Competencies in Computer Security and Resolution of Technological Problems in Higher Education Students

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Abstract

Starting from the importance of preserving our information and protecting our devices against attacks on their vulnerabilities, this article aims to establish the level of knowledge in computer security and problem-solving of students at a university in northwest Mexico. This research has a quantitative approach where the European Framework of Digital Competencies for Citizenship was used as a reference to identify and establish the level of the competencies that were evaluated. The IKANOS Test was used as a data collection tool. The results show that students know the importance of keeping their devices safe and how valuable the information found on them is. On the other hand, the results also show a considerable percentage of students who do not have the knowledge and are at a basic level of knowledge to solve technical problems with their devices.

Keywords

Digital Literacy, Cybersecurity, DigComp, Digital Skills, Data Protection

1. Introduction

Computers and devices are very important, as well as what they contain, for all people. It is very important to protect your computer and the valuable information on it. We just have to imagine what would happen in your life if all of your financial records, schoolwork, and personal correspondence were suddenly altered, destroyed, or publicly exposed [1]. A threat is anything that can cause harm. In the context of computing security, a threat can be a thief, a virus, an earthquake,

or a simple user error. By itself, a threat does not cause any harm unless it exploits an existing vulnerability. A vulnerability is a weakness, anything that has not been protected against threats, which opens the possibility of damage [1].

Viruses are one of the main threats to the security of our computer files. Computer viruses invade all types of computers, from mainframes, servers and personal computers to pocket computers [2], which is why we must have the knowledge to protect our devices and valuable information against these types of threats.

A competence is not static knowledge, but the application of knowledge, skills and/or attitudes in specific situations [3]. Digital competence is one of the basic competences of 21st century citizens; in Spanish universities, digital competence is included as a transversal competence [4]. Currently, with the appearance of the Internet of Things and mobile technology, digital technological infrastructures are found in the daily life of society, and the belief that their correct acquisition is necessary for true equality of opportunities and social inclusion, requires working on new digital skills that go beyond the fact of being a regular user [5].

The European Digital Competence Framework for Citizenship (DigComp) was first published in 2013 by the European Commission. This reference framework was intended to be a tool to improve the digital competence of citizens, supporting the countries of the European Union in the formulation of policies that allow the development of digital competences, as well as planning education and training initiatives to improve the digital competence of specific target groups. DigComp establishes a language on how to identify and describe key areas of digital competence and therefore offers a common reference at the European level [6].

2. Methodology

In this research, the aim is to obtain only the level of competencies that belong to the competency area "Network Security" and "Problem Resolution" established by DigComp. The present work is a research with a non-experimental quantitative approach, of a descriptive cross-sectional type [7].

The research was carried out in a Faculty of a University in the Northwest of Mexico, with a population of 2450 students. The sampling used was probabilistic stratified to obtain representation of the students belonging to the three stages of training: Basic, Disciplinary and Terminal. The sample size was obtained using the following formula:

$$n = n \big/ \left(1 + \left(z2xp\left(1-p\right)\right) \big/ \left(e2N \right) \right)$$

where a confidence level of 95% and a margin of error of 5% was established, obtaining a sample size of 332 students.

The IKANOS Test was used as an instrument, which is developed by the IKANOS project, which helps citizens obtain a self-diagnosis of their digital pro-

file, based on the assessment of the following parameters: Potential for the development of digital skills, training background in the field of ICT and level of digital competence [8]. IKANOS Test uses the European Digital Competence Framework (DigComp) to establish the level of digital competence of citizens.

The Digital Competencies Framework for Citizens establishes 21 digital competencies. In Table 1, the 21 digital competencies can be identified, as well as the area of competencies to which each of them belongs.

Table 2 graphically explains the levels of competencies established by Dig-Comp.

3. Results

The results show that the average age of the students who make up the sample is 20 years. Figure 1 shows that 38% of the students are male and 62% are female students.

Competency area 4: Network security.

Table 3 shows the level of competence that students have in competence area 4: Safety.

Table 1. DigComp competency areas [9].

Competence areas	Competencies
Information and digital literacy	1.1. Browsing, searching and filtering data, information and digital content. 1.2. Evaluation of data, information and digital content 1.3. Management of data, information and digital content
Communication and collaboration	2.1. Interaction through digital technologies 2.2. Sharing through digital technologies 2.3. Citizen participation through technologies digital 2.4. Collaboration through digital technologies 2.5. Netiquette 2.6. Manage digital identity
Creation of digital content	3.1. Development of digital content 3.2. Integration and reworking of digital content 3.3. Licenses and Copyright 3.4. Programming
Network security	4.1. Device protection 4.2. Protection and privacy of personal data. 4.3. Protection of health and well-being 4.4. Environmental protection
Problem resolution	5.1. Technical problem resolution 5.2. Identification of technological needs and responses 5.3. Creative use of digital technologies 5.4. Identification of digital competence gaps

Table 2. Skill levels [10].

