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An Examination of Digital Technology Skills in Higher Education in the Post COVID -19 Era

Dr. Juan Carlos Barrera
Elmhurst University, IL USA
Prof. Vangeliya Pavlova Petkova MA
Elmhurst University, IL USA

Abstract

Remote collaboration and working from home are two of the latest career-ready trends that require a basic understanding of information technology (IT) and new digital technology skills (DTS). The National Association of Colleges and Employers (NACE) has pointed out the critical role that higher education institutions play in assessing students' DTS, while ensuring that university graduates have earned sufficient expertise in IT for a successful transition into today's workplace. However, the COVID-19 pandemic revealed that people's DTS needed to complete their work remotely varied across industries and professions, and it became more noticeable in the workplace when employers saw high employee turnover rates and chaotic work environments that resulted in decreasing productivity and individual performance struggles. Moreover, proficiency testing and certifications in basic DTS have failed to capture changes in the latest technology developments because their design and scope are mostly subverted to demonstrate proficiency with productivity software and some business applications, not on new technologies and their trends. Consequently, this research aims at surveying the students' DTS in the scope of three domains: [1] Cyber Security Awareness, [2] Usage of the Internet or The World Wide Web, and [3] Productivity Software.

Keywords: Digital Technology Skills, Technology Skills

1. Introduction

The COVID-19 pandemic forced the entire world to isolate itself in different forms, ranging from business lockdowns, people staying at home, forcible reclusion of citizens at home (e.g., China), and any form of human connection through community engagement (e.g., recreation activities, church services, social events, etc.) came to an abruptly mandated halt (Choi et al., 2020). Further, everyone felt the economic impact of self-isolation when we had to devise new ways to keep functioning at some minimum capacity (Knight et al., 2021). Many businesses could not even achieve a minimal functioning capacity because their operations depended on the workers' physical presence to complete their work (Okorie et al., 2020). Conversely, the service sectors (e.g., financial, education, general services, etc.) were at an advantage because the use of technology allowed them to continue operating at partial and/or at a full capacity through creative work arrangements (i.e., hybrid and/or online) while maintaining some level of efficient collaboration (Vyas & Butakhieo, 2021). However, businesses in the service sectors did not expect to go through a digital transformation that would turn them into virtual entities overnight. The digital aspect of today's workplace has turned into the innovative organizational asset capable of optimizing worker's productivity and resilient against disruption (D'Arcy & Marketing, 2011). Consequently, people and business organizations need to embrace digital work along with the learning of new skills. Stieglitz & Brockmann (2012) pointed out that workers need to develop new digital skills to succeed in the digital work environment.

However, despite of the many benefits realized through technology in organizations, there are still many concerns about the design of a digital and/or hybrid workplace that could deliver better control and agility when confronted with unforeseeable events that could create widespread disruption (e.g., climate, social unrest, other pandemics, war, terrorism, etc.), while developing and maintaining a technology savvy workforce ready to perform during crises (Duong et al., 2023).

The ability to engage in remote collaboration and work from home became the most desirable professional attribute since the beginning of the COVID-19 pandemic and it is in high regard according to several professional organizations, such as: The National Association of Colleges and Employers (NACE), The National Work Readiness Council (NWRC), and The New Commission on the Skills of the American Workforce, to mention only a few of them. These organizations emphasize the need to address any gaps in basic digital technology skills to enable professionals to meet the new demands of today's workplace (i.e., work from home and remote collaboration). Moreover, with the latest technologies permeating all aspects of human life, developing new digital technology skills is a daunting task to everyone because of the wide range of technology applications to all human endeavors (Zakaria et al., 2004). More so, the definition of a digital technology skill is subject to change as the technology itself changes at an unprecedented pace (Andriole et al., 2017). Consequently, previous catch-up attempts to develop DTS were somewhat successful for a short time. However, the COVID-19 pandemic brought to light the gaps in people's DTS, when people found themselves ill-prepared to work remotely and to collaborate online at unprecedented levels due to various reasons (Aissaoui, 2022).

