The Relative Importance of Digital Competences for Predicting Student Learning Performance: An Importance-Performance Map Analysis

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Abstract: Today's higher education learning environment expects students to have such digital skills as navigating a learning management system, using word processing or presentation software, and searching for online information. The widespread use of digital technology in teaching and learning has necessitated a need for students to be digitally competent in order to perform well in their studies. However, different types of digital competence may be necessary at different stages of the students' learning journey, and some digital competences may be more essential to students' academic performance than others. To identify the digital competences that students perceive to be most important for their learning performance, and to determine students' perception of their level of performance in these digital competences, this study adopted the Digital Competence Framework for Citizens 2.2 (DigComp) to design a survey questionnaire and collect responses from university students. An importance-performance map analysis (IPMA) was conducted to examine the relative importance of each of the five digital competence areas and the 21 digital competences identified in DigComp, as well as how each performs in relation to the others, in predicting student learning performance. Study findings revealed that the problem solving competence area was perceived to be the most important for student learning performance, followed by information and data literacy, and communication and collaboration. The respondents did not perceive the digital content creation and safety competence areas as important for their learning performance. The study findings also found that the respondents differed in their perception of how well they were performing in these competence areas. Using DigComp as a point of departure, this study makes a novel attempt to determine the relative importance of each of the five digital competence areas and 21 digital competences identified in the framework, as well as how each one compares to the others in performance when it comes to predicting how well students will perform in their learning.

Keywords: DigComp, digital competences, digital skills, higher education, importance-performance map

1. Introduction

From primary and secondary schools to universities, today's students are utilising digital technology to varying degrees in their learning. In addition to searching for information on the web, students learn to use a variety of computer hardware, software, and telecommunication technologies, such as digital devices (e.g., computers, smartphones), productivity software (e.g., Google Docs Editors, Office 365), messaging apps (e.g., WhatsApp, Telegram), learning management systems (e.g., Moodle, Blackboard), and so on. The role of digital technology has become even more significant during the COVID-19 pandemic when learning was delivered online because of large-scale school closures.

Students must possess the necessary digital competences in terms of knowledge, skills, and attitudes to effectively use digital technology for learning (Vuorikari, Kluzer and Punie, 2022). The levels of students' digital competence vary depending on their prior experience with digital technology and how they apply that technology in their learning. Students may need to go beyond basic usage of digital technology to achieve higher proficiency levels because digital competence is multi-faceted and includes topics such as information and data literacy; communication and collaboration; media literacy; digital content creation; safety; intellectual property; problem solving; and critical thinking (European Commission, 2019). Knowing how to send a text message and conduct a web search will not suffice to improve academic performance.

This study adopted the Digital Competence Framework for Citizens 2.2 (DigComp) (Vuorikari, Kluzer and Punie, 2022) to design a survey questionnaire and collect responses from university students at a local university. Specifically, an importance-performance map analysis (IPMA) was conducted to examine the importance of each of the five digital competence areas and 21 digital competences, and how they compare to each other in predicting how well students will perform in their learning.

The study findings may help educational institutions, educators, and students to improve students' learning performance by helping them to identify and prioritise digital competences that are important but have a low performance level. The study findings may also help educational institutions and educators identify competence gaps, which would enable them to devise action plans to help students develop their digital competence and proficiency.

The remainder of this paper provides a background to the research, explains the research design and method, presents the data analysis results, and concludes with a discussion of the study findings.

2. Research background

2.1 Digital competence

Digital competence is a broad concept with multiple dimensions (Ilomäki et al., 2016), involving not only the effective use of digital tools but also digital behaviours (e.g., communication, teamwork) and digital mindsets (e.g., lifelong digital learning) (Martzoukou et al., 2021). Digital competence is a mix of knowledge, skills, and attitudes that can be developed throughout life in both formal and informal learning settings (European Commission, 2019).

Another concept that is frequently used interchangeably with digital competence is digital literacy (Ilomäki et al., 2016). While digital literacy refers to the technical skills of using digital tools from a technical perspective, digital competency is a broader concept involving a socio-cultural perspective of the knowledge, capabilities, and dispositions that individuals and society need to be successful in the digital age (Falloon, 2020).

