

Education in Cybersecurity – A Case Study

JORGE BARBOSA

Department of Informatics and Systems Engineering,
Polytechnic University of Coimbra,
Rua Pedro Nunes, 3030-199, Coimbra,
PORTUGAL

Abstract - The inclusion of soft skills linked to Cybersecurity and cyber defense in the academic curricula of higher education courses is a very current issue. Several studies have been carried out in this regard, given the increasing importance of creating awareness about good practices in accessing computer networks, particularly the Internet. These studies primarily consist of recommendations on building the curricula of such courses, guiding the correct ways to do this. Our approach here is from the perspective of the students who may be the target of these cybersecurity skills. In this sense, we are developing a study in a Portuguese higher education institution to understand what higher education students think about this issue and their perception of the need for training in the area. We will ask students from various areas of education about this topic. We will then present an extended study when the preliminary results of a pilot test study are completed and shown. We questioned 423 students from the Informatics Engineering Degree course and analyzed the data obtained in the survey. Since then, this analysis of the data obtained in this study allows us to conclude that the students who participated in this study are very aware of issues related to cyber security and the need to be taught at least the fundamental concepts of cyber hygiene and cyber protection to all to all higher education students. In addition to this first conclusion, most of these students are concerned about the causes and consequences of cyber-attacks and the lack of knowledge that most people have about this problem.

Key-Words: - Cybersecurity, Cybersecurity Curricula, Higher Education, Soft Skills, Students Survey, Cyber-secure posture, Cyber-safe behavior.

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1 Introduction

1.1 Scope of this Study

The scope of this study is not to analyze alternative curricula for teaching cybersecurity to higher education students but rather to obtain data by conducting student surveys in the classroom, which makes it possible to extract knowledge about what these students perceive from whether or not higher education students have general training in cybersecurity that allows them to use computer networks in a world that is on the one hand increasingly interconnected but on the other hand increasingly subject to cyber-attacks when using computer equipment.

We consider this study and the data to be obtained critical and necessary. Depending on the results obtained, higher education institutions will have more elements that allow them to establish whether or not the topic of cyber security from the user's perspective needs to be included, maybe as soft skills, in all higher education course curricula.

1.2 The Current Reality

The exponential increase in the use of ICT in all economic areas and even in all homes, as well as the diversification and sophistication of computer equipment and the large number of applications to be used with this equipment, create constant pressure on ICT professionals. The need for this type of professional has also grown substantially in recent years.

In particular, a subsector of these professionals, those specializing in Cybersecurity, presents a shortage in the number of these professionals available. This shortage is aggravated by the constant evolution of cyber-attack techniques, which requires these professionals to have extensive and permanent training to be up-to-date on these new techniques so that they can protect the organizations to which they belong. ISACA's annual State of Cybersecurity Report [1] identified several reasons for this shortage, including the complexity and breadth of the skill set professionals must master.

1.3 TeleTeaching and Telework

The recent COVID-19 pandemic brought the use of distance learning technologies, teleteaching, to the present day. Suddenly, students at all levels of education and teachers faced the need to use these technologies safely. However, as it turned out then, many of these students and teachers, particularly at more fundamental levels of education and in less technical areas, needed to learn, even essential, how to use such technological means safely. In addition, this use was done at home, and to avoid security problems, home networks' security needed to be minimally configured and robust, which it usually should not be.

With the pandemic, this became an absolute necessity if there was already a perception of the need to train the general population, particularly younger people, in Cybersecurity. In the current post-pandemic period, initiatives in this regard have multiplied, mainly because the use of remote means of work, called teleworking, became commonplace and came to be at the mercy of the experience and habits acquired at that time.

1.4 How to do this Training

Many publications have been made on the issue of including cybersecurity training in school curricula, notably higher education courses, and how to do so. A very interesting perspective on Curriculum Development is presented in [2], where the authors present a curriculum guideline developed and obtained through consultation with various sources such as globally well-known documents, reports, and frameworks specifically designed for cybersecurity.

Also, [3] describes how to introduce and teach Cybersecurity in curricula from a PESTLE perspective. As it is based on the PESTLE analysis, an analysis studies the critical external factors (Political, Economic, Sociological, Technological, Legal, and Environmental) that influence the application scenario; in this case of cybersecurity training, it is an excellent guide for decision-makers and professionals of education in making strategic decisions involved in the construction of higher education course curricula. There are many other excellent references for building a cybersecurity curriculum [4], [5], [6], [7] and [8].

In the UK, cybersecurity education is also a concern. In [9], a study is presented in which 100 undergraduate computer science courses in the United Kingdom are analyzed. In this study, the author's objective is to evaluate the ability of the country's software developers to create secure software and also to evaluate the extent to which

students in these courses are being taught about the relevance of considering security issues in software development. It is not mentioned whether the principles of cyber hygiene and cyber protection in the use of computer equipment are taught in the curricula of these courses.

In [10], the authors "*aim to discover what factors influence the adoption of new curriculum at the undergraduate level*" and as we also have this concern and to have some measurability on some aspects that can influence and lead to possible improvements, carried out if the inquiry presented.

However, as we have already mentioned, we understand that it is necessary to train more professionals in the area and, without neglecting this need, to train all students in a more basic but no less effective and necessary way.

1.5 Fundamentals for the Current Study

Therefore, this project was born from this perspective, focusing on the student's perspective to infer their perception of this training at this non-professional level.

An attempt is also made to draw lessons on how to do this to reach students and convey that such training is necessary from a positive perspective, not just another subject that students should take in their higher studies.

The perspective of this study is broader than that reported here as it will be applied to various areas of study in higher education, a range of different higher education institutions, and courses selected for this purpose. These courses will not necessarily be only in the technical area, in particular courses in informatics engineering, but, as mentioned, in different places.

Therefore, we will present the preliminary results of a pilot study on a significant universe of higher education students, namely students taking undergraduate courses in informatics engineering at a higher education institution that offers engineering courses at the bachelor's and master's levels.

The choice of these degree courses in this pilot project is deliberate because, considering the context and profile of the students to whom the survey questionnaire was applied, we think these courses are appropriate to assess and improve the project itself at this stage.

Subsequently, the results of the various planned phases of the project will be presented.

2 Statistical Study Developed

2.1 Application Environment

The survey was distributed to approximately 490 students from three undergraduate courses in Informatics Engineering, LEI. These courses were the Bachelor's Degree in Informatics Engineering, which runs during daytime hours; the Course in Informatics Engineering, which runs after work hours; and the Course in Informatics Engineering — European Course, European Computer Science Engineering Course, a transnational and multi-grade course. In addition to regular students, some Erasmus students were also present.

For a better characterization of the sample and to consider correlations between the types of students and their responses, in addition to indicating in the survey the Course in which they were enrolled, they were also asked to indicate their gender so that it could be analyzed whether there was some tendency in the answers depending on the gender of the respondents.

Likewise, considering that any of these three courses have a curricular plan by Bologna, each course has a curricular plan spread over three academic years; they were asked to indicate how

many enrollments they had already completed on the course. This distinction between the number of enrollments is because we want to correlate the time in Higher Education with possible experience and contact with situations of exposure or knowledge of cyber-attack actions and their possible predisposition and knowledge of how to face and treat them.

Finally, to survey a more restricted and responsible environment, the surveys were distributed during written exam tests in which students were present. Three curricular units were selected, one from each academic year, and students were invited to fill out the surveys, with these responses being anonymous and optional.

2.2 Student Distribution

Table 1 and Table 2 show the distribution of students by gender. In the survey, students could choose one of 3 options: Male, Female, or Other. However, only male and female students responded to the surveys.