NACE identifies technical proficiency as one of the eight key career-ready competencies that equip graduates to succeed in the workplace while providing them with a path to a lifelong career management. However, it also recognizes that technology is a broad concept that changes as new innovations and discoveries are introduced in the workplace and in people's lives. Consequently, the definition of technology must be understood from a broader perspective and the assessment of DTS must be continually updated to reflect changes to the conceptual definition of technology. Santandreu-Calonge & Aman-Shah (2016) stated that there is a mismatch between the digital skills obtained through Higher Education Institutions, and the DTS required at the workplace because the workplace is ahead in adopting new technologies, as they are driven by different missions. Therefore, graduates have no choice but to bridge the gap in DTS through self-study with the tools available at the time of need. Consequently, this research work aims at surveying the students' DTS in the scope of three domains of interest to the researchers: [1] Cyber Security Awareness, [2] Usage of the Internet or The World Wide Web, and [3] Productivity Software, since they are identified in the DTS literature as of critical importance for career readiness (Brunetti et al., 2020). Additionally, the researchers are interested in answering the following research questions:

RQ_1. What are the differences in DTS proficiency among different genders in the student body?
RQ_2. What is the connection (if any) between the students' professional background (based on their demographic information) and their DTS proficiency?

2. Related Work

Socrates, the ancient philosopher once said that "The secret of change is to focus all of your energy not on fighting the old, but on building the new", and building something new through the application of knowledge in a purposeful manner is at the heart of today's digital transformation of the workplace and also at the heart of the people's lives. Skolnikoff (1994) stated that technology represents the application of knowledge for achieving practical goals in a reproducible way, including tangible tools (e.g., utensils or machines), and intangible ones (e.g., software) (Mitcham, 2022). However, over the years this definition has grown to include new discoveries and innovations in the world. For instance, (Gilster & Glister, 1997. p. 1) defined technology as the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers. Further, Bawden (2008) pointed out that the terminology to describe knowledge about technology ranges from digital literacy, computer literacy, information literacy, network literacy, to media literacy. What's more, the concept of technology continues to change over time and researchers must embrace these new constructs to advance their understanding of it. For instance, (Calvani et al., 2009) referred to digital technology competency as a framework of articulated competencies that include not only the possession of procedural skills, but also more complex components (e.g., data analysis and collaboration).

In this later definition, there is an emphasis on skills, which is a notion to consider DTS as a continuum that goes from the acquisition of instrumental skills to the development of strategic skills, to identify stable reference frameworks (Carretero et al., 2017).

In the context of employment and productivity, Leahy & Wilson (2014) noted that digital skills are developed over time in formal and informal environments, through social interactions, learning from peers, and/or self-learning with any resource at hand. Consequently, it is expected that people's DTS differ from one another over time. In addition, Santandreu Calonge & Aman Shah (2016) stated that there is a mismatch of digital skills obtained through Higher Education Institutions and that graduated students seek to compensate the skill gaps through self-taught online courses. Self-learning is difficult to account for, since only people who seek self-development are more likely to pursue it (Chapman & Aspin, 2001). Consequently, employee productivity levels will vary based on DTS self-taught by own desire, leaving employers to see the gap in DTS as an issue that they cannot detect early enough during the applicant's screening process, only after productivity issues arise.

In the context of higher education and the future, DTS has been studied in specific professional fields that have stricter professional certification and legal requirements, such as: healthcare (Buabbas et al., 2016), clinical practice (Gratton et al., 2016), and teaching and education research (Černochová et al., 2020) (Sailer et al., 2021). Despite numerous DTS self-assessments, professionals have not been able to keep abreast of the latest technology developments and the new skills needed to perform at the workplace. For instance, Portillo et al. (2020) stated that educators experienced shortcomings in DTS during the COVID-19 lockdowns, which resulted in negative emotions, and a noticeable sense of a digital divide among different demographics. Moreover, the post COVID-19 pandemic era continues to accelerate the widespread digitalization of numerous sectors that are unprepared for such a change, and it is also compounding the negative effects of other issues such as access to technology (Cheshmehzangi et al., 2022), and the digital divide (Jackman et al., 2021). Lastly, The Organization for Economic Cooperation and Development (OECD) Learning Framework 2030 cites 'digital literacy' as a core competency for future education (Taguma et al., 2018). Consequently, there is a need to keep assessing students' DTS to capture any skill gaps before they join the workforce (Di Gropello et al., 2010).

