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HAZARDS AND RISKS OF MACHINE-TOOLS: AN EXPERIENCE IN THE MECHANICAL TECHNOLOGY AND VEHICLES COURSE

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Abstract

Given the specificity of the Higher Professional Technical Courses it is important that the classes are oriented in order to promote a learning with a strong connection to the practice and its course. Following this principle, it was proposed to the students of the Mechanical Technology and Vehicles course of the School of Technology and Management of the Polytechnic Institute of Bragança (Portugal) that attended in 2017/2018 the course unit "Safety and Environment", the accomplishment of a practical work that had as scenario the laboratory of Mechanical Technology. The experience had a positive impact on students learning, since, in addition to allowing them to work on content in a contextualized way, it contributed, among other things, to developing their autonomy and communication skills.

Keywords: Higher education, learning in context, safety and hygiene at work, machine-tools.

1 INTRODUCTION

The Higher Professional Technical Courses (HPTCs) consists in a training typology of Higher Education of short course and confers a Higher Professional Technical Diploma [1], [2]. The HPTCs has 120 ECTS (credits according to the European Credit Transfer and Accumulation System) and the duration of four semesters. It consists of a set of course units (CU) organized in the components of general and scientific training, technical training and training in the work context, which is achieved through a traineeship in the last semester.

The HPTC in Mechanical Technology and Vehicles (MTV) of the School of Technology and Management (ESTiG) of the Polytechnic Institute of Bragança (Portugal) is part of the area of technology training and integrates in its study plan the CU "Safety and Environment", which is taught in the 2nd semester of the 1st year. The classes are theoretical-practical (2 hours per week) and the contents cover the theme of safety and hygiene at work, with greater incidence in the first theme. At the end of the CU it is intended that the students know the principles of Management of Prevention of Work Safety System and Environmental Management, with a main focus in the context of mechanical technology and vehicles.

Given the particularity of the HPTC, it is important that in the classes of their CU, whenever possible, a more student-centered learning is promoted, with a greater connection to the practice and its course. It should be noted that, more and more, the higher education teacher, in addition to being concerned with the scientific content domain working with his students, must also pay attention to what is happening at the level of the environment learning relative to the CU that teaches [3].

Considering these purposes, in the 2017/2018 academic year, in the scope of the safety theme of the "Safety and Environment" CU, it was proposed to a MTV class, the accomplishment of a practical work in which the scenario in study was the laboratory of Mechanical Technology, more properly the existing machine-tools.

2 METHODOLOGY

The experience was carried out with the 22 students who attended the CU "Safety and Environment". The students were all male, with ages between 18 and 22 years, and all had Portuguese nationality with an exception of one student who was from Cape Verde.

In the first classes of the CU were approached the theoretical concepts related to the area of safety and hygiene at the work [4], [5] and were resolved practical exercises on the subject. As soon as it was considered that the students already had some information on the theme, it was proposed that

they be organized into groups of three or four elements (it was formed six groups) and discussed with them the type of practical work that they would carry out. Thus, it was decided that this would have as a field of action the machine-tools from the Mechanical Technology laboratory of ESTiG, so the title chosen was "Hazards and risks associated with the use of machine-tools of the Mechanical Technology laboratory of ESTiG". In terms of classification, it was stipulated that the work would have a weight of 70% in the final grade of the CU.

The first task of each group was to choose a machine-tool from the laboratory. The selected machine-tools were: two mechanical lathes, a radial drilling machine, a milling machine, a band saw and a mechanical saw, which are industrial machines for chipper manufacturing processes. Their characteristics and functioning in general terms were already known by the students, since they were attending the “Automotive Materials Processing I” CU, where they approach those contents.

The work proposed to the students was divided into six phases, which are explained below:

- Phase I - Data collection in regarding the use of machine-tools in the laboratory (Fig. 1- (a) to 1-(f)). To accomplish this phase, in some of the CU classes, the students went to the laboratory accompanied by the teacher / researcher (one of the authors of this text).

Figure 1. Machine-tools from the Mechanical Technology laboratory of ESTiG selected by students: mechanical lathes (a) and (b); radial drilling machine (c), milling machine (d), band saw (e); mechanical saw (f).