4 general levels	Basic		Intermediate		Advanced		Highly specialized	
8 granular levels	1	2	3	4	5	6	7	8
Task complexity	Simple task	Simple task	Well-defined routine tasks and simple problems	Well-defined non-routine tasks and problems	Different problems and tasks	Most appropriate tasks	Solve complex problems with limited solutions	Solve complex problems with greater interaction factors
Autonomy	With guide	With guidance when necessary	On my own	Independent according to my needs	I am a guide for others	Able to adapt to others in a complex context	It is integrated to contribute to professional practice and guidance for others.	Propose new ideas and processes
Cognitive domain	Memory	Memory	Comprehension	Comprehension	Applying	Evaluating	Creating	Creating

Table 3. Levels of competencies in competency area 4: Security.

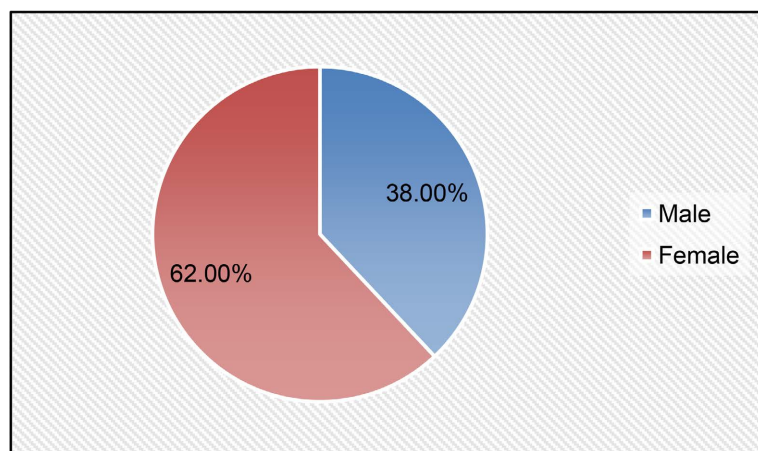| Competence	Level of competition			
	Essential	Intermediate	Advanced	Highly specialized
Device protection		x		
Protection of personal data and privacy			x	
Protection of health and well-being			x	
Environmental protection			x	

Figure 1. Gender of the sample.

Competency: Device protection.

According to what is shown in Table 3, in the "Device Protection" competition, the students are evaluated at an intermediate level. It is important to note that, although the students are at an intermediate level, a significant percentage of the students obtained the highly specialized level in terms of understanding the security advantages and risks when using devices or systems connected to the Internet, for example: smart watches or smart home devices, as shown in Figure 2.

Regarding the importance of keeping the operating system, antivirus systems and other computer programs updated to avoid security problems, 43.1% of the students are highly specialized to carry out the necessary software updates, 43.10% are at a level advanced and a small percentage are at the basic and intermediate levels, these results can be seen in Figure 3. With these results it can be inferred that a percentage greater than 80% of the students keeps their operating systems and antivirus systems updated. Devices, allowing you to increase the security of your devices and reducing the risk of being damaged by a malware attack or a system malfunction.
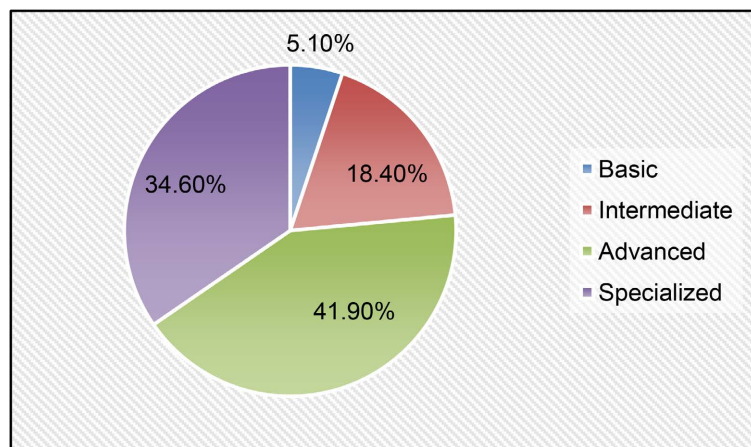

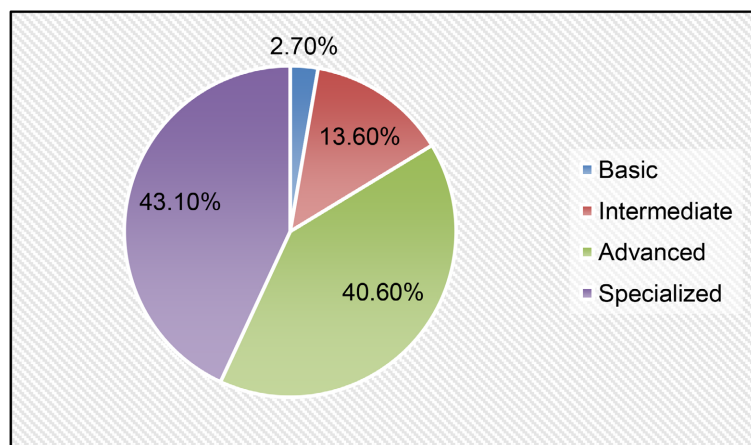**Figure 2.** Advantages and risks with devices connected to the internet.

