examination of employers' direct communication to potential employees via job advertisements. Our analysis provides two contributions. First, this is one of the first papers to empirically rank-order skill demand. In doing so, it is clear that oral and written communication, collaboration, and problem solving skills are in high demand by employers, with particular emphasis on the pairing of oral and written communication. This finding is supported by our systematic review of the literature, which found that across all studies/reports analyzed, these four skills were found to be noted most often. Furthermore, it is apparent that many of the skills suggested in the literature as being critical for workplace success are in very low demand by employers, and some were not found to be mentioned at all (e.g., social responsibility). Second, although previously implied in the literature, homogenous development of 21st century skills may not be effective in preparing students for workforce entry. This assertion is supported by our study, which showed differential demand of some skills by education level and degree field requirements. Overall, these findings provide a more nuanced picture of 21st century skill requirements for individuals transitioning from postsecondary education to the workforce.

Limitations

Several limitations associated with this study should be noted. First, although 80% to 90% of all job advertisements can be found online (Carnevale et al., 2014), the advertisements

sampled in our study do not represent all online job posts as we web scraped data from only two websites. Each of these websites required recruiters to pay a fee for marketing their job openings online. Consequently, our findings may have been biased on the fact that companies lacking financial resources to pay for online recruiting were not included in our sample. In addition, the websites used may have attracted different types of companies and/or jobs based on their intended demographics that may not be representative of the general population. Besides potential bias from the websites sampled, our data may not have been representative of the population of job openings as our study ignored advertisements posted offline, which may have possessed different characteristics than what we observed in our analysis.

A second limitation associated with our study is that we focused only on job advertisements requiring a postsecondary college credential. Although this is in line with the new jobs being created in the U.S. economy (Carnevale et al., 2016), it is possible that our sample may have been limited as we required employers to specify the minimum education level to be an "associate's," "bachelor's," or "graduate" degree ("master's," "doctoral," or "professional" degree). However, it is possible that the terms we used may have unintentionally excluded advertisements that used alternative terminology for degree type or failed to report a required minimum education level as the job being advertised would assume a college degree (e.g., physician). In a similar vein, a third limitation of this study was the use of exact word match as the approach to identifying 21st century skills in job advertisements. Although we evaluated Type I errors to limit the number of false positives in our results, we were unable to assess power or the ability to identify true positives. Therefore, it is possible that employers used alternative language to specify 21st century skills that we did not search for. To improve power, we attempted to develop synonyms for each term, where possible, based on using thesauri and

expert judgment from a hiring specialist that has experience in online marketing of job openings; however, it is unclear how many true positives went undetected. Finally, this study assumed that all 21st century skills mentioned in job advertisements were of great importance to employers. However, given the limited space available in job ads, it is unclear whether employers may have been interested in 21st century skills that they did not explicitly state. More research is needed to better understand how employers craft their job advertisements to better shed light on the utility of analyzing this source of data.

Implications

In light of these limitations, our finding that there is a clear-cut demand for a limited number of skills (oral communication, written communication, collaboration, and problem solving) points to two implications. First, although framed as critical to the 21st century worker, these skills have long been important to both higher education institutions and employers. Since 1977, U.S. higher education institutions have begun reform efforts to improve the state of general education programs as many critics (e.g., the Carnegie Foundation for the Advancement of Teaching) have felt that college students lack generic capabilities for workforce success (Gaff, 1981). Furthermore, for the last 60 years, academics have discussed the importance of skills, such as oral and written communication, in the ever-changing world and economy (e.g., Bailey, 1953; Horn, 1959). And it has not just been academics discussing these skills, but employers both within and outside of the United States. In an international review of skills sought by stakeholders, Billing (2003) analyzed employer surveys dating back to the 1970s from the United Kingdom Commonwealth, Europe, and the United States, and found that although there was some disagreement for collaboration (ranked number two for the United Kingdom Commonwealth and Europe, and number 12 for the U.S.) and problem solving (ranked numbers

three, eight, and nine for the United Kingdom Commonwealth, U.S., and Europe, respectively), across countries communication skills ranked either first or second. Therefore, our findings support decades of research prior to the 21st century highlighting the importance of these skills for workplace success by both academics and employers.

Second, although prior frameworks of 21st century skills have noted that individuals must possess as many as 17 skills for workplace success (e.g., McCloy, Putka, Purli, Robbins, & Le, 2017), our analysis demonstrated that the average job post specified only 1.69 skills and 30% stipulated no skills of interest. We hypothesize that this discrepancy stems from the nature of job advertisements in that employers have a limited number of words (depending on the parameters of the job aggregation website) to describe their organization, position being hired, and desired characteristics of a successful applicant. This may put employers in the position of more likely mentioning highly desirable skills that may be uncommon in applicants due to the inability to include a comprehensive inventory of preferred skills. Therefore, our finding that oral and written communication were the most common co-occurring skills across all jobs, degree fields, and nearly all education levels (minus associate degree-level jobs, which emphasized oral communication and social intelligence) may suggest that these skills are important for workplace success, but scarce in the applicant pool. This is supported by a recent survey of 1,000 business executives and hiring managers who indicated that only approximately 40% of recent college graduates possess adequate oral communication skills, even though this is the most in-demand attribute for recent hires (Hart Research Associates, 2018). Similarly, although employers have noted that written communication is critical for workplace success, they have indicated that 47% and 28% of recent two- and four-year degree graduates are deficient in this skill, respectively (Casner-Lotto & Barrington, 2006). These findings suggest that employers perceive a major

skills gap (i.e., a skill that is in high demand, but in low supply) for both oral and written communication, and as a result, may highlight these skills at a higher rate when advertising positions. Clearly, to close this skills gap it is vital that the U.S. higher education system adopt student learning outcomes accountability standards that emphasize these skills to improve workforce preparedness for college graduates.