Then, in each of these tables, students are divided by the courses they attend and also by the number of enrollments they already have

Table 1. Distribution of Female Students

Females													
Course	LEI - Daytime				LEI - After Work				LEI - ECS				Total
	1st Year Exam	2nd Year Exam	3rd Year Exam	Subtotal	1st Year Exam	2nd Year Exam	3rd Year Exam	Subtotal	1st Year Exam	2nd Year Exam	3rd Year Exam	Subtotal	
Total of Responses	17	8	8	33	2	0	1	3	1	1	0	2	38
	1st Year Exam				2nd Year Exam				3rd Year Exam				
Number of Enrollments	1st Enroll	2nd Enroll	3rd Enroll	Subtotal	1st Enroll	2nd Enroll	3rd Enroll	Subtotal	1st Enroll	2nd Enroll	3rd Enroll	Subtotal	
Total of Responses	11	9	13	33	2	0	1	3	0	1	1	2	38

Table 2. Distribution of Male Students

Males													
Course	LEI - Daytime				LEI - After Work				LEI - ECS				Total
	1st Year Exam	2nd Year Exam	3rd Year Exam	Subtotal	1st Year Exam	2nd Year Exam	3rd Year Exam	Subtotal	1st Year Exam	2nd Year Exam	3rd Year Exam	Subtotal	
Total of Responses	190	41	80	311	32	8	7	47	18	9	0	27	385
	1st Year Exam				2nd Year Exam				3rd Year Exam				
Number of Enrollments	1st Enroll	2nd Enroll	3rd Enroll	Subtotal	1st Enroll	2nd Enroll	3rd Enroll	Subtotal	1st Enroll	2nd Enroll	3rd Enroll	Subtotal	
Total of Responses	119	63	129	311	14	6	27	47	13	3	11	27	385

Therefore, this division of responses will allow correlated data to be obtained and will help us understand the influences on the responses of each student profile and sub-profile.

In this study, we will present the responses obtained in the surveys in graphs, aggregating the data according to different data combinations. For example, we will present general data in which the results shown refer to students as a whole without dividing students by gender or Course. We will also present graphs showing results by student gender. Finally, we will present graphs that consider the number of students who have been enrolled.

Therefore, with this choice, we tried to analyze the possible influence that the student's gender may have on the answers and also the influence on the student's maturity in the Course, that is, whether the number of years the student has already studied influences their answer.

This finer and more correlated analysis will be the subject of more detailed future studies to be published.

2.3 Survey Structure

To cover the conditions mentioned above in the survey and to get a perception of what students have about different aspects of Cybersecurity, two groups of questions were included in the survey: a first group of questions to characterize the sample and a Second group of questions to assess students' opinions on Cybersecurity and the experience they already had or did not have with situations related to it.

Compound questions are also considered in addition to simple questions in the second group of questions. In addition to answering a fundamental question, these are questions in which students had to grade their perception of that particular aspect. This grading was done by presenting students with a Likert scale with values from 1 to 5, in which students indicated a value on this scale if they answered Yes to the first part of the question.

Therefore, the questions asked were the following:

1. First group of questions – Sample Characterization

- a. Gender:
 - Male
 - Female
 - Other
- b. Course:
 - LEI Daytime
 - LEI After-work
 - LEI European Course / Erasmus Student
- c. Number of Course Enrollments:
 - First Enrollment
 - Second Enrollment
 - Third or more Enrollment

2. Second group of questions – Characterization of the Experience

a. Understand the concepts of Cybersecurity and Cyber defense?

- No
- Yes

b. Have you had any training (any) in this area?

- No
- Yes

c. Do you believe that this subject should be part of the curricula of Higher Education courses?

- No
- Yes

d. Have you ever been asked for help/advice on these matters that you knew how to respond to?

- No
- Yes

e. As an IT user, do you feel cyber threatened in this use?

- No
- Yes If yes, how much?

1 = a little, 5 = a lot

1	2	3	4	5
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f. In this use of IT, do you seek to have a cyber-secure posture?

- No
- Yes If yes, how much?

1 = a little, 5 = a lot

1	2	3	4	5
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g. In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors?

- No
- Yes If yes, how much?

1 = a little, 5 = a lot

1	2	3	4	5
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2.4 Data Correlation

Through this set of questions, we will correlate the data provided to obtain information and extract knowledge considering different combinations of answers given depending on the type of respondents to the survey, such as gender, Course, number of enrollments, whether or not you have already had training in the area and other considerations.

From this study presented here, some lessons were drawn regarding the correlations that could and should be considered. Therefore, this aspect of correlations will be improved in the subsequent phases of the study. The objective will be to obtain, based on other data combinations, the possibility of considering more correlations to obtain more information and extract other knowledge.

In this analysis of results, we will only analyze some of the correlations, although some can already be done and will be presented in future papers.

3 Results Analysis

3.1 General Results - Simple Questions

- **Answer Chart for Question:** “Understand the concepts of Cybersecurity and Cyber defense?”

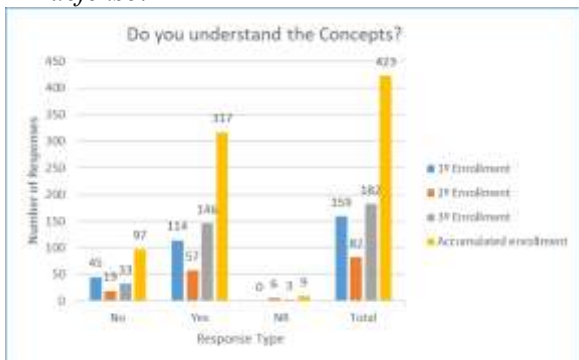


Fig. 1: Understand the concepts of Cybersecurity and Cyber defense?

- **Responses and Graph Analysis**

From the analysis of the graph shown in Figure 1, as expected, given the profile of the responding students, students of a Computer Engineering course, a large majority of respondents, almost 75%, indicated that they know the concepts of Cybersecurity and Cyberdefense.

As would also be expected, the predominance of "No" answers is given by students with only one enrollment to date. However, the number of students with more enrollments is still relatively large, especially with three or more enrollments for students with this training profile.

- **Answer Chart for Question:** “Have you had any training (any) in this area?”



Fig. 2: Have you had any training (any) in this area?”

- **Responses and Graph Analysis**

This graph, Figure 2, reveals that despite the profile of these students, the number of students who respond that they have not attended any training in the area of Cybersecurity is huge, 75,4%, even among students with three or more enrollments. This number is practically the same when comparing students with fewer enrollments and those with more who answered "No".

Considering the positive responses, the enrollment numbers for the three groups are already close to what seems to be expected for this question, as the students with the highest enrollments respond positively in more significant numbers. However, these numbers are still overall and partly very low.

From a global point of view, only a quarter of students respond that they have already had training, which is a meager value for students in this area.

- **Answer Chart for Question:** “Do you believe that this subject should be part of the curricula of Higher Education courses?”

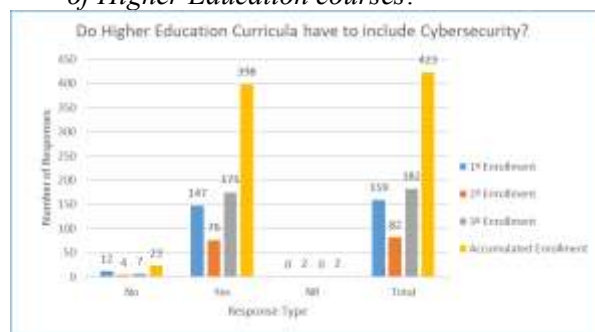


Fig. 3: Do you believe that this subject should be part of the curricula of Higher Education courses?

- **Responses and Graph Analysis**

This question is not only about the possible need for training in Cybersecurity but also whether training in the area is necessary for all higher education courses.

This question is the most consensual of all those considered and aligns with what was predicted and the results obtained in the previous question. In a way, it can be considered that students themselves do not have much training in the area, and the lack of this training reflects this fact in the high number of positive responses to this question.

Also, the fact that they are students in this training area probably makes them more aware of this issue, which will also be reflected in the high number of positive responses.

The number of negative responses is residual, representing only 0.5% of the responses globally, and very few students did not answer this question, as Figure 3 shows.

- **Answer Chart for Question:** “Have you ever been asked for help/advice on these matters that you knew how to respond to?”

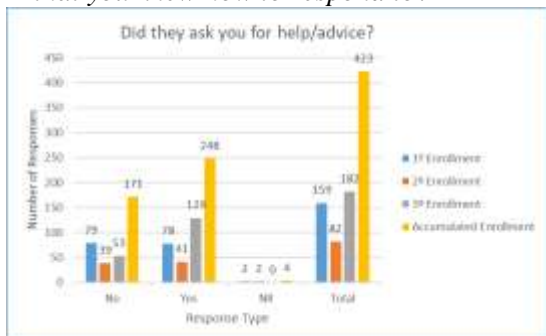


Fig. 4: Have you ever been asked for help/advice on these matters that you knew how to respond to?