Figure 3. Software update.

In contrast to the previous results, a considerable percentage of students do not have the knowledge or have basic knowledge to configure the firewall parameters of their devices, as shown in Figure 4. Although the majority of students deal with keeping your devices up-to-date, failing to configure firewall settings correctly increases the threat of your devices being affected by malicious software.

Beyond keeping your computer updated and with adequate configuration to prevent malicious attacks, there are several very common threats on social networks that consist of tricking users into performing actions that they should not perform and could compromise the information on their devices. In this sense, a significant percentage of students do not know how to identify the different types of threats such as phishing, 30.7% of students are at a basic level and 37% at an intermediate level. Results illustrated in Figure 5.

Competition: Protection of personal data and privacy.

Table 3 shows that the sample of students demonstrates an advanced level in the "Protection of personal data and privacy" competence; this data is consistent with the fact that the majority of students have the knowledge to restrict or deny
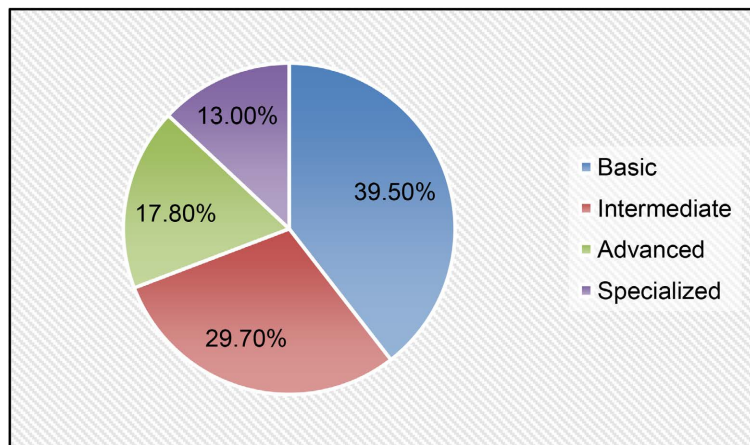
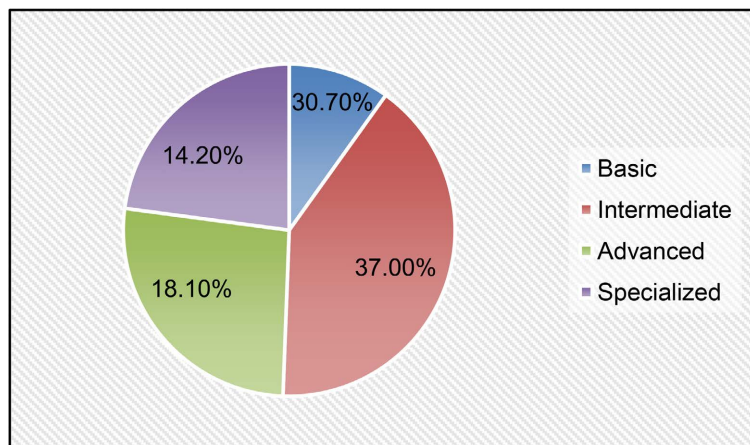**Figure 4.** Knowledge to configure firewall.

Figure 5. Knowledge of how computer viruses work.

access to the location, geographical on their devices, **Figure 6** establishes that 34.6% have a highly specialized level and 32.5% have an advanced level of competition.

Regarding the protection of personal data, there is a threat in email messages that try to violate devices with the intention of obtaining, in congruence with the advanced level in data protection competence, **Figure 7** shows that the 40.7% of students have a highly specialized level to identify suspicious email messages and 35.5% are at an advanced level, inferring that a high percentage of students can identify suspicious messages that allow greater protection of their personal data.