In the context of remote work and DTS, Arntz, et al., (2020) found out that the COVID-19 pandemic caused a record number of people to work from home, which resulted in a chance for women to catch up with their male counterparts in terms of acquiring DTS for productivity and closing the gap in pay (Allas et al., 2020), while Nachit & Belhcen (2020) pointed out that the COVID-19 pandemic created a high adoption rate of digital technologies and new DTS development. Further, Ali (2020) stated that in addition to resources and staff readiness in higher education, student accessibility and motivation played an important function in the acquisition of new DTS during the pandemic and beyond. Finally, according to Priyono et al. (2020) small businesses coped with the environmental changes due to the COVID-19 pandemic by pursuing a business model transformation through the acquisition and adoption of digital technologies and new digital skills (Leahy & Wilson, 2014).

3. Methodology

The researchers surveyed business students' DTS from a local university, in the scope of three domains of interest: [1] Cyber Security Awareness, [2] Usage of the Internet or The World Wide Web, and [3] Productivity Software. Additionally, the researchers were interested in answering the following research questions:

RQ_1. What are the differences in DTS proficiency among different genders in the student body?

($H_{0/RQ1}$): There are no differences in DTS proficiency among different genders in the student body.

RQ_2. What is the connection (if any) between the students' professional background (based on their demographic information) and their DTS proficiency?

More specifically:

What is the relationship (if any) between students' class level and their digital technology skills?
What is the relationship (if any) between students' employment status and their digital technology skills?
What is the relationship (if any) between students' occupation and their digital technology skills?

($H_{0/RQ2}$): There are no relationships between the students' professional background (i.e., demographics) and their DTS proficiency.

To test these hypotheses and to answer the research questions, the researchers created a 25-item 5-point Likert scale survey that covered eight self-assessment questions for [1] Cybersecurity Awareness, nine self-assessment questions for [2] Usage of the Internet or The World Wide Web, and eight self-assessment questions for [3] Productivity Software. In addition, the survey included 4 questions about students' demographic information regarding gender, class level, employment status, and occupation. Furthermore, the following statistical test were applied to the data from the survey:

For $\mathbf{H_{0/RQ1}}$, The Kruskal-Wallis H test, this is a rank-based nonparametric test that can be used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable. It is considered an extension of the Mann-Whitney U test to allow the comparison of more than two independent groups (MacFarland et al., 2016).

For $\mathbf{H_{0/RQ2}}$, The Kendall's Tau-C correlation coefficient (with an α=0.05), this is a test to find out if there were any connections between the student's demographics (i.e., class level, employment status, and occupation) and their DTS proficiency. Kendall's Tau is used to understand the strength of the relationship between two variables. Further, the variables of interest can be continuous or ordinal and should have a monotonic relationship. Tau-c is more suitable than Tau-b for the analysis of data from non-square (i.e., rectangular) contingency tables (Berry, et al., 2009).

3.1 Survey Distribution

The researchers used a commercial platform (i.e., Qualtrics) to distribute the survey to participants in this study. Qualtrics supports survey design by checking format, suitability for deployment in browsers and/or mobile devices, and it provides helpful advice on survey length and wording best practices. Furthermore, once the survey was created on Qualtrics, it was tested for reliability by running the Cronbach's alpha test which provides a measure of the internal consistency of a test or scale, and alpha takes a numeric value between 0 and 1 (Kaur et al., 2018).
The formula for Cronbach's alpha is:

$$\alpha = \frac{N\,\bar{c}}{\bar{v} + (N-1)\,\bar{c}}$$

Where: N = the number of items. $\bar{c}$ = average covariance between item-pairs. $\bar{v}$ = average variance.