- **Responses and Graph Analysis**

In this question, Figure 4, in which we purposely left many aspects open, the distribution between negative and positive answers is approximately one negative to one and a half positive.

It is expected that students in this area will be highly demanded by friends and family to solve problems with computer hardware and software, so it is not surprising that they will also be highly demanded on issues related to Cybersecurity.

It is also worth noting that practically the same number of negative and positive responses were obtained in the case of students with one enrollment, with the same trend being observed in students with two enrollments. Considering the number of enrollments, practically half of the students in these two subgroups answered "No" and the other half answered "Yes".

Almost two-thirds responded affirmatively to students with three or more enrollments, and only almost one-third responded negatively. Considering this profile of students and their "experience" in higher education in the area, these data are coherent.

3.2 General Results - Compound Questions

- **Answers Charts for the composite question:** “As an IT user, do you feel cyber threatened in this use?”

- **Answer Chart of Base Question**

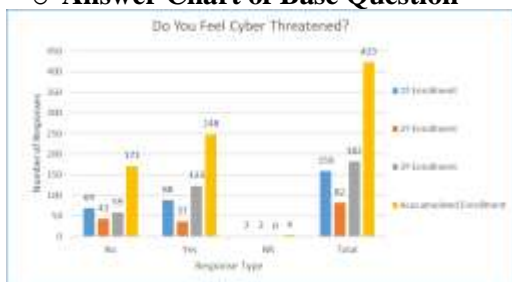


Fig. 5: As an IT user, do you feel cyber threatened in this use? – Base Question

- **Answer Chart of Likert Scale-Based Graduation**

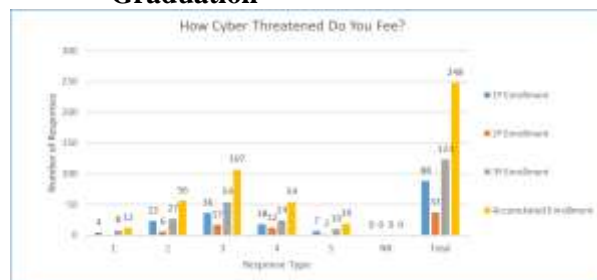


Fig. 6: As an IT user, do you feel cyber threatened in this use? – Likert Scale Based Graduation

- **Responses and Graph Analysis**

This question is one of three composite questions asked to students in the survey. In these questions, the student answers an initial fundamental question. Suppose they have answered "Yes" to it. In that case, they will grade their answer according to a Linkert scale, indicating an integer value from 1 to 5, with "1" reflecting less concern about the issue and "5" indicating more significant concern.

In the specific case of this question, analyzing Figure 5 and Figure 6 reveals that many students, around 58.6%, are concerned about cybersecurity issues, as they answer "Yes" and feel threatened.

A significant number of students, around 40.4%, appear unconcerned; as they answer "No" they feel afraid. This relatively large number of negative responses is worrying. It should be analyzed with more care and detail to understand why there are so many negative responses given the current context regarding Cybersecurity. In part, and only based on the data obtained, it can be considered that this high number of "No" responses is due to the relatively large number of students with a single enrollment who responded "No", around 43.4% of these students. Perhaps their relative, incipient lack of knowledge of this subject leads them to respond negatively. However, there is also a large number of students with a single enrollment who answered "Yes", around 55.3%.

The data relating to students with three or more enrollments are as expected. Although a significant number of students from this sub-profile, around 32.4%, responded "No" the remaining 67.5% responded "Yes", meaning they feel cyber threatened.

Regarding the grading of "fear" that the students who answered "Yes" did, the graph aligns with what seemed to be expected. The distribution presented in the graph is like a pure Gaussian Normal Distribution, as the most significant number of occurrences is in the average central value, "3", with the distribution being practically equal in the lateral values corresponding to the left and right of the value central and decreasing

towards the extremes of the graph with very similar values between the occurrences on the left and right.

The average value, "3," represents approximately 43% of the total responses, indicating that many students feel moderately cyber-threatened.

The maximum number on the scale, "5," as indicated by a still significant number of students, around 7.6%, which means that there are students who consider themselves very "cyber threatened", with this value being slightly higher than the referring to students who do not feel threatened at all, around 5.2%.

- **Answers Charts for the composite question:**
 “In this use of IT, do you seek to have a cyber-secure posture?”

○ **Answer Chart of Base Question**

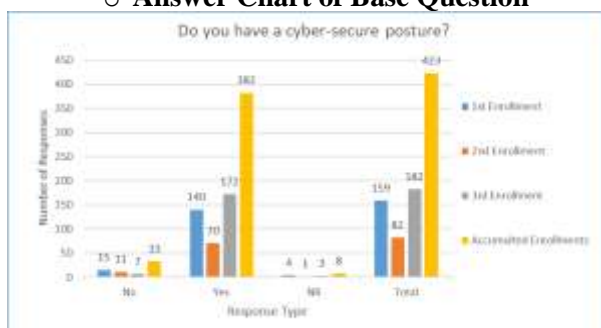


Fig. 7: In this use of IT, do you seek to have a cyber-secure posture? – Base Question

○ **Answer Chart of Likert Scale-Based Graduation**

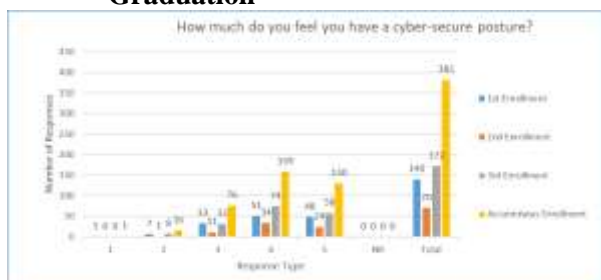


Fig. 8: In this use of IT, do you seek to have a cyber-secure posture? – Likert Scale Based Graduation

- **Responses and Graph Analysis**

These two graphs, Figure 7 and Figure 8, confirm two presumptions that we already expected: 1st, it would be natural for students of this profile, ICT students, to be careful when using computer networks, and 2nd, this stance would be, in relative terms, similar whatever the number of years in higher education. This stance shows that these students are sensitive and aware of possible problems that may arise from less careful use of computer networks from a security point of view.

- **Answers Charts for the composite question:**
 “In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors?”

○ **Answer Chart of Base Question**

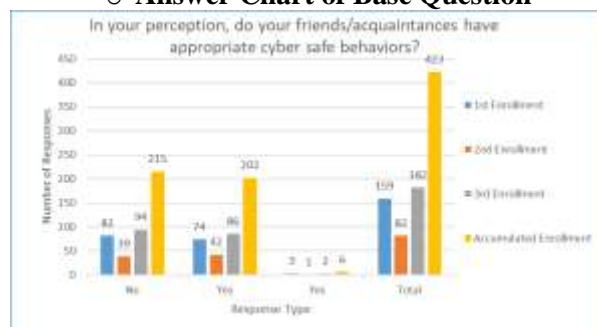


Fig. 9: In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors? – Base Question

○ **Answer Chart of Likert Scale-Based Graduation**



Fig. 10: In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors? – Likert Scale Based Graduation

- **Responses and Graph Analysis**

Through these graphs, Figure 9 and Figure 10, it can be seen that there is a balance between the answers given by any of the three groups of students, taking into account the number of years of higher education they have, with a slight predominance of "No" answers, 50.8%, over the answers "Yes", 47.8%. Thus, these students' perceptions of the care their friends take when using computer networks could be more convincing. The answers are practically divided into equal parts: those who consider that they take action and those who do not.

Analyzing the grading they do in this care, 41% of the responses are attributed to the average value, and it is worth noting that the higher gradings, 4 and 5, are superior as a whole, 32.2%, to the set of lower gradings, 1 and 2, which total 26.7%. This data shows that although the distribution shown in the base graph is practically equitable, those who indicated "Yes" in this first graph are firmly convinced that their friends take this care seriously when using networks, unlike

those who indicated "No", who are slightly less convinced of this.

3.3 Female Results - Simple Questions

- **Female Answer Chart for Question:**
 “Understand the concepts of Cybersecurity and Cyber defense?”