To examine the synonymous use of the digital competence and digital literacy concepts, Spante et al. (2018) conducted a systematic review of articles in higher education research. They reported that the use of the concepts varies based on such characteristics as regions (e.g., US or Continental Europe), disciplines (e.g., health or teacher education), research aims (e.g., developing educational systems or developing student competence), and research focus (e.g., macro at societal level or micro at student level).

The development of DigComp is based on the European Commission's definition of digital competence, which states:

> *Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking (European Commission, 2019, p. 10).*

As digital competence is one of the key competences for lifelong learning (European Commission, 2019), it may be advantageous for students to begin acquiring digital competence in primary school and for teachers to use appropriate pedagogical practices to support students and prepare them for the digital age (Pöntinen and Räty-Záborszky, 2020). Ilomäki et al. (2016) suggest that being able to use and apply digital technologies should be embedded in all learning and teaching. Learning these skills requires practising them through complex, challenging, and authentic learning activities.

2.2 Digital Competence framework for citizens (DigComp)

DigComp was developed to help people in the European Union assess their digital competence for learning, working, and societal participation purposes. It also helps in decision-making and the formulation of digital policy and strategy. DigComp has gone through several iterations, i.e., DigComp 1.0 in 2013, DigComp 2.0 in 2016, DigComp 2.1 in 2017, and the latest DigComp 2.2 in 2022 (Vuorikari, Kluzer and Punie, 2022).

DigComp identifies 21 digital competences that are grouped into five key competence areas, i.e., information and data literacy, communication and collaboration, digital content creation, safety, and problem solving. These digital competences indicate the knowledge, skills, and attitudes that are needed to use digital technology well.

DigComp is organised into five dimensions: (1) Dimension one identifies the five digital competence areas; (2) Dimension two describes each of the 21 digital competences; (3) Dimension three details the proficiency levels of each competence; (4) Dimension four provides examples of knowledge, skills, and attitudes relevant to each competence; and (5) Dimension five provides some use cases.

3. Research design and method

3.1 Construct operationalisation

To operationalise the constructs, this study adopted DigComp's 21 digital competences that are grouped into five key competence areas, i.e., information and data literacy, communication and collaboration, digital content creation, safety, and problem solving (Vuorikari, Kluzer and Punie, 2022). Notably, each digital competence can have eight levels of proficiency, from being able to perform simple tasks to solving complex problems. In a way, it is very similar to moving up Bloom's cognitive hierarchy from remembering, understanding, applying, and evaluating, to creating (Anderson and Krathwol, 2001).

As the target respondents of this study were bachelor's degree students at a local university, to measure their proficiency level for each digital competence, this study adapted proficiency level five (i.e., applying), with the expectation that as undergraduate university students, the respondents are supposed to be able to perform different tasks and solve different problems, as well as guide others. To measure perceived learning performance, five self-developed items were used. Table 1 presents a summary of the operationalisation of the constructs.

Table 1: Operationalisation of the constructs

Construct	Indicator Code	Indicator Description	Mean	SD	Outer weight	P value
Information and data literacy	Info_1	I can use search engines and their search functions to search for digital data, information, and content.	3.79	.946	0.383	<0.001
	Info_2	I can evaluate the credibility and reliability of different digital data, information, and content.	3.51	.876	0.369	<0.001
	Info_3	I can manage digital data, information, and content for easier organisation, storage, and retrieval.	3.62	.905	0.363	<0.001
Communication and collaboration	Comm_1	I can use a variety of digital technologies to interact with others.	3.81	.923	0.187	<0.001
	Comm_2	I can share digital data, information, and content through a variety of appropriate digital tools.	3.75	.906	0.201	<0.001
	Comm_3	I can participate in society as a citizen through the use of public and private digital services.	3.64	.919	0.213	<0.001
	Comm_4	I can propose different digital tools and technologies for collaborative purposes.	3.54	.929	0.195	<0.001
	Comm_5	I am aware of different behavioural norms and know-how while using digital technologies to interact with others in a digital environment.	3.60	.928	0.202	<0.001
	Comm_6	I can use different ways to protect my reputation online.	3.57	.920	0.170	<0.001
Digital content creation	Create_1	I can use different ways to create and edit content in different formats.	3.57	.951	0.290	<0.001
	Create_2	I can modify, refine, improve, and integrate digital information and content to create new, original and relevant content and knowledge.	3.49	.960	0.317	<0.001
	Create_3	I can use different rules of copyright and licenses that apply to digital data, information, and content.	3.43	.984	0.257	<0.001