'Internal consistency describes the extent to which all the items in a test measure the same concept or construct and hence, it is connected to the inter-relatedness of the items within the test' (Tavakol & Dennick, 2011. p. 53). In addition, Alpha is affected by the test length and dimensionality. A high value of alpha (> 0.90) may suggest redundancies and show that the test length should be shortened, while a low value for alpha may mean that there aren't enough questions on the test (George & Mallery, 2021). As a rule, an alpha score of more than 0.7 and less than 0.90 is desirable to accept the survey for research (Conroy, 2014).

Finally, after passing the Cronbach's test (α=0.81), the survey was made available to the student body by posting its Qualtrics link into the social media sites associated to the school, which is one of the best practices according to Dillman (2011), and by extending an invitation via a mass email to all students. Israel (2011) pointed out that online surveys continue to provide several benefits to the respondents and researchers, such as low cost, wide availability of survey design and implementation tools that facilitate data cleaning and improve the survey experience for everyone (Archer, 2003).

4. Results

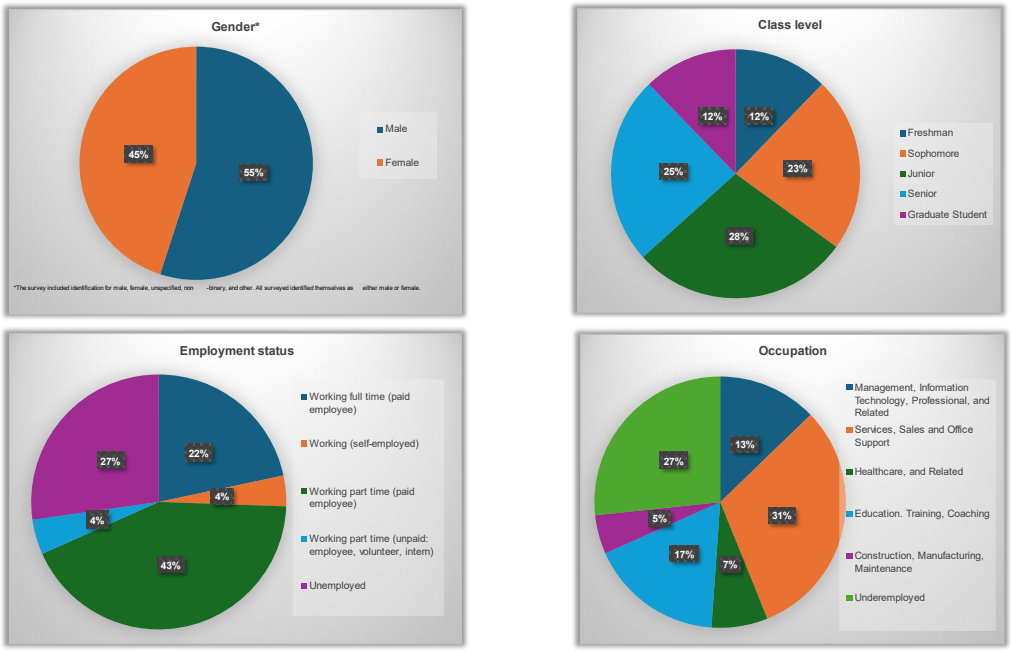


Figure 1: Sample Demographics (n = 180)

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.907	.921	25

Reliability			
		N	%
Cases	Valid	180	100.0
	Excluded[a]	0	.0
	Total	180	100.0

Table 1: Cronbach's Alpha Test

Survey section	Hypothesis	Alpha level	p-value	U of Mann-Whitney Test	Interpretation
Overall	H_0: There are no differences in the Digital Technology Skills between male and female students participating in this research. H_1: There are differences in the Digital Technology Skills between male and female students participating in this research.	5%=0.05	.060	3397.500	We fail to reject the null hypothesis H_0
1	H_0: There are no differences in Cybersecurity Awareness between male and female students participating in this research. H_1: There are differences in Cybersecurity Awareness between male and female students participating in this research.	5%=0.05	.047	3365.000	We reject the null hypothesis H_0
2	H_0: There are no differences in the Level of Internet or World Wide Web Skills between male and female students participating in this research. H_1: There are differences in the Level of Internet or World Wide Web Skills between male and female students participating in this research.	5%=0.05	.304	3678.000	We fail to reject the null hypothesis H_0
3	H_0: There are no differences in the Level of Proficiency with Productivity Software between male and female students participating in this research. H_1: There are differences in the Level of Proficiency with Productivity Software between male and female students participating in this research.	5%=0.05	.161	3550.000	We fail to reject the null hypothesis H_0