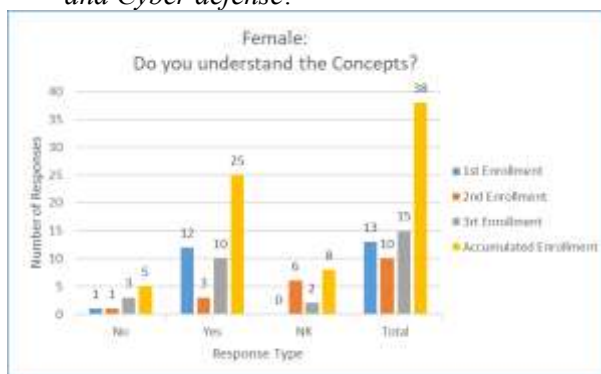


Fig. 11: Female: *Understand the concepts of Cybersecurity and Cyber defense?*

- **Female Responses and Graph Analysis**

The answers given by female students, Figure 11, align with the results obtained in this question when we consider them globally for both genders. Therefore, these data show no significant influence of gender, in this case female, on the responses.

However, there is a relatively high number, 21.1%, of non-responses "NR" to this question by female student respondents.

As shown in the respective graph, this does not happen in the answers given by male students.

Thus, the data reflected in the graph of aggregated responses, female plus male, are due to this female gender.

Given the number of non-responses, "NR", this subgroup may have more hesitations in responding.

- **Female Answer Chart for Question:** “Have you had any training (any) in this area?”



Fig. 12: Female: *Have you had any training (any) in this area?*

- **Female Responses and Graph Analysis**

The number of responses from students of this gender aligns with the answers given in the aggregate graph, which are from female and male students. In this case, the percentage of female students who respond that they did not have training is slightly higher, with almost 84.2% of "No" against 15.7% of "Yes", Figure 12.

As mentioned in the aggregate graph, these results were not expected in students with this ICT profile.

- **Female Answer Chart for Question:** “Do you believe that this subject should be part of the curricula of Higher Education courses?”

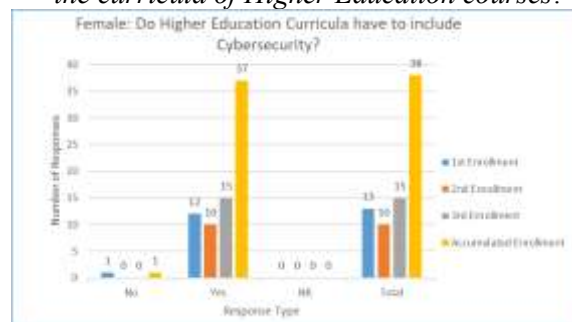


Fig. 13: Female: *Do you believe that this subject should be part of the curricula of Higher Education courses?*

- **Female Responses and Graph Analysis**

The number of responses from students of this gender aligns with the answers given in the aggregate graph, Figure 13, including female and male students.

As in the aggregate graph, these results were to be expected from students with this ICT profile, which again shows that these students are conscious of the seriousness of this cybersecurity issue and are aware of the need for everyone to have at least basic training in the area.

- **Female Answer Chart for Question:** “Have you ever been asked for help/advice on these matters that you knew how to respond to?”

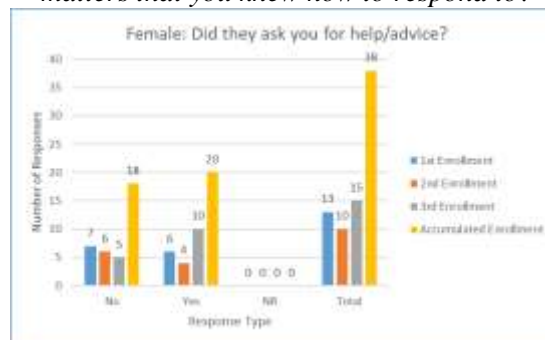


Fig. 14: Female: *Have you ever been asked for help/advice on these matters that you knew how to respond to?*

• **Female Responses and Graph Analysis**

Figure 14 shows the "No" and "Yes" answers as practically equal; almost half are negative, and the other half are positive.

This data is different from the aggregate graph because, in the aggregate, more or less 40% of "No" and 60% of "Yes" were obtained. However, in this case, the 38 female students who responded to the survey are almost uniformly distributed across the 3 different enrollment numbers that these students completed, which may partly explain. Unlike the aggregate data graph, this graph does not notice a predominance of students with three or more enrollments who would theoretically be more sought after by their friends to help solve problems.

3.4 Female Results - Compound Questions

- **Female Answers Charts for the composite question: "As an IT user, do you feel cyber threatened in this use?"**

- **Female Answer Chart of Base Question**

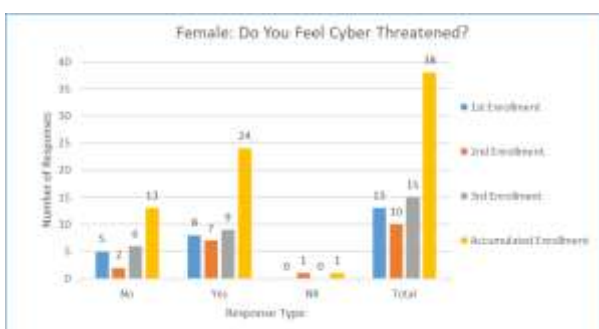


Fig. 15: Female: *As an IT user, do you feel cyber threatened in this use?* – Base Question

- **Female Answer Chart of Likert Scale-Based Graduation**

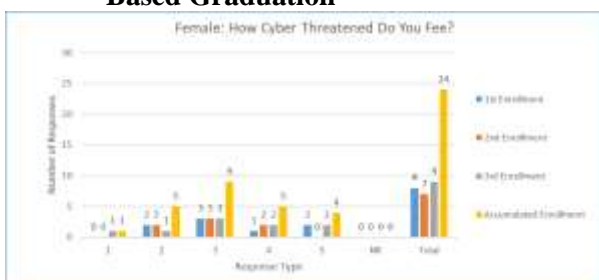


Fig. 16: Female: *As an IT user, do you feel cyber threatened in this use?* – Likert Scale Based Graduation

• **Female Responses and Graph Analysis**

From the analysis of the graphs shown in Figure 15 and Figure 16, in this case, considering the three graphs, the aggregate, that of female students, and that of male students, we found that despite there

being slight percentage variations between the responses, in the aggregate, 40.4% are not afraid and 58.6% are; in females, 34.2% are not afraid and 63.2% are, and in males, 41% are not afraid and 58.2% are, the variations between the graph of male and female students do not seem significant to us to the point of giving us absolute certainty that gender has some significant influence on the answers.

However, given the significant disparity between the number of elements in the sample of female students and that of male students, we consider that we cannot accurately indicate any trend due to gender, as biases may occur due to the disparity mentioned above between the female and male samples.

- **Female Answers Charts for the composite question: "In this use of IT, do you seek to have a cyber-secure posture?"**

- **Female Answer Chart of Base Question**

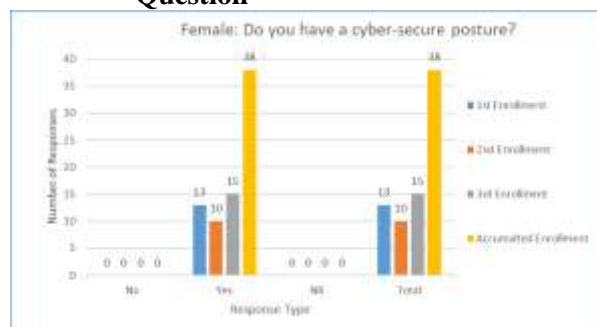


Fig. 17: Female: *In this use of IT, do you seek to have a cyber-secure posture?* – Base Question

- **Female Answer Chart of Likert Scale-Based Graduation**

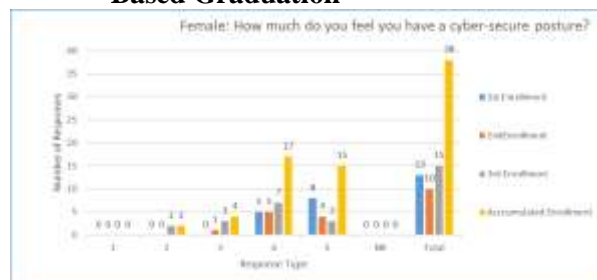


Fig. 18: Female: *In this use of IT, do you seek to have a cyber-secure posture?* – Likert Scale Based Graduation

• **Female Responses and Graph Analysis**

The analysis of this graph shown in Figure 17 and Figure 18, shows that all students, 100%, indicate that they try to behave cyber safely when using computer networks.