Another very important aspect for data protection is to identify the security of the websites that ask us to enter our personal data, these are, to identify if the website has secure protocols such as https, security certificates, or if They are hosted on government servers or commercial servers. In this sense, as shown in **Figure 8**, a percentage greater than 60% of students know how to identify the security and authenticity of the websites that ask them to enter their personal data.
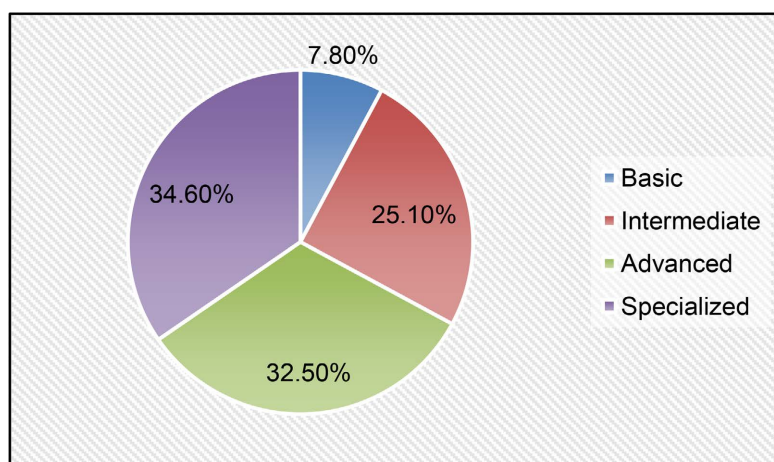

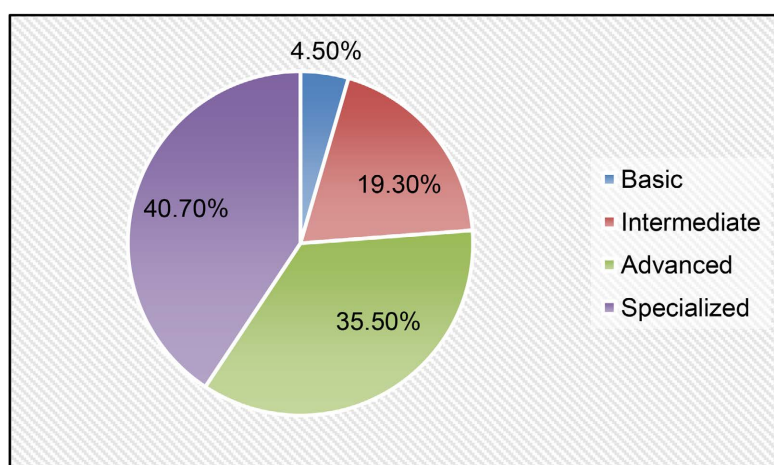
Figure 6. Geolocation service configuration.

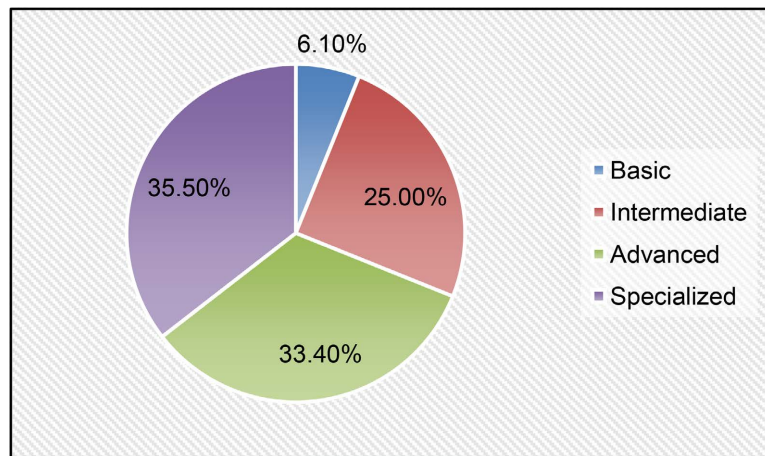**Figure 7.** Suspicious email messages.

Figure 8. Identification of secure websites.

Nowadays, people use at least one social network to share and be connected with other people, it is very important to identify that we should not share on social networks to keep our personal data safe. This research shows that 58.1% have a highly specialized level to identify which personal data should not be shared and displayed on the Internet through social networks, illustrated in **Figure 9**.

Competence: Protection of health and well-being.

As seen in **Table 3**, the students are at an advanced level with respect to the "Protection of health and well-being" competence; in **Figure 10**, only 2.4% of the students are not aware that they must manage their time. What happens using their digital devices, and a percentage greater than 80% are very aware of the effects that devices can cause when using them.

Another issue in terms of health protection is to be careful with ergonomic aspects when using the devices, such as taking care of the lighting, the posture in which they remain, as well as sedentary lifestyle. In the same sense of the advanced level of the students in terms of health protection, only 5.4% of the students do not have sufficient knowledge to take care of the ergonomic aspects when using their devices and thus prevent possible effects on their health (illustrated in **Figure 11**).

Competence: Protection of the environment.