Conclusion

Student development of 21st century skills is greatly needed to promote workforce preparedness and long-term success of the U.S. economy. To add to the discussion on which skills are of greatest importance for students to develop before entering the workforce, this study investigated skill demand based on direct communication from employers to potential employees via job advertisements. The four most in-demand 21st century skills found across roughly 142,000 job advertisements were oral and written communication, collaboration, and problem solving. Furthermore, differences in skill demand by education level and degree field were noted. It is our hope that these findings can add to the discussion on developing accountability standards to improve student development of 21st century skills in the United States.

Notes

1. Defined as the period between December 2007 and January 2010 (Carnevale, Jayasundera, & Gulish, 2016).
2. Scrapy Documentation [Online] http://doc.scrapy.org/en/latest/topics/architecture.html. Accessed on November 2016
3. Due to the very large sample size examined (N = 141,941), statistical tests of percentage differences (i.e., two sample t-tests between percentages) were not applied due to the high degree of power possessed. Findings in this study were replicated with a dataset (N = 118,149) collected one year after the data reported. Results of the replicated data are presented as supplementary information.

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Table 1

Definitions of 21st century skills examined

Skill	Definition	Times Noted in Literature Reviewed
Collaboration	"Build collaborative relationships with colleagues and customers; be able to work with diverse teams, negotiate and manage conflicts" (Casner-Lotto & Barrington, 2006, p.16)	13
Problem Solving	Demonstrating the ability to apply critical thinking skills to solve problems by generating, evaluating, and implementing solutions (Burrus & Robert, 2017)	11
Communication Skills	"Effectively communicate multiple types of messages across multiple forms and varying audiences" (Markle et al., 2013, p.13)	10
Critical Thinking	"Exercise sound reasoning and analytical thinking; use knowledge, facts, and data to solve workplace problems" (Casner-Lotto & Barrington, 2006, p.16)	9
Oral Communication	"Articulate thoughts, ideas clearly and effectively" (Casner-Lotto & Barrington, 2006, p.16)	8
Written Communication	"Write memos, letters, and complex technical reports clearly and effectively" (Casner-Lotto & Barrington, 2006, p.16)	8
Ethics	"Demonstrate integrity and ethical behavior; act responsibly with the interests of the larger community in mind" (Casner-Lotto & Barrington, 2006, p.16)	8
Cultural Sensitivity	"Ability to learn from and work collaboratively with individuals representing diverse cultures, races, ages, gender, religions, lifestyles, and viewpoints" (Casner-Lotto & Barrington, 2006, p.16)	8
Adaptability	The ability to respond effectively to feedback (Pellegrino, 2012)	7
Creativity	"The ability to generate new ideas, novel integration of existing ideas, and application of new ideas in a real-world setting" (Markle et al., 2013, p.13)	6
Continuous Learning	Ability to acquire new knowledge and skills (Casner-Lotto & Barrington, 2006)	6
Self-Direction	Demonstrating the ability and flexibility to learn on the job and prepare for future challenge (De Fruyt, F., Wille, B., & John, O. P. 2015).	4
Time Management	The efficient use of time and management of workload (Binkley et al., 2012)	3
Professionalism	"Demonstrate personal accountability and employing effective work habits" (Casner-Lotto & Barrington, 2006, p.16)	3
Service Orientation	An inclination to be courteous and helpful in dealing with customers (National Research Council. 2011)	3

Table 1 Continued

Definitions of 21st century skills examined

Skill	Definition	Times Noted in Literature Reviewed
Leadership	Plan, cultivate, and inspire the success of employees internal to the organization (Burrus & Robert, 2017)	3
Social Intelligence	"Ability to connect to others in a deep and direct way, to sense and stimulate reactions and desired interactions". (Burrus, J., & Roberts, R. D. 2017, p.271)	3