This percentage is slightly higher than the percentage in the aggregate graph, 90.3%, as this graph also reflects the responses of male students

whose percentage value of positive responses is slightly lower, 89.4%, than that indicated here by the male students.

It should also be noted that the values attributed to graduation are very similar in both the responses of the female students and the male students, with high scores in the indicated graduation predominating here and in both graphs.

- **Female Answers Charts for the composite question:** *“In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors?”*

- **Female Answer Chart of Base Question**

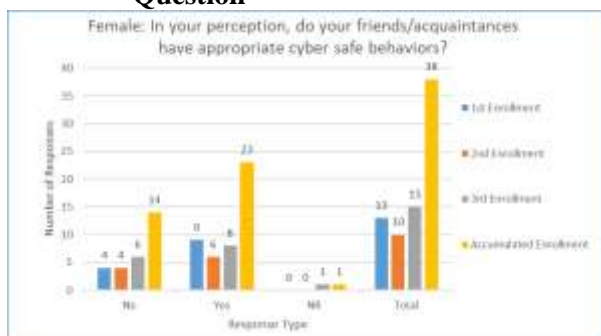


Fig. 19: Female: *In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors?* – Base Question

- **Female Answer Chart of Likert Scale-Based Graduation**

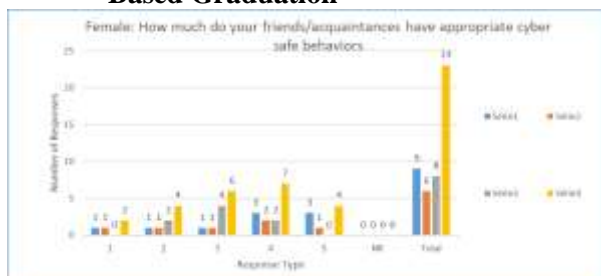


Fig. 20: Female: *In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors?* – Likert Scale Based Graduation

- **Female Responses and Graph Analysis**

There is a clear tendency in the female students' responses, reflected in the percentage values shown in Figure 19 and Figure 20, 36.8% "No" and 60.5% "Yes", to consider that their friends and acquaintances take care to have a safe posture when using computer networks, probably because they have it.

As can be seen in the respective graph, the male students' answers are different, with percentage values of 52.2% "No" and 46.5% "Yes," which are more balanced and similar values.

These different answers may be due not only to different perceptions of friends and acquaintances but probably also because the female students consider in their answers a more significant number of female friends than male friends, which, in a way, considering this, leads us to think that in each specific context of these two subgroups, the answers are consistent.

On the other hand, there is the already mentioned issue of the disparity in the size of the two samples, that of female and male students, which can cause bias in the results.

If we consider the grading of "Yes" answers, surprisingly, there are no significant percentage differences. In the case of female students, the percentages obtained are 26.1% in the accumulated negative values and 73.9% in the accumulated positive values. In the case of male students, these percentages are 26.8% in the accumulated negative values and 73.2% in the accumulated positive values, which, in a way, can be considered surprising. However, the female students were assigned a much higher percentage value of "5", the maximum on the scale of 17.4%, than the male students, who were only assigned a percentage of 4.4% of "5".

Therefore, this issue requires a deeper study and consideration of more balanced samples between the two subgroups.

3.5 Male Results - Simple Questions

- **Male Answer Chart for Question:** *“Understand the concepts of Cybersecurity and Cyber defense?”*

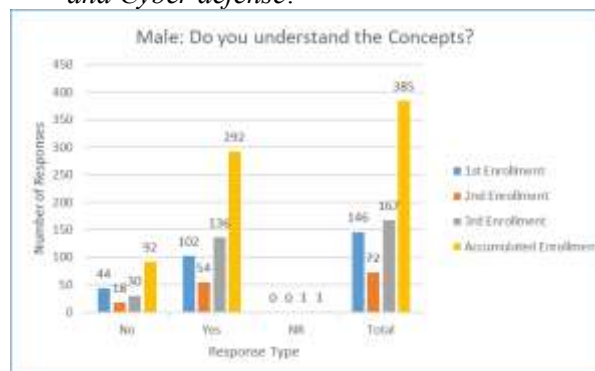


Fig. 21: Male: *Understand the concepts of Cybersecurity and Cyber defense?*

- **Male Responses and Graph Analysis**

Although with different percentage values, 75.8% of male students respond affirmatively to this question against 65.8% of female students, Figure 21, these values are not very different, so we can consider that the results between these two subgroups are in line,

which will be natural Given that we are considering ICT students.

Therefore, these data show that gender does not significantly influence the answers to this question.

However, contrary to the student's answers, only one student did not answer the question "NR," while 21.1% of female students did not. This data shows that students are more convinced about what is asked here.

- **Male Answer Chart for Question: “Have you had any training (any) in this area?”**

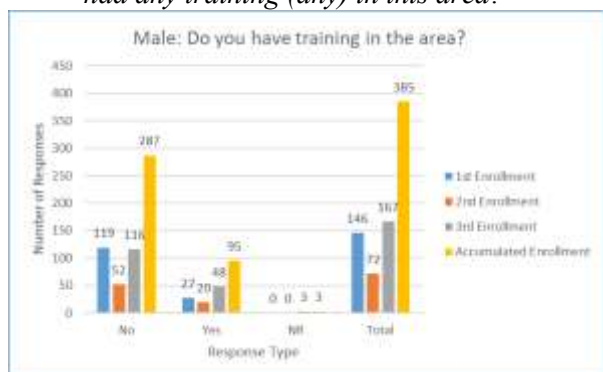


Fig. 22: Male: *Have you had any training (any) in this area?*

- **Male Responses and Graph Analysis**

The results obtained here and shown in Figure 22, 74.5% of male students responded that they had never had any training in the area and 24.7% responded "Yes", that they had already had training in this area.

Although these results are similar to those obtained for female students, they are surprising for students in this area of ICT, mainly if we consider the high number of "No" responses from male students with three or more enrollments.

- **Male Answer Chart for Question: “Do you believe that this subject should be part of the curricula of Higher Education courses?”**

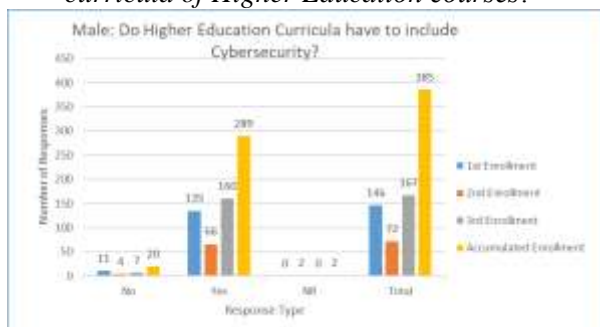


Fig. 23: Male: *Do you believe that this subject should be part of the curricula of Higher Education courses?*

- **Male Responses and Graph Analysis**

These results, Figure 23, align with the expected results and the results obtained from the students' answers. In this case, % of students answered "Yes" and % "No."

Although some students answered no, the percentage value corresponding to these negative answers is not necessarily significant.

As mentioned, these results were expected from students with this ICT profile and showed us that they know the seriousness of this cybersecurity issue and the need for basic training.