Table 2: Gender

Survey section	Hypothesis	Alpha level	p-value	Kendall's tau-c	Interpretation
Overall	H_0: There is no relationship between the students' class level and their Digital Technology Skills. H_1: There is a relationship between the students' class level and their Digital Technology Skills.	5%=0.05	0.010746	0.184444	We reject the null hypothesis H_0
1	H_0: There is no relationship between the students' class level and their Cybersecurity Awareness. H_1: There is a relationship between the students' class level and their Cybersecurity Awareness.	5%=0.05	0.225621	0.087685	We fail to reject the null hypothesis H_0
2	H_0: There is no relationship between the students' class level and their Level of Internet or World Wide Web Skills. H_1: There is a relationship between the students' class level and their Level of Internet or World Wide Web Skills.	5%=0.05	0.010144	0.170370	We reject the null hypothesis H_0
3	H_0: There is no relationship between the students' class level and their Proficiency level with Productivity Software. H_1: There is a relationship between the students' class level and their Proficiency level with Productivity Software.	5%=0.05	0.000009	0.300741	We reject the null hypothesis H_0

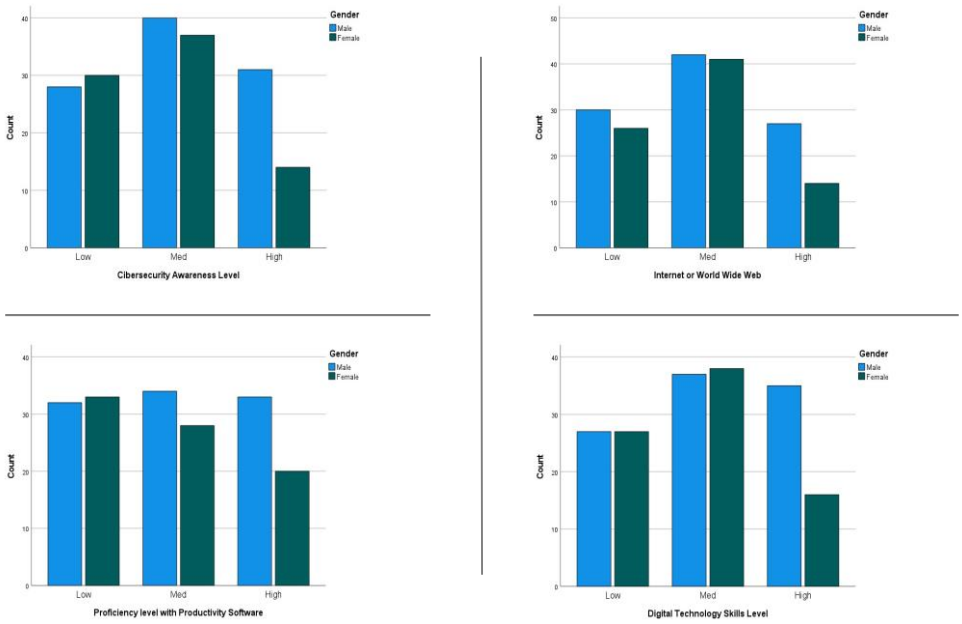
Table 3: Class Level

Survey section	Hypothesis	Alpha level	p-value	Kendall's tau-c	Interpretation
Overall	H_0: There is no relationship between the students' employment status and their Digital Technology Skills. H_1: There is a relationship between the students' employment status and their Digital Technology Skills.	5%=0.05	0.005742	0.194907	We reject the null hypothesis H_0
1	H_0: There is no relationship between the students' employment status and their Cybersecurity Awareness. H_1: There is a relationship between the students' employment status and their Cybersecurity Awareness.	5%=0.05	0.240681	0.079815	We fail to reject the null hypothesis H_0