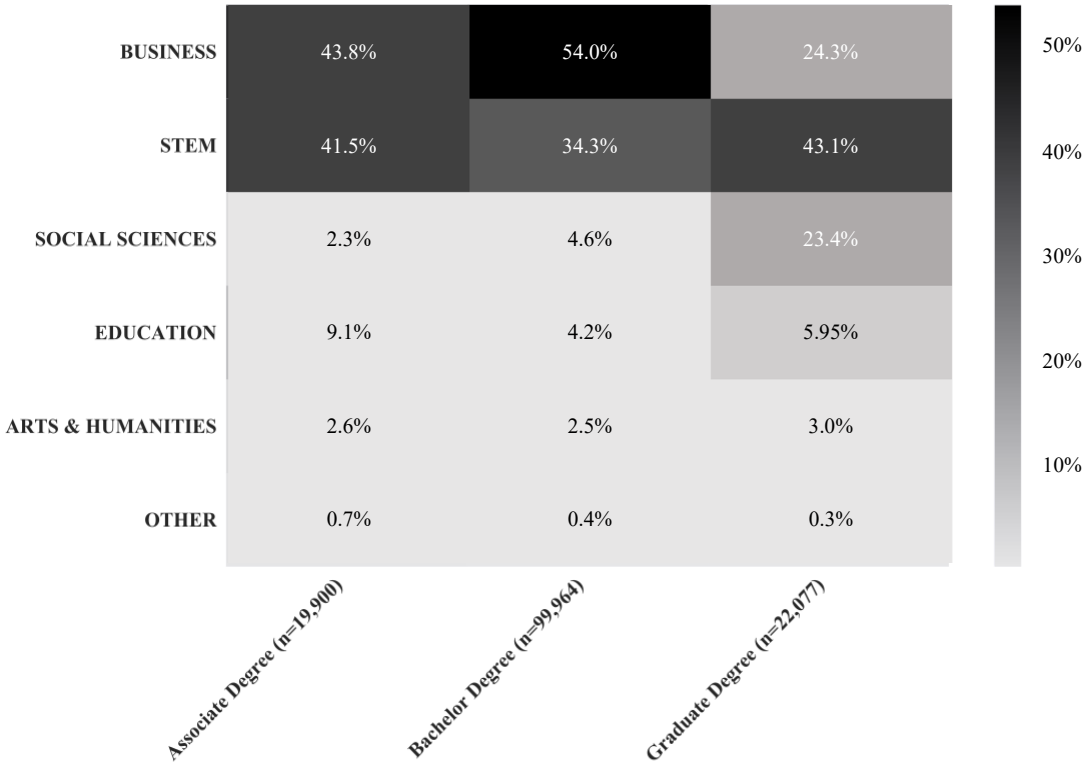

Figure 1. Proportion of job advertisements based on the interaction of degree level and field.

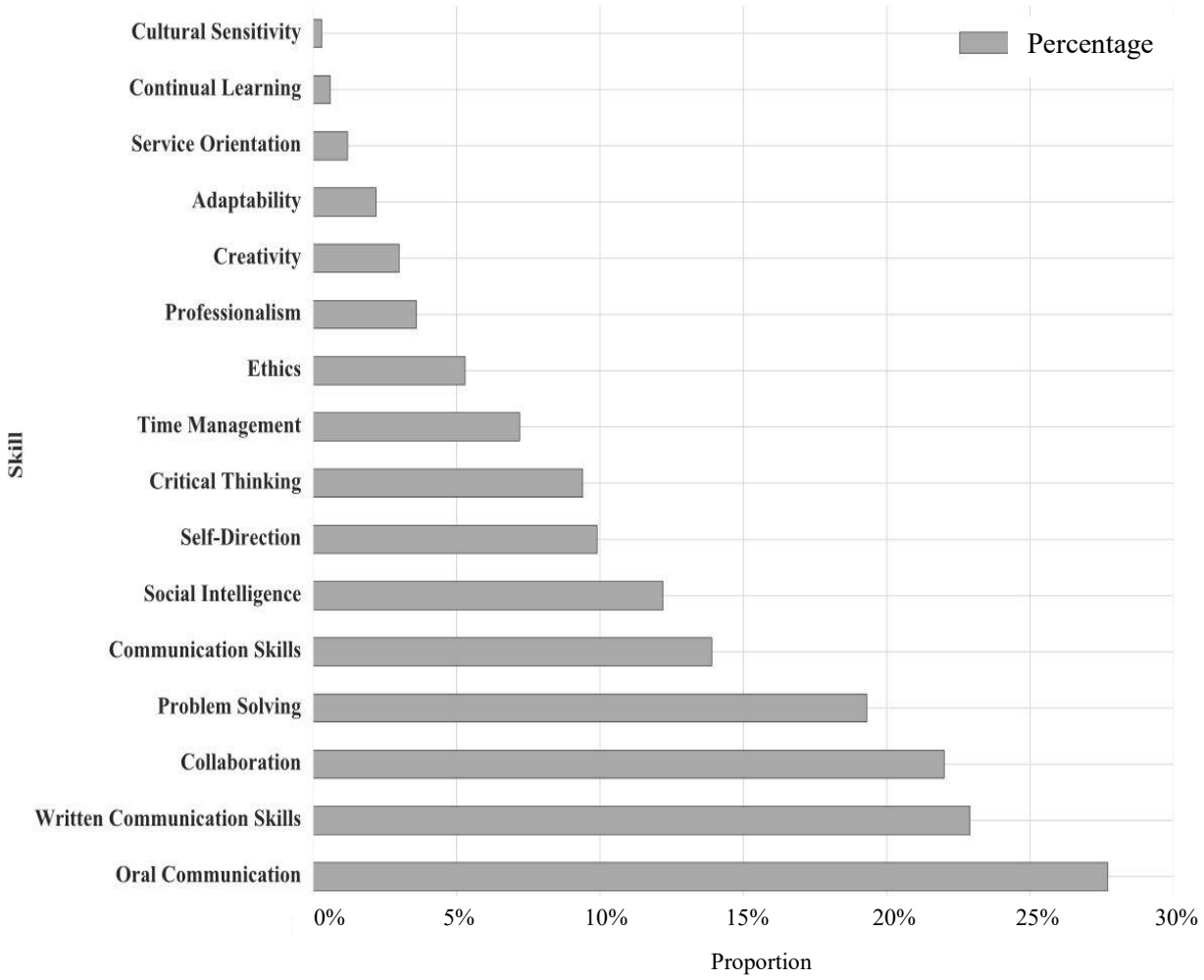

Figure 2. 21st century skill demand expressed as proportion of total job advertisements examined.