- **Male Answer Chart for Question: “Have you ever been asked for help/advice on these matters that you knew how to respond to?”**

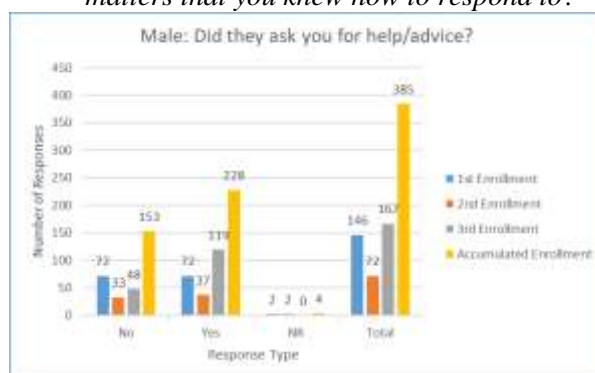


Fig. 24: Male: *Have you ever been asked for help/advice on these matters that you knew how to respond to?*

- **Male Responses and Graph Analysis**

Unlike the answers given by female respondents, in which the answers "No" and "Yes" were practically half for each of these hypotheses, Figure 24, here there is a more precise separation between these two answer options, with "No" being indicated in 38.7% of cases and "Yes" in 59.2%.

However, here and also contrary to what was found for female students, the number of male students in each of the three types of enrollment numbers is predominantly students with three or more enrollments completed. In contrast, there was practically one uniform distribution across the three possible enrollment numbers for female students.

Theoretically, this greatly affects the answers because students with three or more enrollments compared to the other two types should not only be asked more to help friends or acquaintances, but they should also feel more confident and knowledgeable and, as such, be more predisposed to giving that help.

Contextualizing these two cases of female students with what was mentioned above, we can even consider that the answers given by the two genders of students are in line with each other. These

differences are probably not directly related to the respondents' gender but, yes, with their technical capabilities to help.

3.6 Male Results - Compound Questions

- **Male Answers Charts for the composite question:** “As an IT user, do you feel cyber threatened in this use?”

○ Male Answer Chart of Base Question

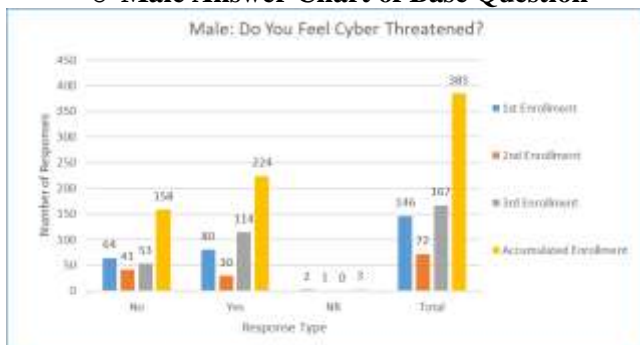


Fig. 25: Male: As an IT user, do you feel cyber threatened in this use? – Base Question

○ Male Answer Chart of Likert Scale-Based Graduation

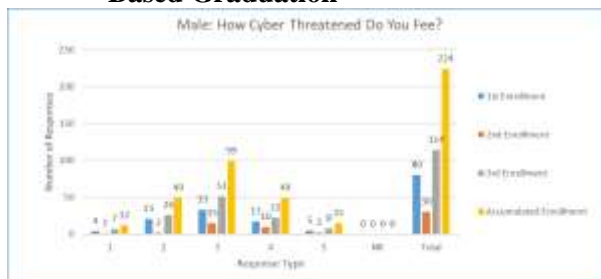


Fig. 26: Male: As an IT user, do you feel cyber threatened in this use? – Likert Scale Based Graduation

- **Male Responses and Graph Analysis**

The answers given here and shown in Figure 25 and Figure 26 by male students show that 41% are not afraid, and 58.2% are. As we saw in the answers given by the female students, 34.2% are not afraid, and 63.2% are.

Thus, the variations between the graphs of male and female students do not seem significant enough to give us absolute certainty that gender has any significant influence on the answers.

However, given the significant disparity between the number of elements in the sample of female students and male students, we consider that we cannot accurately identify any bias in responses due to gender, as biases may occur due to the already

mentioned disparity between the sample sizes of female and male respondents.

Although a relatively large number of students consider themselves afraid, in terms of graduation, the majority of responses correspond to the average value "3," 44.2% of responses.

Interestingly, the number of responses below or above this average value "3" is practically equal, with 27.2% of male students choosing the value "1" or "2" and 28.6% choosing the value "4" or "5". It is also curious that the values "glued" to the average value "3", that is, "2" and "4" have the same number of responses, 49, which corresponds to a percentage of 21.9%.

It is also worth noting, as mentioned in the respective analysis, that the distribution in this graduation graph of this answer in the case of the female students is very similar to this, practically as well as here a normal distribution in which the respective Gaussian has very similar values to the left and right of the average value and with a practically equal downward curve on one side and the other of the average value "3".

- **Male Answers Charts for the composite question:** “In this use of IT, do you seek to have a cyber-secure posture?”

○ Male Answer Chart of Base Question

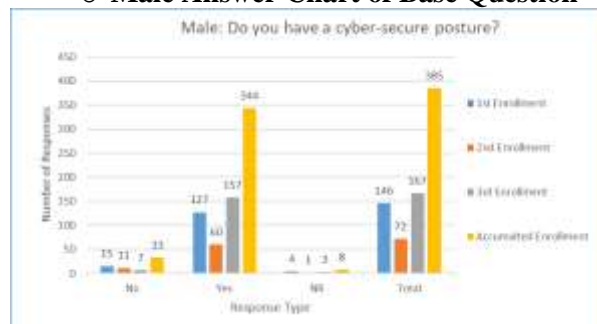


Fig. 27: Male: In this use of IT, do you seek to have a cyber-secure posture? – Base Question

○ Male Answer Chart of Likert Scale-Based Graduation

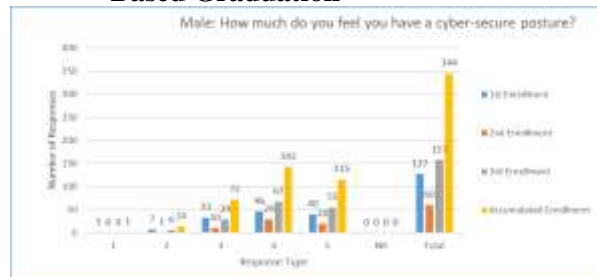


Fig. 28: Male: In this use of IT, do you seek to have a cyber-secure posture? – Likert Scale Based Graduation

• **Male Responses and Graph Analysis**

From the analysis of the graphs shown in Figure 27 and Figure 28, we found that a significant percentage of male students, 89.4%, answered "Yes" and had safe attitudes when browsing computer networks. Those who answered "No" correspond to only 8.5% of male students, with approximately 2% answering "NR."

This number, although slightly lower than the 100% corresponding to the female students' positive responses, is a very high value, which reveals that male students are also very concerned about taking self-defense measures when browsing computer networks.

As also appropriately mentioned, it is also worth noting that the values attributed to graduation are very similar in both the responses of female and male students, with high scores in these higher degrees predominating here and in both cases.

- **Male Answers Charts for the composite question:** *“In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors?”*

- **Male Answer Chart of Base Question**



Fig. 29: Male: *In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors?* – Base Question

- **Male Answer Chart of Likert Scale-Based Graduation**

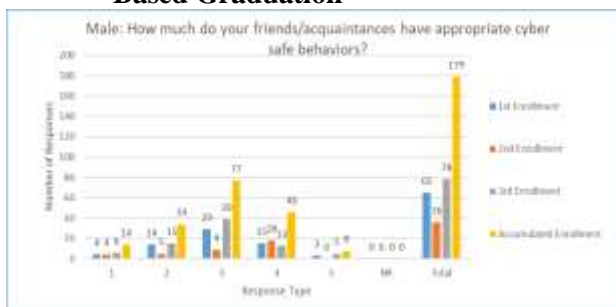


Fig. 30: Male: *In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors?* – Likert Scale Based Graduation

• **Male Responses and Graph Analysis**

As can be seen in these graphs, Figure 29 and Figure 30, male students' responses correspond in percentage terms to 52.2% for "No" responses and 46.5% for "Yes"; that is, more balanced and similar values than those we analyzed for the female students' responses were, respectively, 36.8% and 60.5%.

These different responses may be due not only to different perceptions of friends and acquaintances but probably also because female students consider in their responses a more significant number of female friends than male friends, which, in a way, considering this, leads us to think that in each specific context of these two subgroups, the answers are consistent.

On the other hand, there is the already mentioned issue of the disparity in the size of the two samples, that of female and male students, which can cause a bias in the results.