Digital devices that are no longer used or become obsolete are electronic waste that become a potential pollutant for the environment. As seen in **Table 3**, in the "Protection of the environment" competence, students infer an advanced level of competence; in congruence with this result, 43.7% of students have an advanced level of knowledge on how they should be eliminated no longer using devices or digital consumables, such as placing them in places where they can be recycled to minimize their environmental impact (as illustrated in **Figure 12**).

Another very important aspect for caring for the environment is reducing electricity consumption or the use of green energy. Therefore, the relevance of having the knowledge to configure our devices that allow the greatest possible energy savings, as shown in **Figure 13**, the majority of students have an ad-

vanced and highly specialized level to configure their devices to save energy, such as closing applications that are not being used, turning off Wi-Fi or Bluetooth when they need to be on.
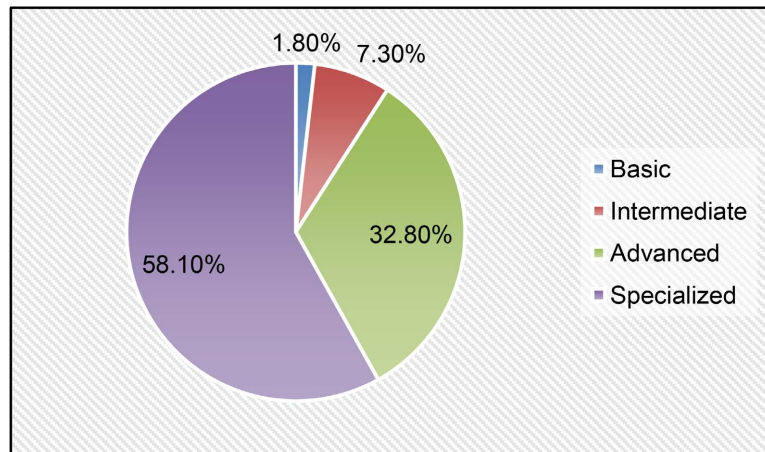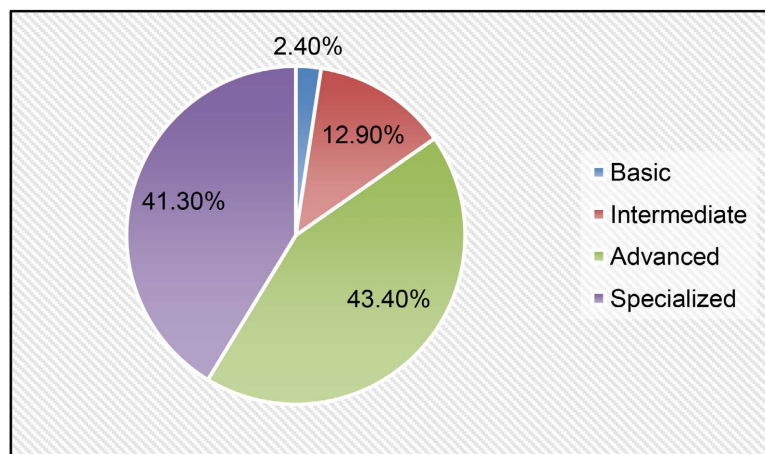

Figure 9. Share personal data.

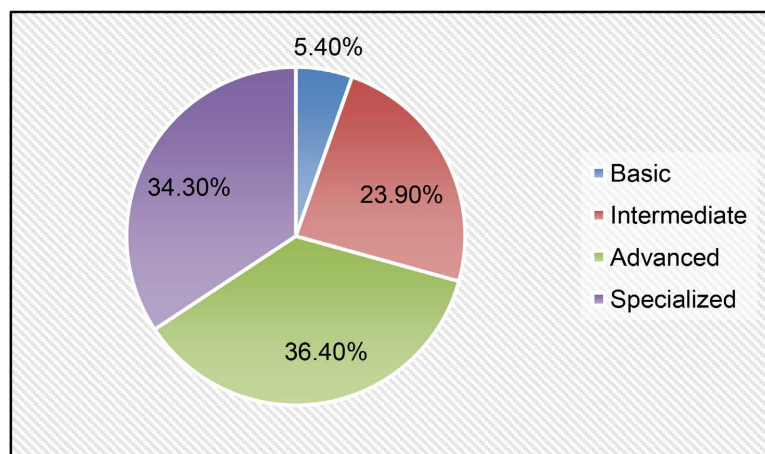**Figure 10.** Management of time of use of digital devices.

Figure 11. Care of ergonomic aspects.