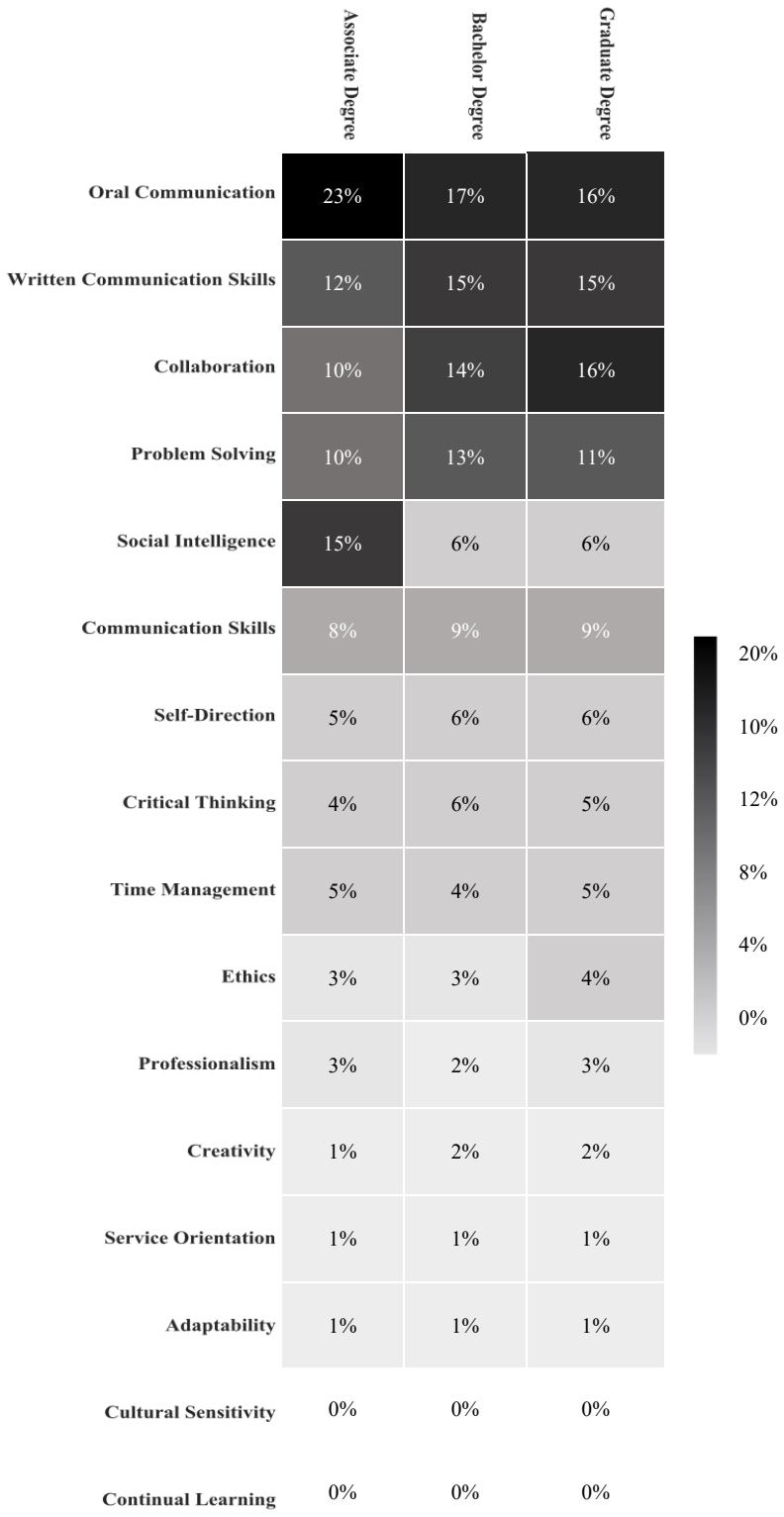

Figure 3. 21st century skill demand by degree level.