Surprisingly, there are no significant percentage differences if we consider the graduation of "Yes" responses. In the case of female students, the percentages obtained are 26.1% in accumulated negative values and 73.9% in accumulated positive values. In the case of male students, these percentages are 26.8% in accumulated negative values and 73.2% in accumulated positive values, which can be considered surprising.

However, female students assigned a much higher percentage of "5", the maximum on the scale, 17.4%, than male students, who only assigned some responses corresponding to the percentage of 4% to this maximum value.

As mentioned, analyzing this topic requires a more in-depth study and consideration of samples from these two subgroups, which are more balanced and reasonably sized.

3.7 Enrollment Results - Simple Questions

- **Enrollments Answer Chart for Question:** *“Understand the concepts of Cybersecurity and Cyber defense?”*

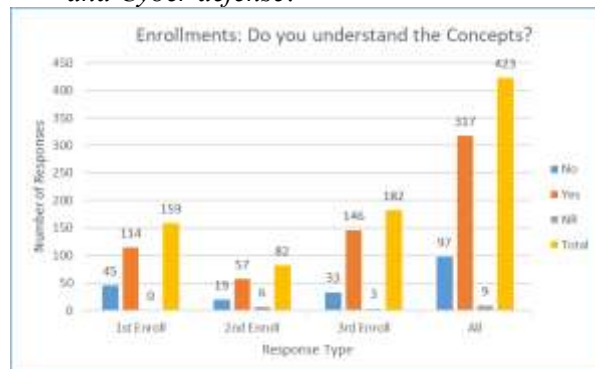


Fig. 31: Enrollments: *Understand the concepts of Cybersecurity and Cyber defense?*

• **Enrollments Responses and Graph Analysis**

The answers shown in the graph of Figure 31 to this question, analyzed from the perspective of considering the answers given by students grouped according to the respective number of enrollments, are within our expectations, considering that the respondents are students in the ICT area.

Thus, we found that, in all enrollment numbers, the "Yes" responses were significantly higher than the "No" responses, which we consider pretty positive.

Of the "Yes" respondents in the 1st enrollment, we had 27% positive responses; for the 2nd enrollments, 13.5%, and for the 3rd enrollments, 34.5% in absolute value, considering the total aggregate number of students without differentiating gender or other factors. The percentages corresponding to the "No" responses were 10.6%, 5.5%, and 22.9%, respectively.

We also calculated the percentages obtained based not on the absolute total number of enrollments but rather on the relative number of all students enrolled in each of the enrollment subgroups. In this second approach, we had 71.7% of "Yes" respondents in 1st enrollment, 69.5% in 2nd enrollment, and 80.2% in 3rd enrollment. The percentages corresponding to the "No" responses in this approach were 28.3%, 23.2%, and 18.1%. The analysis of the percentages obtained with this second approach allows us to have a more excellent perception of the results because, in this way, the percentages relating to "Yes" and "No" are complementary to the 100%, which better portrays reality than the consideration made in the first approach in which the total value added was considered.

This last approach to obtaining percentage values aimed to filter and perspective the evolution over the years of study in Higher Education that students have regarding these issues related to Cybersecurity.

Therefore, in the following questions related to the number of enrollments, we will consider this second approach, as it allows us to obtain a more realistic perspective of the data, which in turn provides better information and, thus, better knowledge.

• **Enrollments Answer Chart for Question:**

“Have you had any training (any) in this area?”

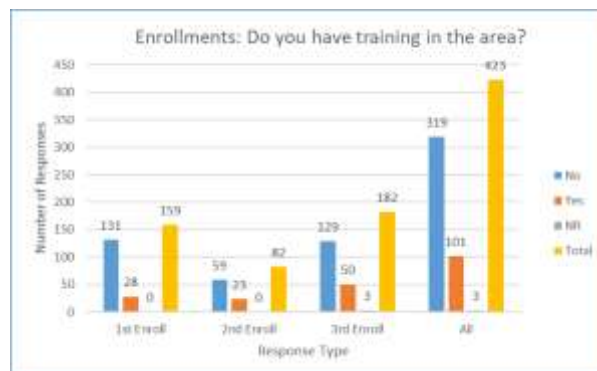


Fig. 32: Enrollments: *Have you had any training (any) in this area?*

• **Enrollments Responses and Graph Analysis**

Somewhat surprisingly, as shown in Figure 32, considering that the total sample is only ICT students, the percentage of students who respond that they have never had any training in the area of Cybersecurity is surprising, a fact that has already been observed previously in the analyses already carried out but which from this perspective appears more pronounced.

Note that even among students with three or more enrollments, the number of "No" respondents is huge, approximately 2.6 more students respond negatively than those who respond positively.

Therefore, we have that the percentage of students in 1st enrollment who answer "No" is 82.4%, those in 2nd enrollment correspond to 72% of the answers, and those in 3rd enrollment or more correspond to 70.9% of the answers obtained "Yes" answers correspond to 17.6%, 28%, and 27.5%, respectively.

• **Enrollments Answer Chart for Question:**

“Do you believe that this subject should be part of the curricula of Higher Education courses?”

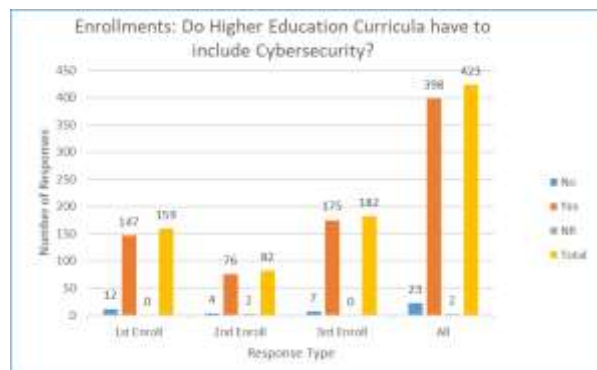


Fig. 33: Enrollments: *Do you believe that this subject should be part of the curricula of Higher Education courses?*

• **Enrollments Responses and Graph Analysis**

As verified in other answers, practically all students, regardless of the number of enrollments they have completed, favor inclusion in the curricula of higher education courses.

Analyzing the data shown in Figure 33, it can be seen that, 92,5% of students with 1st enrollment responded "Yes", and 92.7% of the students with 2nd enrollment also responded "Yes", and finally 96,2% of students with 3rd or more enrollments also responded "Yes".

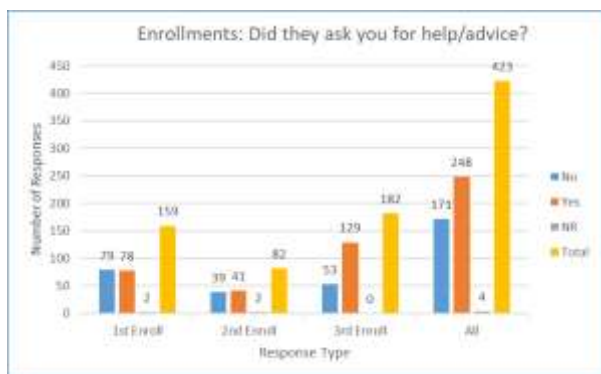


Fig. 34: Enrollments: *Have you ever been asked for help/advice on these matters that you knew how to respond to?*

- **Enrollments Answer Chart for Question:** *“Have you ever been asked for help/advice on these matters that you knew how to respond to?”*

• **Enrollments Responses and Graph Analysis**

The graph in Figure 34 shows that half of the 1st Enrollment students answered "No," or 49.7% of responses, and the other half, 49.1%, answered "Yes."

The same happens with students in their 2nd enrollment, where almost half, 47.6%, answered "No" and the other half, 50%, answered "Yes".

In the case of students in their 3rd or more enrollments, the situation is quite different. These students in their 3rd enrollment mostly answer "Yes", corresponding to 70.9% of the answers obtained, and the remaining 29.1% answer "No".

These data are as expected, although a slightly higher number of "Yes" responses for students in 2nd enrollment was expected.