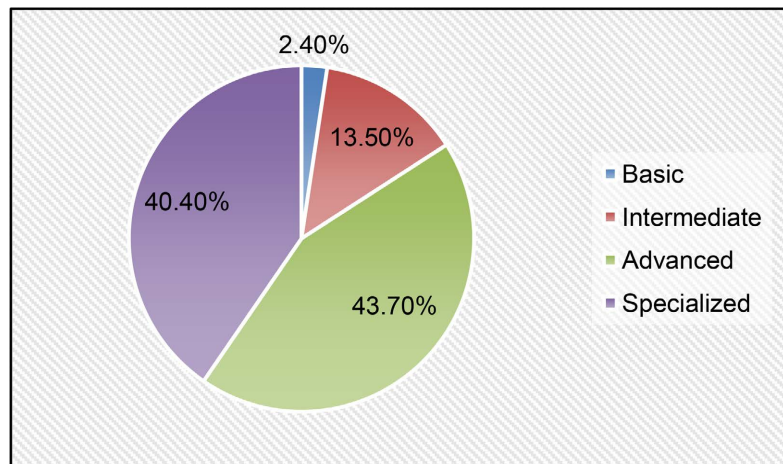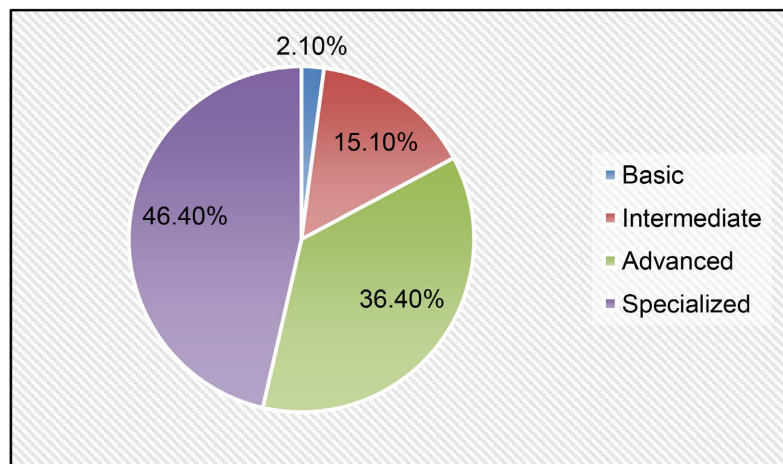**Figure 12.** Recycling of digital devices and consumables.

Figure 13. Reduction of energy consumption.

Competency Area 5: Problem solving

Table 4 shows the level of competence that students have in competence area 5: Problem solving.

Competency: Resolution of technical problems.

In this technical problem solving competition, students are at an advanced level. When faced with a technical problem, most students are able to find solutions on the Internet to solve their technical problems, either by consulting the support page of the manufacturer of the devices or instructional videos uploaded to YouTube by other users, as illustrated in Figure 14.

Regarding knowing the reasons why a digital device cannot connect to the Internet, such as, for example, incorrect Wi-Fi password, airplane mode activated, 50.3% of students are at a highly specialized level of knowledge to recognize the reason and solve the problem, as illustrated in Figure 15.

Competency: Identification of technological needs and responses

The level of the students in the "Identification of technological needs and responses" competition is at an advanced level; when faced with technological

Table 4. Levels of competencies in competency area 5: Problem solving.

Competence	Level of competition			
	Essential	Intermediate	Advanced	Highly specialized
Resolution of technical problems			x	
Identification of technological needs and responses			x	
Using digital technology creatively			x	
Identification of gaps in digital competence			x	
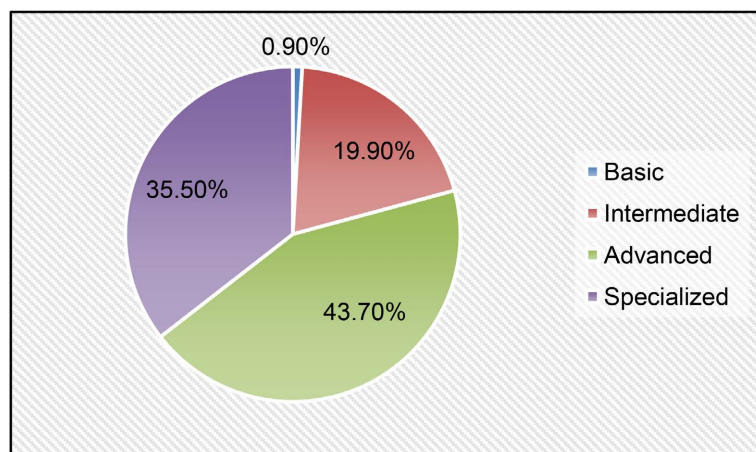
Figure 14. Solution to technical problems on the internet.
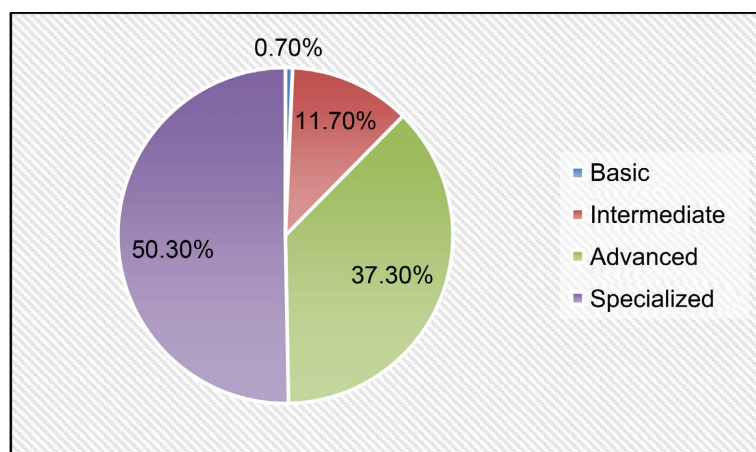
Figure 15. Wi-Fi connection solution.