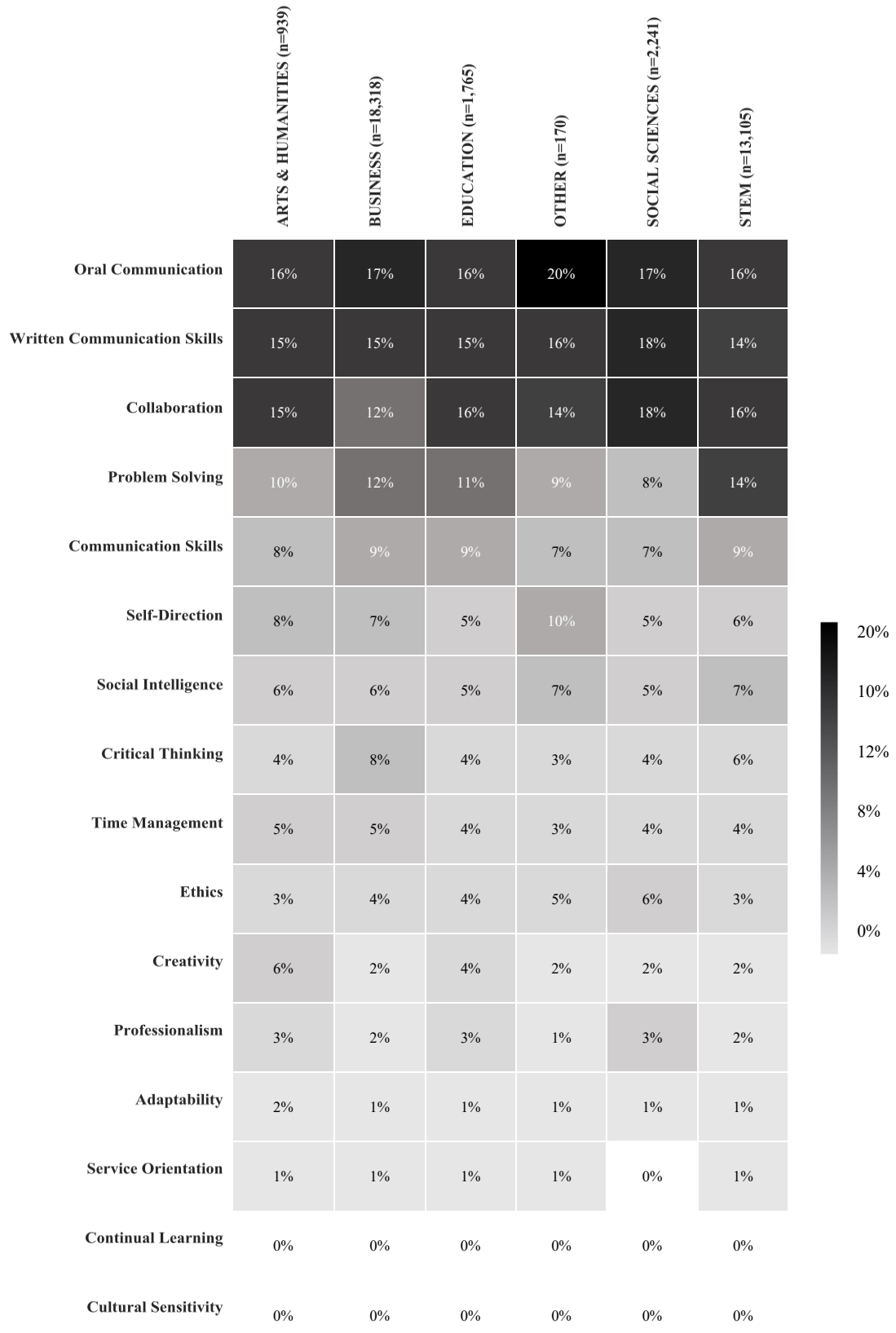

Figure 4. 21st century skill demand by degree field.

Replication Results[1]

A total of 173,495 unique job advertisements (86% from careerbuilder.com and 14% from collegerecruiter.com) were collected between January and March 2018. The five occupational fields most represented in the sample included: (a) business, management, and administration (23%), (b) information technology (16%), (c) finance (14%), (d) science, technology, engineering, and mathematics (14%), and (e) health science (8%). In terms of minimum education requirement, 69% of the job advertisements collected explicitly required some form of a college degree (12% Associate's, 74% Bachelor's and 14% graduate degree). As the objective of this study was to examine 21st century skills requested for college degree holders, only those jobs explicitly requiring some form of a college degree were kept for further analysis, which led to a final sample size of 118,149 job advertisements (68.1% of all advertisements). Of the jobs requiring a college degree, 28% specified a degree field, and the top five most requested fields were engineering (20%), business (20%), accounting (12%), computer science (10%), and nursing (4%). Full-time employment was specified for nearly 100% of the job advertisements that specified employment type. Figure 1 provides the proportion of job advertisements based on the interaction of degree level and field.

21st Century Skill Demand

All jobs. Of the roughly 119,000 job advertisements analyzed, 69% requested at least one 21st century skill included in our study, and of these advertisements, the average number of unique skills appearing in a single post was 1.57 (*Mdn* = 1, *SD* = 1.57, max = 11). Figure 1 presents the frequencies of occurrence by skill and education level. Similar to the previous collected data, the most highly requested skill across all advertisements was oral communication (28%) followed closely by written communication (23%), collaboration (22%) and problem

solving (21%). Aside from these skills, only social intelligence (12%) and self-direction (10%) were found to appear in 10% or more of the advertisements in our sample. Furthermore, skills, such as professionalism, creativity, adaptability, service orientation, continual learning, and cultural sensitivity, were requested in less than 5% of all advertisements (Figure 2). It should be noted that general communication (not specifying either oral or written communication) alone was the fifth most in-demand skill (14%), suggesting that had employers been more specific, the observed percentages of oral and written communication would have been higher. As 46% of job postings (n = 55,055) mentioned more than one 21st century skill, the most popular skill co-occurrences were examined. Results demonstrated that across all job postings, the top five most requested skill co-occurrences were: (a) oral and written communication (21%), (b) oral communication and problem solving (8%), (c) oral communication and collaboration (8%), (d) written communication and problem solving (7%), and (e) written communication and collaboration (7%).