3.8 Enrollment Results - Compound Questions

- **Enrollments Answers Charts for the composite question:** *“As an IT user, do you feel cyber threatened in this use?”*

o **Enrollments Answer Chart of Base Question**



Fig. 35: Enrollments: *As an IT user, do you feel cyber threatened in this use?* – Base Question

o **Enrollments Answer Chart of Likert Scale-Based Graduation**

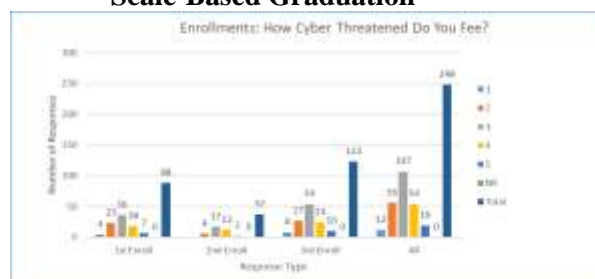


Fig. 36: Enrollments: *As an IT user, do you feel cyber threatened in this use?* – Likert Scale Based Graduation

• **Enrollments Responses and Graph Analysis**

The answers, graphs in Figure 35 and Figure 36, from 1st and 2nd enrollment students, were a bit beyond expectations, as ICT students answered "No" relatively much more than we expected.

For students in their first enrollment, 43.4% answered "No," and 55.4% answered "Yes."

Students in their 2nd enrollment responded similarly, obtaining 52.4% of "No" responses and 45.1% of "Yes" responses.

Now we understand that this number of "No" answers indicates either a lack of knowledge of the real dangers for the user related to cybersecurity actions or an overconfidence of these students due to their relative lack of experience in such situations.

The responses from students in their 3rd enrollment or more are now more in line with expectations. Thus, 32.4% of these students responded "No", and the remaining 67.6% responded "Yes."

Regarding the graduation of "Yes" answers, the three subgroups of students corresponding to the three types of enrollments are within expectations and follow the analyses on this issue that were carried out based on other perspectives. Thus, most students from any of the three subgroups choose the average value

"3" out of the five possible, and the remaining values are chosen from the perspective of a "perfect" normal distribution in which we have a well-modeled Gaussian curve, as we have already described for the analysis based on other perspectives.

- **Enrollments Answers Charts for the composite question: “In this use of IT, do you seek to have a cyber-secure posture?”**
 - **Enrollments Answer Chart of Base Question**

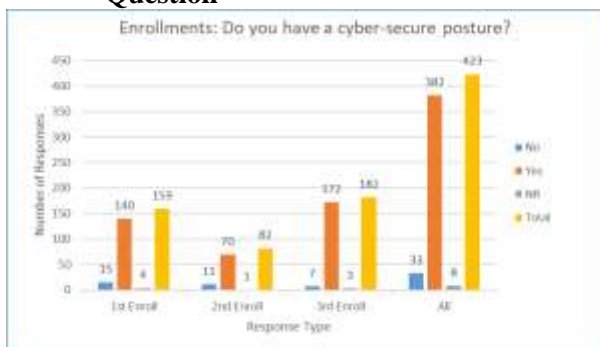


Fig. 37: Enrollments: *In this use of IT, do you seek to have a cyber-secure posture?* – Base Question

- **Enrollments Answer Chart of Likert Scale-Based Graduation**

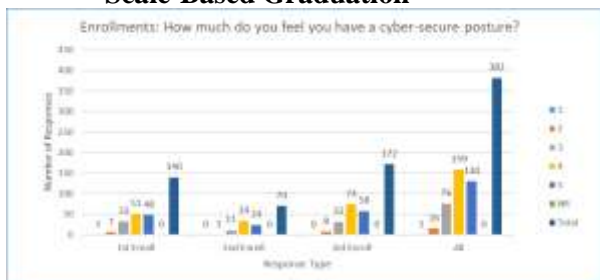


Fig. 38: Enrollments: *In this use of IT, do you seek to have a cyber-secure posture?* – Likert Scale Based Graduation

- **Enrollments Responses and Graph Analysis**

The answers to this question by students, whose response graphs are shown in Figure 37 and Figure 38, from any of the three subgroups meet expectations, with practically all students answering "Yes". "No" answers are marginal and statistically not relevant. This same thing has already been seen in analyses of this question from other perspectives.

Regarding the graduation of "Yes" answers, the three subgroups of students corresponding to the three types of enrollments are also within expectations and agree with the analyses on this issue that were carried out based on other perspectives.

Thus, most students from any three subgroups choose the average value "3" or higher to grade their stance on using IT resources. Many students attribute

one of the two highest values to their posture, "4" or even "5."

Therefore, we consider that students, regardless of their current enrollment numbers in higher education, are very concerned about their cybersecurity stance when using IT resources.

- **Enrollments Answers Charts for the composite question: “In your perception, do your friends/acquaintances have appropriate cyber-safe behaviors?”**
 - **Enrollments Answer Chart of Base Question**

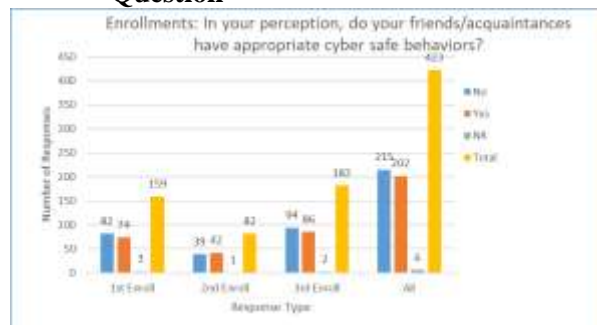


Fig. 39: Enrollments: *In your perception, do your friends/acquaintances have appropriate cyber safe behaviors?* – Base Question

- **Enrollments Answer Chart of Likert Scale-Based Graduation**



Fig. 40: Enrollments: *In your perception, do your friends/acquaintances have appropriate cyber safe behaviors?* – Likert Scale Based Graduation

- **Enrollments Responses and Graph Analysis**

The data in this graph, shown in Figure 39 and Figure 40, shows that regardless of the number of enrollments, the number of "No" and "Yes" answers is practically the same. That is, in all three subgroups of students considering their enrollment, half of the students answered "No," and the other half answered "Yes."

Concerning students in 1st and 2nd enrollment, this was expected. Regarding students and 3rd or more enrollments, the number of "Yes" answers was expected to be greater than the number of no answers.

Regarding the graduation that students make of the behavior of their acquaintances and friends, the

distribution obtained in any of the three subgroups considered was also expected. This distribution is very spread out, which reveals, as would be natural, that students may have an opinion about whether or not their friends and acquaintances have safe behavior. However, it may be difficult for them to rate this behavior.

4 Conclusion

The scope of this study was not to analyze alternative curricula for teaching Cybersecurity to higher education students but rather to obtain data by conducting surveys of students in the classroom to extract knowledge about what these students perceive of the need and whether or not they have had general training in Cybersecurity that allows them to use computer networks in a world that is, on the one hand, increasingly connected but, on the other hand, increasingly subject to cyber-attacks when using computer equipment.

Although the results already obtained and shown in this paper are very interesting and allow us to draw some significant conclusions, the scope of the study mentioned above, despite the sample size of 423 students, needed to be expanded. As such, it may not be very objective and not representative of the various areas of higher education and students from other higher education institutions.

As previously mentioned, the study presented here was a pilot study conducted to gather initial data and establish a working methodology for a more comprehensive study. This broader study, to be implemented in subsequent phases, will encompass students from various fields of higher education, not just Computer Engineering courses, and will be conducted in a range of higher education institutions. This expansion promises to provide more comprehensive insights into the perceptions of Portuguese higher education students regarding the necessity of cybersecurity education.

With the planned expansion of the study, we aim to draw more comprehensive conclusions about Portuguese higher education students' perceptions of the necessity of cybersecurity education.

Since then, this analysis of the data obtained in this study allows us to conclude that the 423 students who participated in this study are very aware of issues related to cyber security and the need to be taught at least the basic concepts of cyber hygiene and cyber protection.

In addition to this first conclusion, most of these students are concerned about the causes and consequences of cyber-attacks and the lack of knowledge that most people have about this problem.

The combination of these first two conclusions leads us to consider a third conclusion, perhaps the result of the two previous conclusions and their implications: practically all of these students, around 94%, consider it essential that all people, in particular students from any area of higher education, must have training in Cybersecurity!

Acknowledgment

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The article was created by a single author, and therefore, there were no contributions from any other author at all stages, from the formulation of the survey to the final findings.

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Conflict of Interest

The author has no conflicts of interest to declare.

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