2	H_0: There is no relationship between the students' employment status and their Level of Internet or World Wide Web Skills. H_1: There is a relationship between the students' employment status and their Level of Internet or World Wide Web Skills.	5%=0.05	0.000426	0.239352	We reject the null hypothesis H_0
3	H_0: There is no relationship between the students' employment status and their Proficiency level with Productivity Software. H_1: There is a relationship between the students' employment status and their Proficiency level with Productivity Software.	5%=0.05	0.000171	0.243333	We reject the null hypothesis H_0

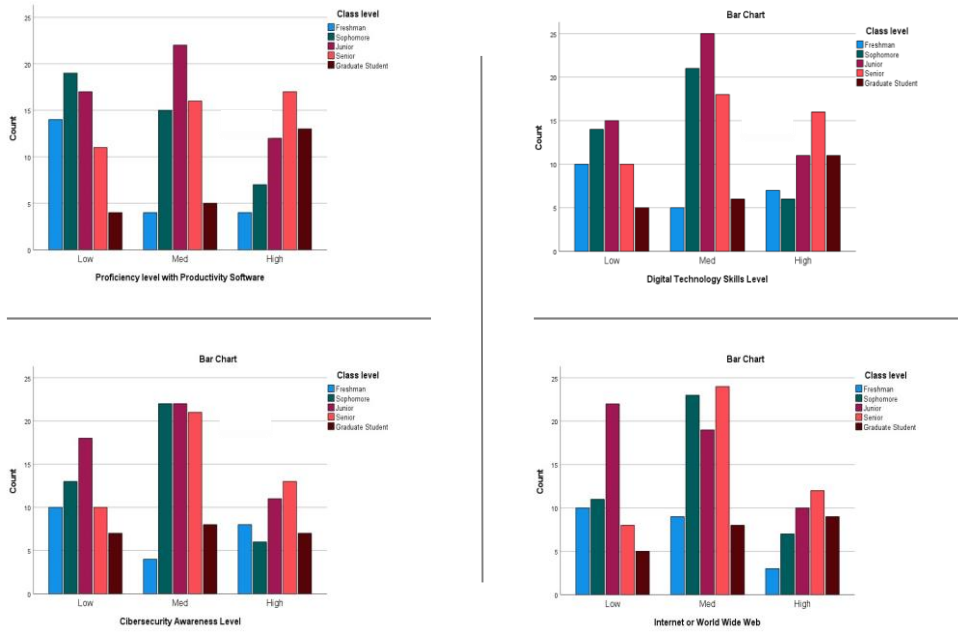
Table 4: Employment Status

Survey section	Hypothesis	Alpha level	p-value	Kendall's tau-c	Interpretation
Overall	H_0: There is no relationship between the students' occupation and their Digital Technology Skills. H_1: There is a relationship between the students' occupation and their Digital Technology Skills.	5%=0.05	0.010246	0.174537	We reject the null hypothesis H_0
1	H_0: There is no relationship between the students' occupation and their Cybersecurity Awareness. H_1: There is a relationship between the students' occupation and their Cybersecurity Awareness.	5%=0.05	0.105233	0.114074	We fail to reject the null hypothesis H_0
2	H_0: There is no relationship between the students' occupation and their Level of Internet or World Wide Web Skills. H_1: There is a relationship between the students' occupation and their Level of Internet or World Wide Web Skills.	5%=0.05	0.004028	0.197222	We reject the null hypothesis H_0
3	H_0: There is no relationship between the students' occupation and their Proficiency level with Productivity Software. H_1: There is a relationship between the students' occupation and their Proficiency level with Productivity Software.	5%=0.05	0.002866	0.205463	We reject the null hypothesis H_0