By education level. No clear differences were noted for some skills by minimum education level requirements. As an example, oral communication was found to be in equal demand for jobs requiring an associate (16%), bachelor (17%), and graduate (16%) degrees. The largest difference observed of any of the top four in-demand skills was for collaboration. This skill was requested for 13% and 15% of jobs requiring at minimum an associate and graduate degree, respectively (Figure 3). In terms of skill co-occurrence, the proportion of jobs that requested more than one 21st century skill and required an associate's, bachelor's, or graduate degree was 70%, 77% and 68%, respectively. Similar to the results across all job posts, the most in-demand paired skills were oral and written communication for jobs requiring an associate's (19%), bachelor's (22%), and graduate degree (20%).

By degree field. Differences were noted by degree field for two of the top four skills observed for all job postings (Figure 4). Specifically, both oral (15%-17%) and written (14%-16%) communication were found to be requested nearly equally for jobs requesting a degree in the STEM (n = 11,547), social sciences (n = 1,613), education (n = 1,374), and business (n = 15,000) fields. However, larger differences were noted between degree fields for collaborative and problem solving skills. For instance, the former skill was requested at a rate that was 33% higher for jobs requiring an education (16%) or social science degree (16%) when compared to those requiring a business degree (12%). In addition, large differences were noted for problem solving. The largest percentage difference was observed when comparing STEM and social science fields. Specifically, jobs requiring a STEM field (15%) requested problem solving skills at a rate that was 88% higher than social science jobs (8%; Figure 4). In regards to skill co-occurrence, across business, STEM, social science, and education degree fields, the top most requested skill co-occurrence was for oral and written communication; however, differences were observed for the second most requested skill co-occurrence by degree field. Specifically, the second most requested skill co-occurrence for business (10%) and STEM (11%) fields was oral communication and problem solving, while in the social science (8%) and education (9%) fields it was written communication and collaboration. Taken together, the results suggest that 21st century skill demand is differential by degree field for some skills.

Comparison between Original and Replicated Results

Overall, the demand of 21st century skills across all education-levels and degree fields was found to be consistent between the original and replicated results. Specifically, the top four skills demanded by employers, in order, were: (a) oral communication, (b) written communication, (c) collaboration, and (d) problem solving. Furthermore, the top co-occurring

skills were found to be identical as well between the two datasets. Unlike the original dataset, no clear differences were noted by education-level for the replicated data. Specifically, in the original dataset we found that both oral communication and social intelligence was found to be higher for jobs requiring an associate's degree, whereas collaborative skill demand progressively increased as degree-level increased. No such observations were noted in the replicated data. However, identical differences in skill demand by degree field were observed between the original and replicated data. In particular, jobs requiring a business degree were found to most infrequently request collaborative skills, while the jobs requiring a social science field least requested problem solving skills. Additionally, skill co-occurrence for the top two paired skills was found to have a similar pattern between the original and replicated data.

Notes

1. Due to the very large sample size examined (N = 118,149), statistical tests of percentage differences (i.e., two sample t-tests between percentages) were not applied due to the high degree of power possessed.