needs, the majority of students are able to find technological solutions that can help them meet personal or professional needs. As shown in Figure 16, 43.1% and 32.5% are at level 3 and 4 respectively on the proficiency level scale.

Digital tools help increase personal productivity, using electronic agendas allows for more efficient time management, the use of devices to create digital notes, alarms, etc. They allow you to create an administrative solution to enhance productivity. 37.9% of students have a highly specialized level in the use of digital tools that allow them to increase their personal productivity, and only 3.6% of students are at a basic level in terms of their use, as shown in Figure 17.

Competency: Use of digital technology creatively

In recent years, artificial intelligence has developed exponentially and is used in all aspects of life, and the academic world is not exempt from this phenomenon. In Figure 18, only 6.3% of the students in the sample do not know what artificial intelligence is and its main applications.

In contrast, the majority of students do not know how machine learning algorithms work, as shown in Figure 19. This behavior could be inferred that law degree students, by their nature, are not interested in knowing how machine learning works, but they would only be interested in how to use it to solve their personal needs.
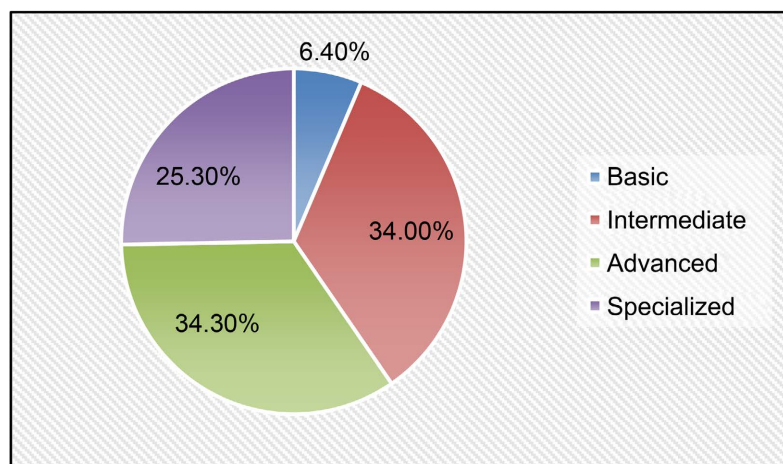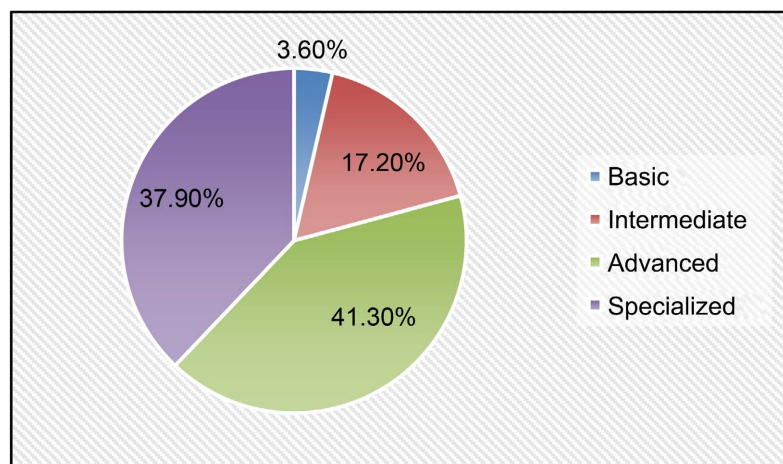

Figure 16. Technological solutions.

Figure 17. Digital tools for personal productivity.

Competence: Identification of gaps in digital competence.