- Phase II - Description of the machine-tool. Characterization of the machine-tool regarding to: application, technical specifications, consumables involved in the operation, supplier, CE marking, type and serial number, date of receipt and data of entry into service, state when it was acquired, maintenance performed, damages and malfunctions registry, modifications or repairs and calibrations performed. This information was consulted in the laboratory, with the help of laboratory technicians and also based on the knowledge acquired at the CU “Automotive Materials Processing I”.
- Phase III - Risk analysis, i.e. identification of hazards and consequent risks associated with the use of the machine-tool. To this end, the students were based on the definitions of hazard and risk contained in the Portuguese legislation [6], which approved the legal regime for the promotion of safety and health at work, in the current version (see ACT website available at: http://www.act.gov.pt, [7]) .
- Phase IV - Selection of the legal and normative framework applicable to the situations in question, based on the documentation indicated [4], [5], [7].
- Phase V - Risk assessment. In this component it was suggested the application of one of the methods studied in the classes, rather the improved matrices method and also called the

composite matrix method [8], [9], [10]. This method integrates the variables Frequency (F), Severity (S), Procedures and Conditions of Safety (PCS) and Number of People Affected (NPA). Each of the four variables is analyzed using a five-level scale. From the product of the classification of the four variables results the magnitude of the risk. The scale ranges from 1 (very bad) to 625 (very good). It also includes a risk index scale with five levels of intervention priority.

- Phase VI - Identification of preventive measures to be implemented (engineering measures, collective protection and safety signage; individual protection equipments; work organization and administrative control and training and information) [4], [5], [7].

Based on the procedures and the analysis performed, the students prepared a PowerPoint presentation, in which synthesized the main ideas of the work, and did an exposition to the class. To promote students attention and make the debate about the work more fruitful, the teacher assigned each group the responsibility to ask questions to one of the other groups previously selected.

In the last class of the semester the students answered a questionnaire. It consisted of two parts. In the first part "General Information" it was asked information of a general nature on a personal and academic level. The second part, "Information related to the CU Safety and Environment", it was intended to listen to the students opinions about the CU classes, namely the difficulties they felt in terms of content, the attitude they had towards the practical work and the contribution to their learning.

The evaluation and reflection on the experience is based on this questionnaire, on the students productions and on the field notes registered by the teacher.

3 RESULTS

The students easily adhered to the proposed task and were committed to its accomplishment, which was visible in the final evaluation, since all who did the work obtained approval to the CU.

Regarding the contents of the CU, the difficulty most pointed by the students was "to identify the legislation applicable to the situations in question" (Phase IV), since 72.7% reported having had some or many difficulties (Fig. 2). This difficulty is related to the fact that there are a vast number of legal and normative diplomas in the field of safety and hygiene at work. It should be noted that legislation such as: the Labour Code [11] in the current version [7], the law [6], the Decree-Law concerning the minimum safety and health requirements for the use of work equipment [12] and the Decree-Law concerning the rules for the placing on the market and putting into service of machines and their accessories [13], among other diplomas [7], were thoroughly consulted by the students in order to implement prevention measures.

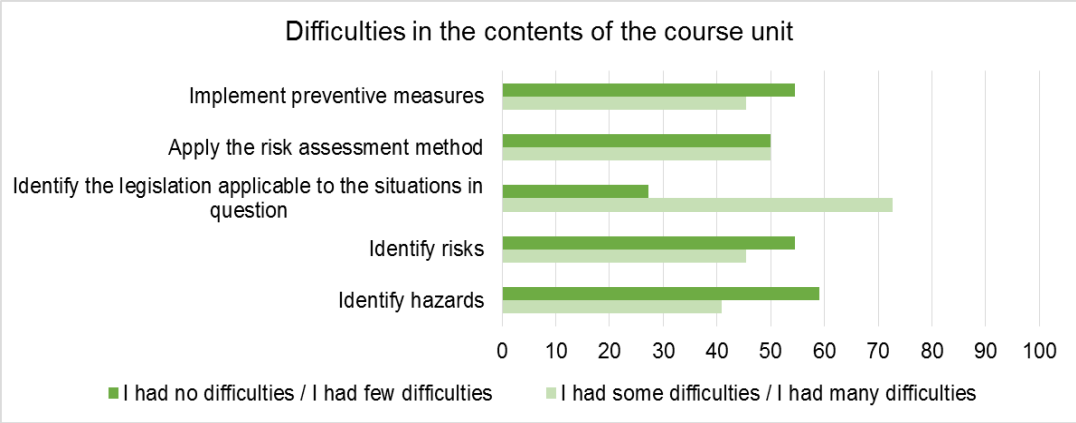

Figure 2. Difficulties felted by the students in the contents of CU.