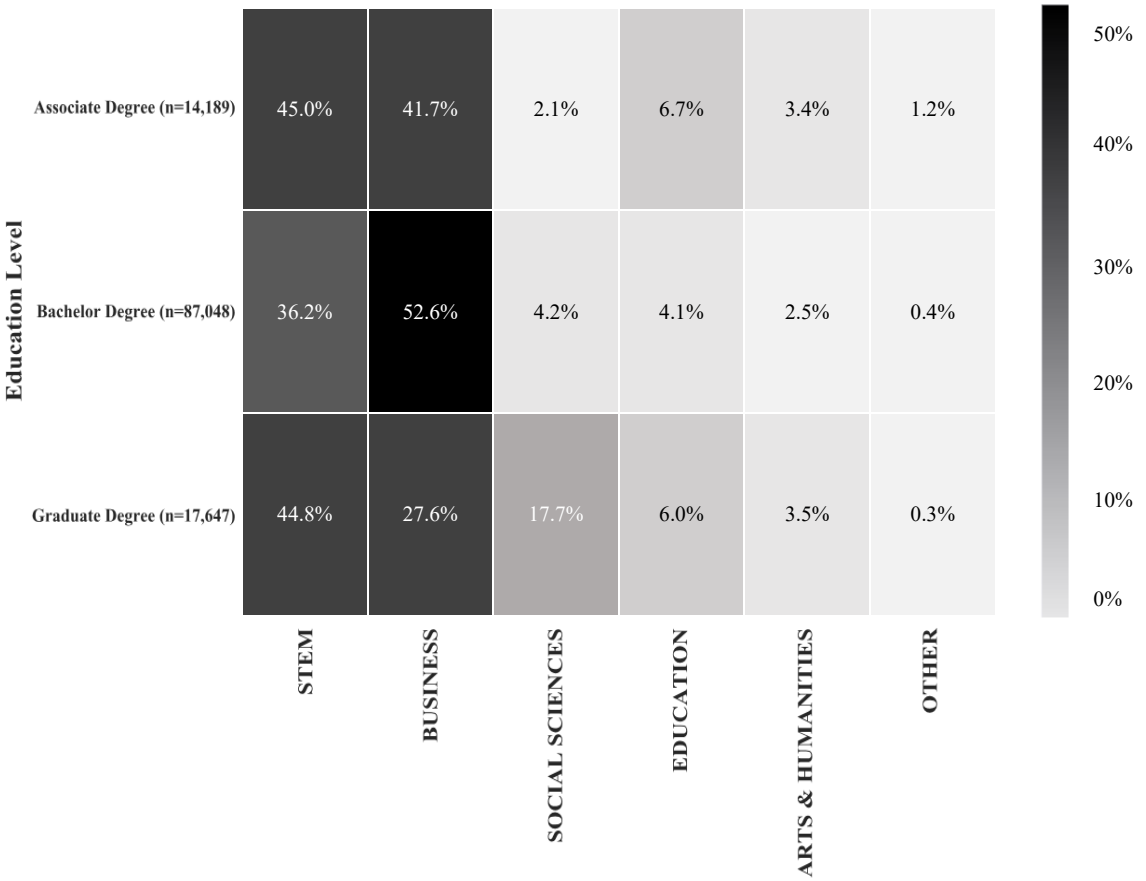

Figure 1. Proportion of job advertisements based on the interaction of degree level and field.

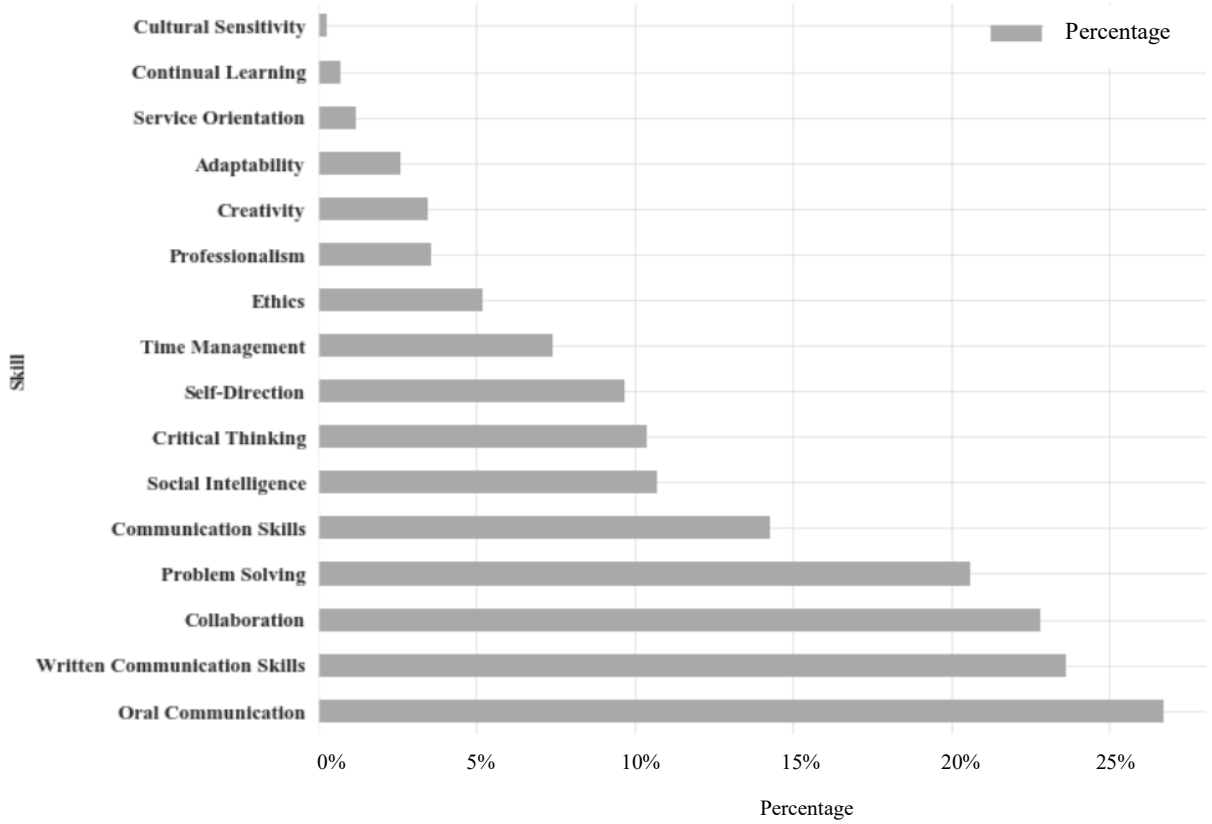

Figure 2. 21st century skill demand expressed as proportion of total job advertisements examined.