Construct	Indicator Code	Indicator Description	Mean	SD	Outer weight	P value
	Create_4	I can operate, with the help of instructions, a computing system to solve different problems or perform different tasks.	3.54	.894	0.291	<0.001
Safety	Safety_1	I can use different ways to protect devices and digital data, information, and content.	3.46	.936	0.306	<0.001
	Safety_2	I can use different ways to protect my personal data and privacy in a digital environment.	3.52	.940	0.266	<0.001
	Safety_3	I know how to avoid health-risks and threats to physical and psychological well-being while using digital technologies.	3.56	.931	0.287	<0.001
	Safety_4	I can show different ways to protect the environment from the impact of digital technologies and their use.	3.43	.974	0.295	<0.001
Problem solving	Problem_1	I can use different solutions to technical problems in a digital environment and operating digital devices.	3.41	.949	0.283	<0.001
	Problem_2	I can use different digital tools and possible technological solutions to solve personal needs.	3.56	.892	0.299	<0.001
	Problem_3	I can use different digital tools and technologies to create knowledge and innovative processes and products.	3.45	.969	0.263	<0.001
	Problem_4	I am aware of specific aspects in my digital competence that need to be improved on or updated.	3.50	.953	0.289	<0.001
Perceived learning performance	Perform_1	My current overall level of digital competence is sufficient for me to acquire new knowledge.	3.65	.834	0.229	<0.001
	Perform_2	My current overall level of digital competence is sufficient for me to improve my academic performance.	3.64	.804	0.239	<0.001
	Perform_3	My current overall level of digital competence is sufficient for me to complete my assignments better.	3.69	.764	0.235	<0.001
	Perform_4	My current overall level of digital competence is sufficient for me to enhance my ability to learn new things.	3.71	.777	0.220	<0.001
	Perform_5	My current overall level of digital competence is sufficient for me to overcome academic challenges.	3.61	.828	0.220	<0.001

3.2 Data collection

A survey instrument was designed to collect data in an online questionnaire survey. The questionnaire consisted of eight sections. Section A asked questions about the learning of digital skills. Sections B to F asked questions about digital competence proficiency. All items were measured using a five-point Likert-type scale, with 5 being "very proficient" and 1 being "not proficient at all." Section G asked about learning performance. All items were measured using a five-point Likert-type scale, with 5 being "strongly agree" and 1 being "strongly disagree." Section H asked several demographic questions.

Bachelor's degree students at a local university were invited to voluntarily complete the online survey questionnaire anonymously. The data collection lasted about three weeks and received a total of 314 responses. A check was performed for multivariate outliers. Using the rule that a response is considered an outlier if the probability of its squared Mahalanobis distance is equal to or less than 0.001 (Tabachnick and Fidell, 2007), there were no outliers and zero responses were removed. Thus, 314 valid responses were retained for further data analysis.

All the 314 respondents were students studying such majors as accounting, business administration, logistics management, marketing, and so on. Of these respondents, 167 (53.2%) were female and 147 (46.8%) were male. Their average age was 20.96 years old, with a minimum age of 18 and a maximum age of 29. In order of frequency, 76 of them (24.2%) were currently in semester 6 or later, 72 (22.9%) in semester 3, 55 (17.5%) in semester 2, 47 (15%) in semester 4, 36 (11.5%) in semester 5, and 28 (8.9%) in semester 1.

The majority of the respondents reported that they obtained their knowledge and skills to work with digital technology from websites (70.4% of the respondents), followed by classes at school (66.6%), YouTube videos (63.4%), friends (51%), and trial and error (30.6%). In order of frequency, 145 respondents (46.2%) agreed and 82 (26.1%) strongly agreed that learning digital skills should be a lifelong personal initiative. However, 34 respondents (10.8%) strongly disagreed and 4 (1.3%) disagreed, whereas 49 respondents (15.6%) somewhat agreed.