The majority of students in the sample are willing to help people and colleagues around them to improve their digital skills, as shown in Figure 20, only 1.2% of them are not willing to share their knowledge to help to the rest of the people.
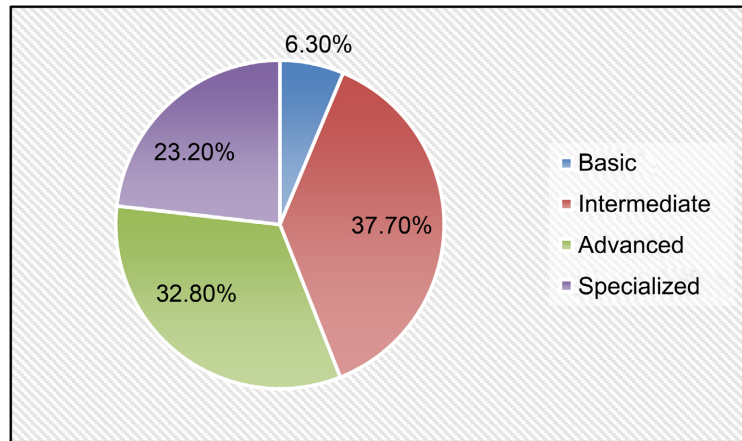

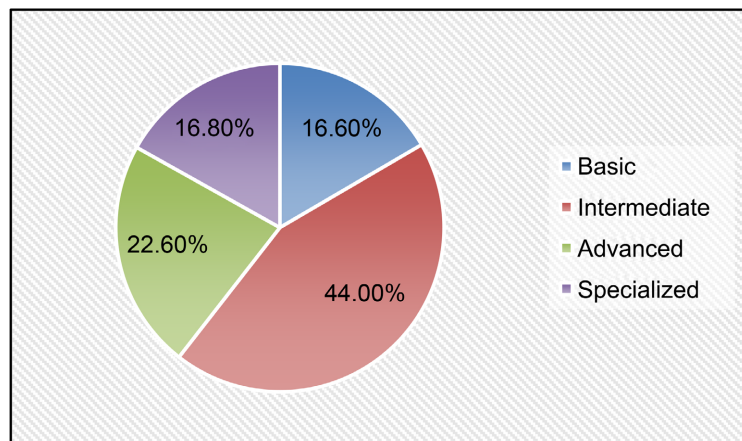**Figure 18.** What is artificial intelligence and its main applications.

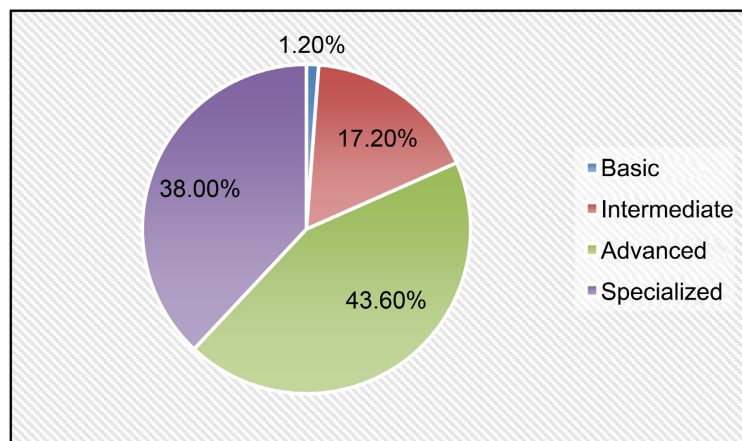**Figure 19.** Operation of learning algorithms.

Figure 20. Help people around you.

4. Conclusions

Protecting devices and their valuable information is a very important activity and people must be aware of its great importance, as well as taking care to have the necessary knowledge to ensure the integrity of their devices and information. In this sense, universities must ensure that they provide society with professionals with the digital skills that the world of the 21st century needs, for this reason, it is of utmost importance to measure the digital skills that students possess, and thus make decisions to potentiate them.

In this research, the objective was established to carry out a diagnosis of competency area 4: Network security and competency, area 5: Problem solving, established in the European Framework of digital competencies. The results of the diagnosis show that the students are at an advanced level in the competencies that make up the two areas of competence, with the exception of the "Device Protection" competency where the students are at an intermediate level. In this competition, we find areas of opportunity that the Faculty's directors must analyze, such as: The average of students say they do not have the knowledge to configure the firewall parameters of their devices, and they do not have the knowledge about how they work computer viruses and how to protect your computers. It was also found that 48.5% of students do not have the knowledge to configure antispyware software and 30.7% do not know the different types of software threats. It is recommended to review the study plan to verify if there is a course that contains these topics to promote it in the student community, or if it does not exist, it is recommended to consider the creation of a new optional course that allows the "Device Protection" competence to be enhanced.

On the other hand, it stands out that 58.1% of students know the importance of their personal data and are very clear about what personal information they can and should not share online using social networks. Likewise, 50.3% of students have highly specialized knowledge to solve wireless Internet connection problems and only 0.7% have a very low level of knowledge or could not solve wireless Internet connection problems.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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