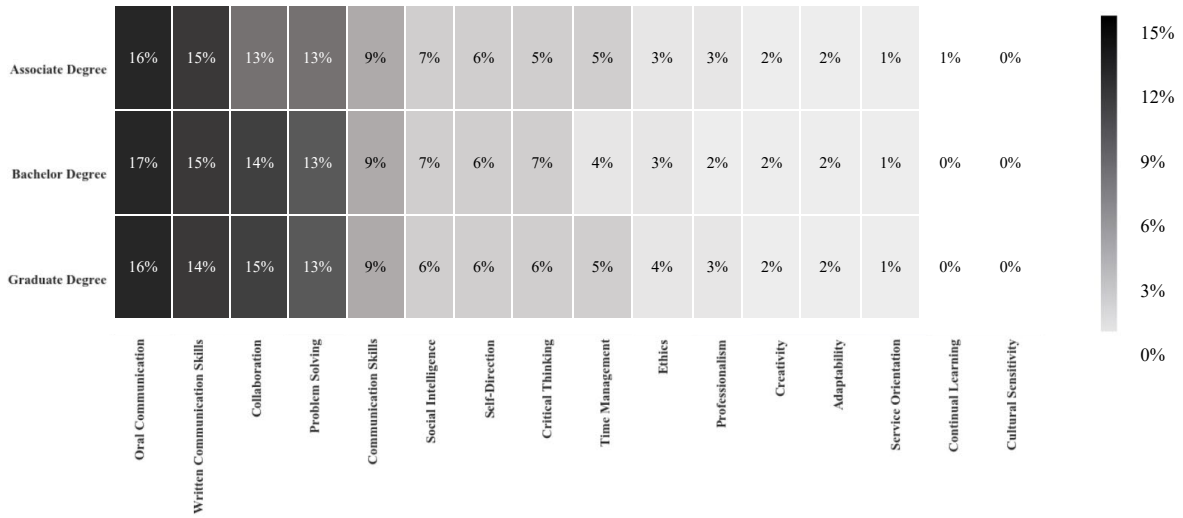

Figure 3. 21st century skill demand by degree level.

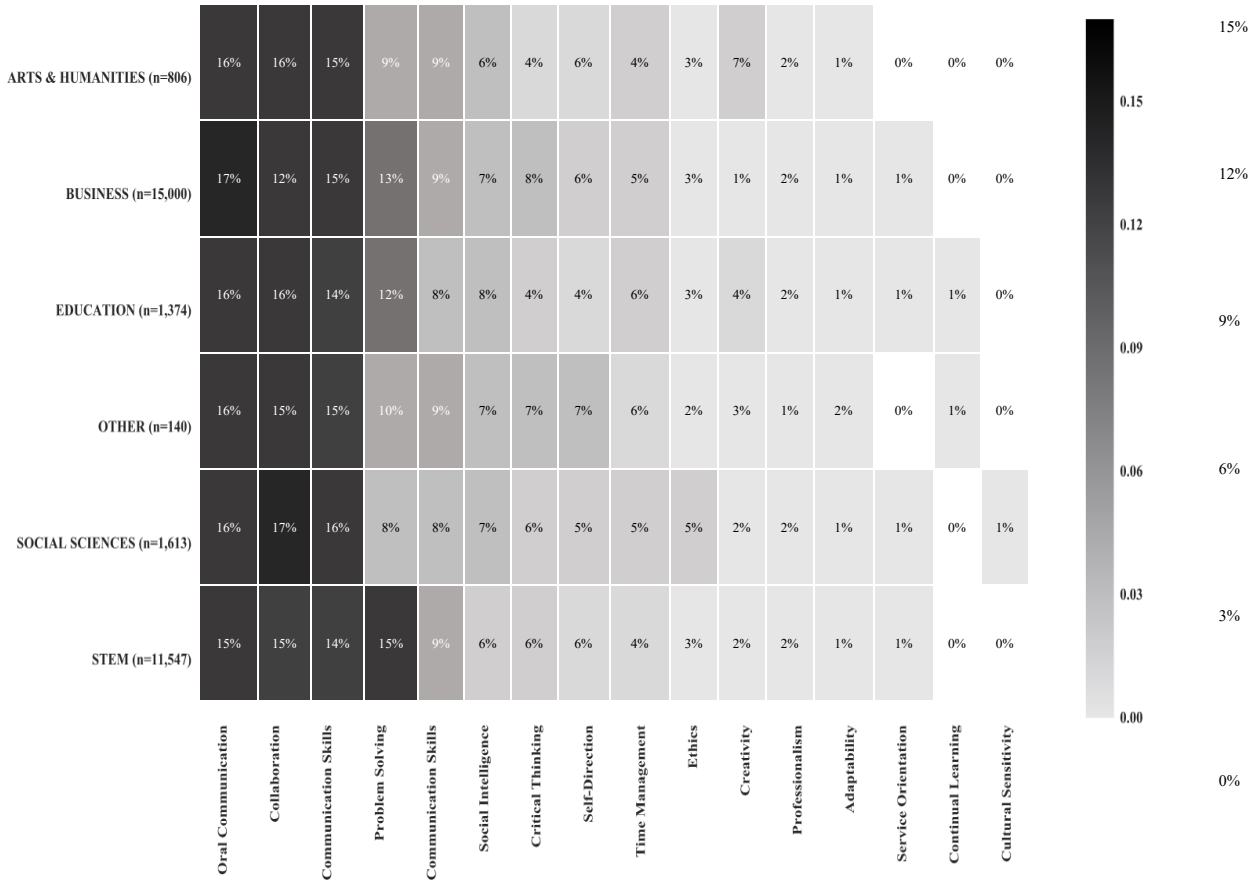

Figure 4. 21st century skill demand by degree field.