4. Data analysis and results

Data were analysed using SPSS for descriptive analysis and SmartPLS for importance-performance map analysis (IPMA). An IPMA can be performed on both the construct and indicator levels. There are two dimensions on an importance-performance map. The x-axis represents the importance dimension, which indicates the total effects of the constructs or indicators on the target construct. The higher the total effect, the more important a construct or indicator is for the target construct. The y-axis represents the performance dimension, which indicates the average rescaled latent variable scores for constructs or rescaled scores for indicators, rescaled to a range from 0 to 100. The higher the score is, the better a construct or indicator performs in relation to the target construct. An IPMA provides useful information that can be used to make decisions about the prioritisation of constructs or indicators by considering their relative importance and performance in relation to the target construct. The prioritisation decisions can assist in the improvement of the target construct (Ringle and Sarstedt, 2016).

Following the suggestion by Ringle and Sarstedt (2016), three requirements were first checked before performing the IPMA: (1) indicators are measured using a metric scale; (2) same scale coding direction; and (3) outer weights estimates must be positive. The measurement and coding of the indicators had already met the first two requirements. The bootstrapping results of 5,000 samples showed that all indicators had positive outer weights and were significant at a 95% significance level (see Table 1).

4.1 IPMA on the construct level

Table 2 indicates the importance and performance values of the constructs, i.e., communication and collaboration, digital content creation, information and data literacy, problem solving, and safety, in relation to the target construct, i.e., perceived learning performance.

Table 2: Importance and performance values of the constructs

Construct	Importance (Total effect)	Performance (Average rescaled LV score)
Communication and collaboration	0.139	66.255
Digital content creation	0.089	62.790
Information and data literacy	0.155	65.963
Problem solving	0.251	62.103
Safety	0.079	62.262

Figure 1 depicts the importance-performance map using a scatter chart based on the analysis results. The x-axis represents the importance of the constructs for explaining the target construct, while the y-axis represents the performance of the constructs in terms of their average rescaled latent variable scores.

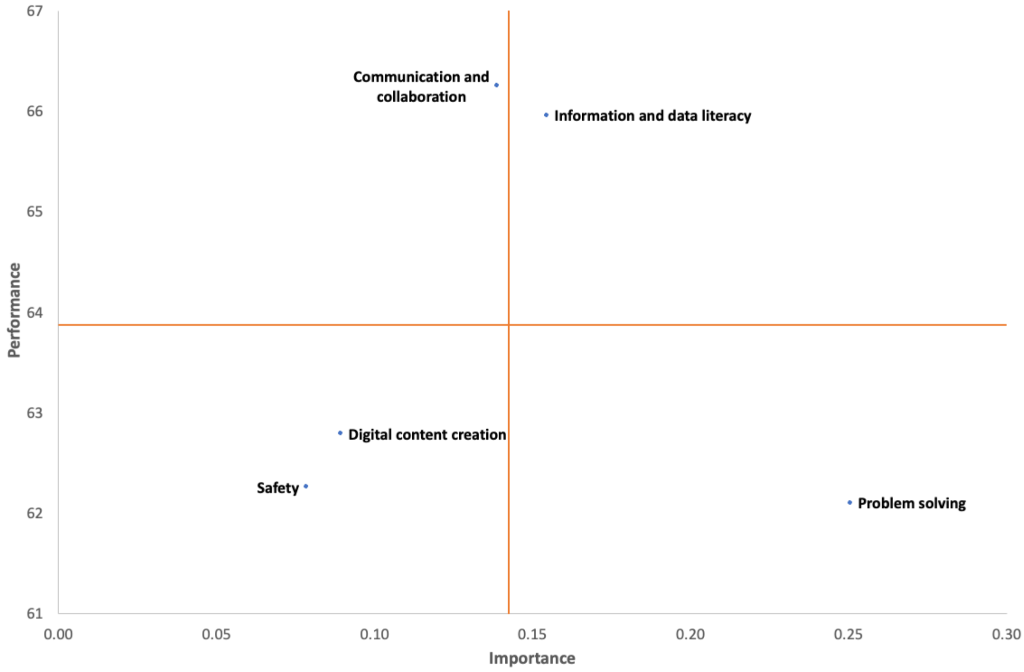

Figure 1: Importance-Performance map of constructs on perceived learning performance