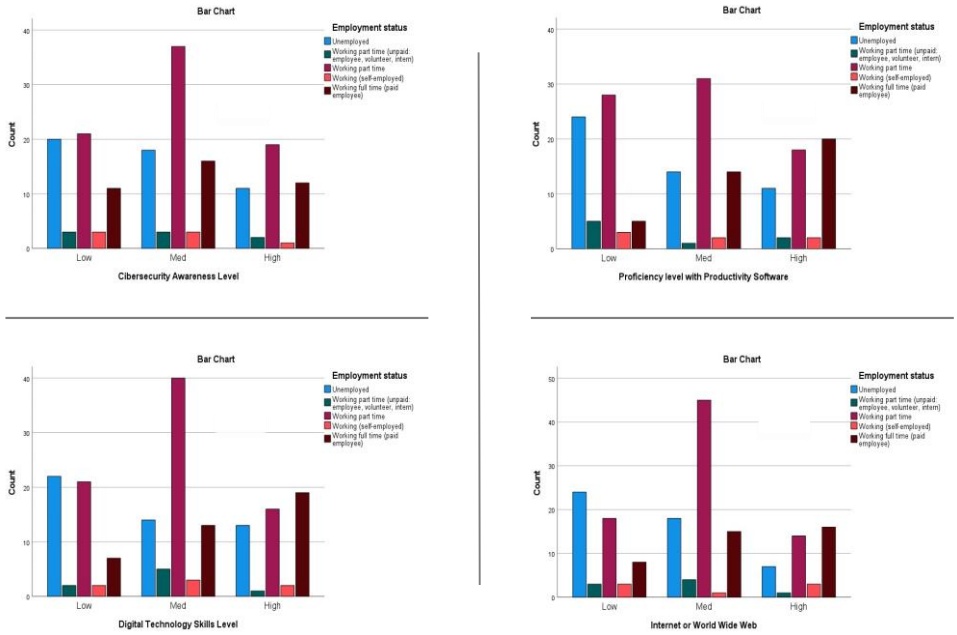
Table 5: Occupation



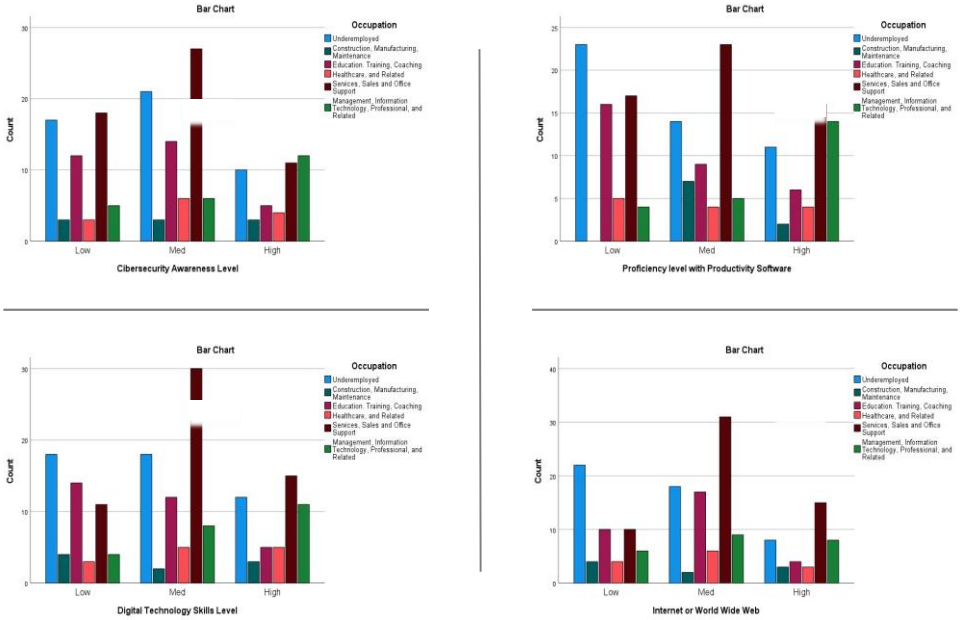
Graph 1: Gender



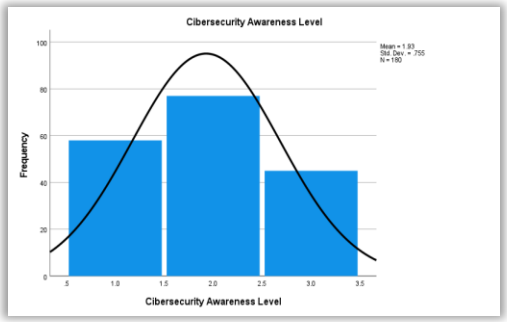
Graph 2: Class Level



Graph 3: Employment Status



Graph 4: Occupation



Graph 5: Cybersecurity Awareness Level

Cybersecurity Awareness Level

		Frequeny	Percent	Valid Percent	Cumulative Percent
Valid	Low	58	32.2	32.2	32.2
	Med	77	42.8	42.8	75.0
	High	45	25.0	25.0	100.0
	Total	180	100.0	100.0	

Table 6: Cybersecurity Awareness Level - Frequencies

The students' background does not seem to have a connection (correlation) with their cybersecurity awareness level. Sultan (2019) argued that the cybersecurity awareness gap is a new 'digital divide' that needs to be addressed with urgency by both sectors, public and private, due to the increasing information security threats and attacks, and their kinetic effects on the real world. Finally, the term "digital divide" relates to inequalities in access to computers, and the Internet between groups of people based on one or more dimensions of social or cultural identity (Gorski, 2005). Furthermore, according to Tarman (2003), the digital divide exists at every possible level: local, national, and globally, but this concept of the digital divide fails to fully capture the inequality and alienation caused by unequal access to technology and education.

5. Conclusions and Future Work

There are some benefits derived from assessing students' DTS in higher education. For example, assessments may reveal the types of new DTS students need to learn, and whether their professional background and/or pathways have had an impact on the DTS they acquire in school or through self-study. What's more, the results from this study may also provide some input for curriculum development, and it could be a conversation starter to create a more formal DTS assessment instrument for school-wide implementation.

Some possible limitations of the study are related to: (1) Sample size. The response rate and the lack of representation from other academic disciplines prevent the generalization of findings (Monroe & Adams, 2012), even if the results are intended to benefit a segment of the student body (business students), and not the entire higher education population. (2) The DTS definition does not cover all technical aspects. This narrow focus (three key areas in the survey) is the