The distinction between the concept of hazard and risk (Phase III) was one of the difficulties detected by the teacher during the classes, which is corroborated by the students, since 40.9% assume that they had some or many difficulties in identifying hazards and 45.5% in identifying risks (Fig. 2). It should be pointed out that, as Freitas [5] refers, the terms hazard and risk are not always used univocally in all countries and situations. In this CU, according to what has already been mentioned, is was assumed the definitions referred to in the Portuguese legislation [6], i.e., Hazard is "the intrinsic

property of an installation, activity, equipment, agent or other material component of the work with potential to cause harm" (p. 6168) and the Risk is "the probability that the damage will materialize according to the conditions of use, exposure or interaction of the material component of the work that presents a hazard" (p. 6168). In the work several groups pointed out the same type of hazards and risks related to the use of the machine-tools they were analyzing, for example:

- Hazards: 1 - "Incorrect fixing of the part to be machined"; 2 - "Absence of protection elements in the machine-tool"; 3- "Inappropriate use of the machine-tool (in uses for which it has not been designed)"; 4 - "Use of wide clothing and accessories"; 5 - "Contact with the part after being machined"; 6 - "Inadequate postures"; 7 - "Disorganization of the workspace".
- Risks associated with the hazards mentioned: 1, 2, 3 - "Projection of fragments or particles, cuts, perforations"; 4 - "Grasping, winding, entrainment, sliding or crushing by or between objects"; 5 - "Burns"; 6- "Dorso-lumbar and musculoskeletal injuries"; 7 - "Falls to the same level, multiple injuries".

Regarding the risk assessment method applied (Phase V), the greatest difficulties were observed in the selection of the scale of values applicable to each variable, given the subjectivity of the method. However, they were easily overcome with a more careful bibliographic consultation, aided by the teacher's clarifications.

Concerning the preventive measures to be implemented (Phase VI), all groups referred, for example, the measure: "Placing adequate signage near the machine-tools". That is, they recommend the replacement of the image indicated in the Fig. 3- (a) that is near to the laboratory machine-tools, by the image indicated in the Fig. 3- (b), according to the legislation [7], [14].

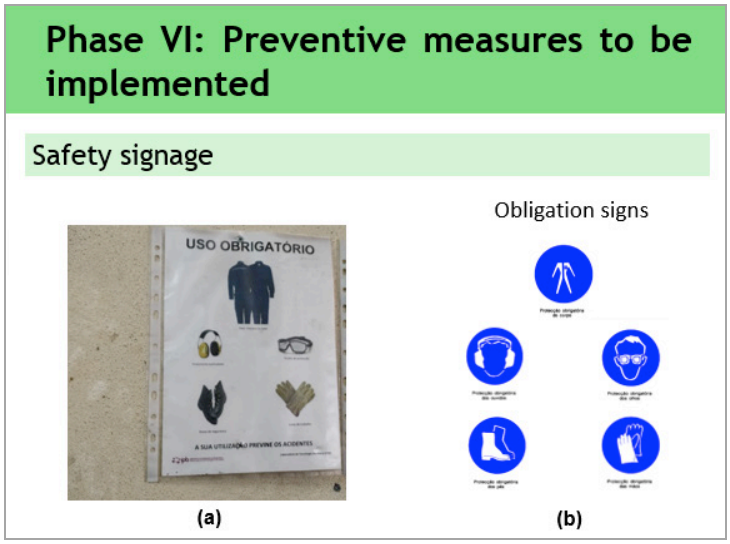

Figure 3. Extract from a presentation of the practical work of a group.

In the case of the use of the mechanical lathes, radial drilling machine, milling machine, band saw and mechanical saw, all preventive measures to be implemented suggested by the students were based on the instruction manuals of the machine-tools available in the laboratory and in the current legislation [7] in the scope of safety and hygiene at work.