The constructs, i.e., communication and collaboration, digital content creation, information and data literacy, problem solving, and safety, had an average importance value of 0.142 and an average performance value of 63.874. Figure 2 shows that the importance-performance map was divided into four quadrants with the plotting of the average importance value (vertical line) and average performance value (horizontal line). The four quadrants are: Quadrant 1 (above-average importance, above-average performance, known as "keep up the good work"); Quadrant 2 (below-average importance, above-average performance, known as "possible overkill"); Quadrant 3 (below-average importance, below-average performance, known as "low priority"); and Quadrant 4 (above-average importance, below-average performance, known as "concentrate here") (Hosseini and Ziaei Bideh, 2013). In terms of priority for making performance improvement for the target construct, Quadrant 4 is the top priority, followed by Quadrant 1, Quadrant 3, and Quadrant 2 (Ringle and Sarstedt, 2016).

Problem solving was in Quadrant 4. Problem solving has a below-average performance of 62.103 but an above-average importance of 0.251 relative to other constructs. This implies that a one-unit increase in the performance of problem solving from 62.103 to 63.103 would increase the performance of perceived learning performance by 0.251 points, from 66.538 to 66.789. As for other constructs, information and data literacy were in Quadrant 1, digital content creation and safety in Quadrant 3, and communication and collaboration in Quadrant 2.

4.2 IPMA on the indicator level

Table 3 indicates the importance and performance values of all the indicators of the constructs, i.e., communication and collaboration, digital content creation, information and data literacy, problem solving, and safety, in relation to the target construct, i.e., perceived learning performance. When the analysis is expanded to the indictor level, it is possible to determine which specific aspects of the construct are the most significant (Ringle and Sarstedt, 2016).

Table 3: Importance and performance values of the indicators

Indicator Code	Importance (Total effect)	Performance (Rescaled score)
Comm_1	0.022	70.223
Comm_2	0.024	68.710
Comm_3	0.025	65.924
Comm_4	0.023	63.376
Comm_5	0.024	64.968

Indicator Code	Importance (Total effect)	Performance (Rescaled score)
Comm_6	0.020	64.172
Create_1	0.022	64.331
Create_2	0.024	62.261
Create_3	0.019	60.828
Create_4	0.024	63.455
Info_1	0.051	69.745
Info_2	0.053	62.818
Info_3	0.051	65.446
Problem_1	0.062	60.271
Problem_2	0.069	64.092
Problem_3	0.056	61.226
Problem_4	0.063	62.500
Safety_1	0.021	61.465
Safety_2	0.018	62.898
Safety_3	0.020	63.933
Safety_4	0.019	60.828

Figure 2 depicts the importance-performance map using a scatter chart based on the analysis results. The x-axis represents the importance of all the indicators of the constructs, i.e., communication and collaboration, digital content creation, information and data literacy, problem solving, and safety, for explaining the target construct, i.e., perceived learning performance, while the y-axis depicts the performance of the indicators in terms of their rescaled scores.