researchers' preference, and the practical limitations (i.e., time, cost, participation, etc.) that come naturally with exploring this broad topic. (3) research from the social sciences provides a myriad of approaches to survey creation, administration, and testing. For instance, Hopwood et al. (2018) suggested that questionnaires and responses should be tested between control and test groups, to determine if they produce consistent results over time, since the interpretation of questions may change over time. However, this study is not intended to be longitudinal. (4) The scope of Digital Technology Skills for self-assessment is not broad enough due to practical limitations (e.g., time, availability of participants, etc.). Althubaiti (2016) noted that research that includes self-assessments is best done when combining self-reporting tools with other information, such as individual's behavior or physiologic data. However, this study does not include the analysis of the behavioral component since this issue is beyond the scope of the study.

The results from this study will be instrumental in creating awareness for the new type of DTS that are needed to perform well in today's workplace (Ciarli et al., 2021). Additionally, the current evaluation of DTS post-pandemic is a conversation that may prompt schools to offer flexible alternatives to self-paced DTS learning and more formal DTS instruction in the classroom. Consequently, future research should include comparisons between the student body of the different schools in a university setting, to examine how other academic areas fare against computer science students, and future work should also include administering two different self-assessment surveys to the same group of participants, because of the natural limitations of self-reporting surveys.

For instance, Devaux & Sassi (2016) pointed out that people are often biased when they report on their own experiences because they are either consciously or unconsciously influenced by "Social Desirability" (i.e., underreport socially undesirable attitudes and behaviors and to over report more desirable attributes). Finally, the researchers strongly believe that continuous monitoring and assessment of emerging DTS will be beneficial to all university graduates as they seek to fit better in tomorrow's work environment (Perifanou et al., 2021).

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