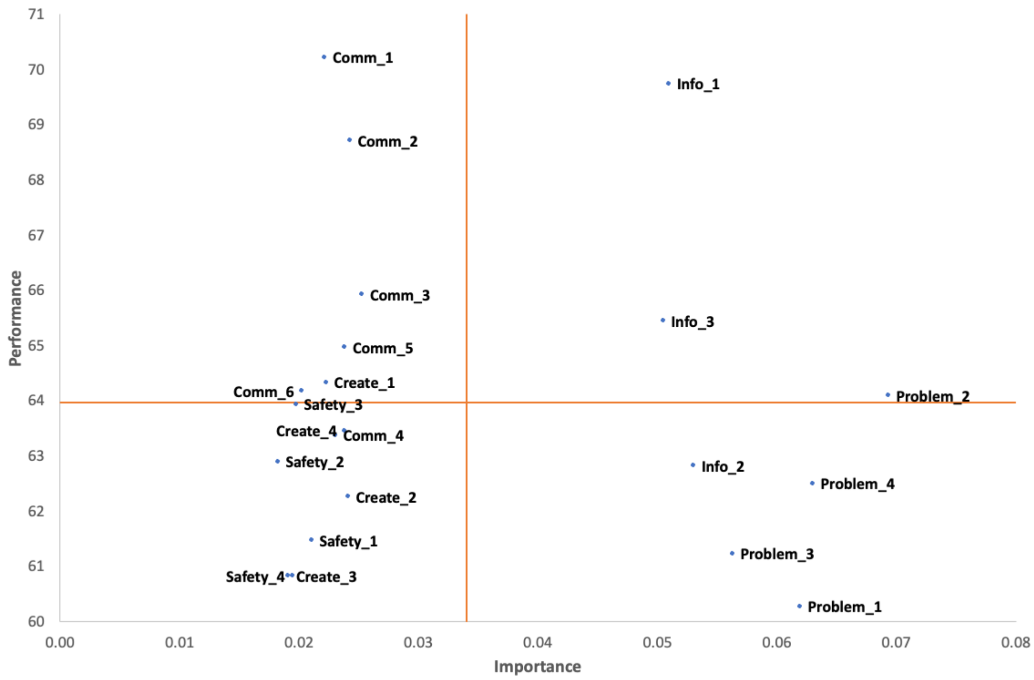

Figure 2: Importance-Performance map of indicators on perceived learning performance

The indicators had an average importance value of 0.034 and an average performance value of 63.975. Figure 2 shows that the importance-performance map was divided into four quadrants with the plotting of the average importance value (vertical line) and average performance value (horizontal line).

Four indicators, i.e., Info_2, Problem_1, Problem_3, and Problem_4, were in Quadrant 4. These indicators had a below-average performance of 62.818, 60.271, 61.226, and 62.500 respectively, but above-average importance of 0.053, 0.062, 0.056, and 0.063, respectively, relative to other indicators. This implies that a one-unit increase in the performance of Info_2, Problem_1, Problem_3, and Problem_4 would increase the performance of the individual indicators of perceived learning performance by 0.053, 0.062, 0.056, and 0.063 points, respectively. As for other constructs, three indicators were in Quadrant 1, eight indicators in Quadrant 3, and six indicators in Quadrant 2.

5. Discussion and conclusion

It appears that school classes are not the only means by which the respondents learn about digital technology; when they needed to learn or had a question about digital technology, most of them searched for information on websites or YouTube videos. This may be because the respondents are in their early twenties and this generation is accustomed to using the web as a key source of information. The majority of them also agreed or strongly agreed that learning digital skills should be a lifelong personal initiative. This finding reflects the common understanding that people need to continuously learn as digital technology evolves (European Commission, 2019; Vuorikari, Kluzer and Punie, 2022). This is even more essential because of the rapid advancement and proliferation of technology, e.g., artificial intelligence, blockchain, and the current trend towards smart nations.

Regarding the digital competence areas, the finding shows that problem solving is relatively more important than communication and collaboration, digital content creation, information and data literacy, and safety for improving student learning performance. This seems to be reasonable because problem solving is mostly about selecting and using the right digital tools to meet personal needs and to create knowledge, innovative processes, or products; identifying and solving technical problems in the course of using these tools; and improving one's digital competence, and thus the problem solving competence area is essential for one's learning performance. However, the respondents perceived that their performance in this competence area was considerably lower than in any of the other four competence areas. Therefore, it may be helpful for future learning design and delivery to incorporate learning activities that can help students improve their problem solving capabilities.

The second and third most important competence areas for improving student learning performance are information and data literacy, and communication and collaboration. The respondents reported above average performance levels in these two competence areas. This reflects that the respondents are familiar with browsing, searching, filtering, evaluating, and managing data, information, and digital content. In addition, the respondents are also comfortable with interacting and sharing data, information, and digital content with others through digital technologies for communication and collaboration purposes. As information and data literacy is perceived to be above-average important for student learning performance, there is room for future learning design and delivery to further enhance students' information and data literacy. However, the respondents considered communication and collaboration to be of below-average importance for their learning performance. It may be reasonable to presume that the use of digital technologies for communication and collaboration purposes is taken for granted by the respondents as everyday activities, and they do not quite see how this can directly contribute to their learning performance.

It is interesting to note that the respondents considered digital content creation and safety to be of below-average importance to their learning performance, and they also did not think they were performing well in these two competence areas. Digital content creation mainly concerns creating and editing new original digital content in different formats with an understanding of copyright and license issues, whereas safety mainly concerns safeguarding digital devices, digital content, personal data, and privacy, as well as protecting health and the environment related to the use of digital technologies. This finding does not mean that digital content creation and safety are not important competence areas. It is possible that because DigComp was originally designed as a general assessment tool to be used in many different contexts, the respondents may not see a direct link between these two competence areas and their performance in the higher education context specifically.

On the indicator level, the findings are rather consistent with those of the construct level. Three problem solving and one information and data literacy competences are perceived to be of above-average importance for student learning performance. However, the respondents perceived that they performed below average in these competences. Notably, the respondents perceived the ability to evaluate the credibility and reliability of sources of data, information, and digital content as particularly important for their learning performance. This finding is significant given the enormous amount of information that is available on the web. Students need to be able to differentiate credible and reliable information from that which is not.

Two information and data literacy and one problem solving competences are above-average important for student learning performance, and the respondents perceived that they were performing above average in these competences. This finding points to the fact that being able to search for and manage data, information, and digital content based on information needs and to select and use digital tools to meet learning needs is essential for academic performance, and the respondents felt they were able to perform these tasks well. This finding supports the idea that an importance-performance analysis at the indicator level provides more useful information than one at the construct level. It also shows that although the respondents did not think they performed well on three other problem solving competences, they thought they performed better than average when it comes to selecting and using digital tools to meet learning needs.

The respondents reported that they performed above average on most of the communication and collaboration competences. This finding is to be expected because of the widespread use of digital tools among today's young generation for communication and collaboration purposes (e.g., social media, e-mail). This may be one reason the respondents are generally confident in their performance in these competences. Similar to the findings at the construct level, the importance of most communication and collaboration competences is relatively below average for student learning performance. Similar to the findings at the construct level, most of the digital content creation and safety competences are below-average important for student learning performance, and the respondents did not think they performed well in these competences.

In conclusion, this study provides an insight into the weaknesses and strengths of current learning design and delivery based on the importance of the 21 digital competences and how well the respondents think they were performing in these competences. If the respondents do not think they are doing well in any competences that are perceived to be of above-average importance, future learning design and delivery will need to improve these major weaknesses. On the other hand, if the respondents reported that they are performing well in any competences that are above-average important, future learning design and delivery will need to leverage these major strengths to further enhance student learning performance (Phadermrod, Crowder and Wills, 2019).

When aiming to enhance student learning performance, the study findings suggest that the top priority is to design learning delivery to help students improve their problem solving competences because these competences have a greater effect on student learning performance, but students do not seem to have a high level of proficiency in these competences. The second priority is to further improve their information and data competences, although the students already feel quite proficient in these competences. Although the finding shows that the digital content creation and safety competences are perceived by the respondents to play a less significant role in their learning performance, given the significance of these competences in digital societies and nations, the third priority is to help students gain a higher level of proficiency in these competences to better prepare them for their societal encounters. The fourth priority is to help students leverage their high level of proficiency in communication and collaboration competences for better learning performance.

Since the study was conducted in a local setting, the results may apply to other undergraduate students in a similar local setting, but they may not apply to other settings. Future research could perform a multigroup analysis to compare different groups of students in terms of education levels (e.g., primary, secondary, undergraduate, postgraduate), nations (e.g., Asian, European), programmes (e.g., business, computing, engineering), learning environments (e.g., face-to-face, blended, online), and so on to examine whether students differ in terms of the importance and performance of digital competences.

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