According to the students, the difficulties in carrying out the proposed group work (Table 1) were mainly due to the lack of attendance at classes (31.8% agree or fully agree) and the fact that they could not select the information that is relevant (27.3% % agree or fully agree).

Table 1. Difficulties felted by the students in carrying out the group work.

	FD/D (%)	A/FA (%)
Lack of motivation for the CU	95.5	4.5
Lack of concentration in the class	86.4	13.6
Not understanding the teacher's explanations	90.9	4.5
Lack of autonomy	77.3	22.7
Not understanding the notes	95.5	4.5
Be afraid / do not feel comfortable to asking questions	81.8	18.2
Lack of study / application	81.8	18.2
Less attendance at classes	68.2	31.8
Lack of coordination between group members	81.8	18.2
Dislike working in a group	81.8	18.2
Lack of organization	77.3	22.7
Unable to select the information that is relevant	72.7	27.3

FD – Fully disagree; D- Disagree; A- Agree; FA – Fully agree.

Reflecting on having the laboratory work scenario, the majority of the students agree or fully agree that this aspect allowed them to have a greater connection with the reality of the course (90.9%), to learn contextually (90.9%) and to increase their motivation (95.5%). It was also an important factor for the consolidation of their knowledge on the theme of safety and hygiene at work in the laboratory (95.5% agree or fully agree), where they had to keep in mind the general principles of prevention referred in the legislation [6].

Carrying out the group work and presenting it was, in general terms, fruitful for the student learning. It should be noted that most students agree or fully agree that it has helped them to clarify some concepts (100%), learn to be more objective (95.5%), feel more confidence in their abilities (95.5%), overcome some of the difficulties (95.5%) and increase their autonomy not being so dependent on the teacher (100%) (Table 2).

Table 2. Advantages of the group work and its presentation.

	FD/D (%)	A/FA (%)
Clarify some concepts	0	100
Improve my ability to argue	9.1	90.9
Feel more confidence in my abilities	4.5	95.5
Participate actively in the class	18.2	81.8
Become aware of my difficulties	9.1	90.9
Overcoming some of my difficulties	4.5	95.5
Learning to be more objective	4.5	95.5
Learning to be more organized	9.1	90.9
Know how to highlight relevant information	13.6	86.4
Achieve structuring information	9.1	90.9
Improve my communication skills	4.5	95.5
Increase my autonomy not being so dependent on the teacher	0	100

FD – Fully disagree; D- Disagree; A- Agree; FA – Fully agree.

At the end of each presentation of the practical work, the colleagues from another group were in charge of posing some questions about the work done, highlighting excerpts from some of the established dialogues (Table 3).

Table 3. Excerpts of dialogues after the works presentations.

Dialogue concerning to the work of Group 2
Group 1: What was the biggest difficulty they had in carrying out the work?
Group 2: After everything we gathered and organized, it was difficult to select the obtained information to make the presentation.
Dialogue concerning to the work of Group 6
Group 3: From the engineering measures, which is or are the most needed?
Group 6: The placement of the protection in the radial drilling machine, to avoid the projection of fragments or particles, cuts and perforations.
Group 3: But the protection does not take efficiency to the machine-tool?
Group 6: Yes, sometimes. But we must apply one of the general principles of prevention established in the law [6] i.e., to combat the risks at source in order to eliminate or reduce the exposure and increase levels of protection.

4 CONCLUSIONS

Overall, their experience motivated the students to the CU and had positive effects on their learning. It should be noted that the students easily adhered to the proposed task and were committed to its accomplishment, which contributed to a better understanding of the contents. This aspect was visible in the final evaluation, since all the students that carried out the work obtained approval in the CU.

It is also worth noting that, according to the majority of the students, the practical work and its presentation allowed them to clarify some concepts, to feel more confidence in their abilities, to overcome some difficulties, to learn to be more objective, improve their communication skills, increase their autonomy, and improve their ability to argue, become aware of their difficulties, learn to be more organized, be able to structure relevant information and participate actively in the classroom.

Since HPTCs are courses that are more directed to professional practice, and integrate a traineeship in a work context, it is urgent to carry out such work. This opinion is corroborated by the students, since the majority agrees or fully agrees that carrying out the practical work based on the laboratory allowed them to have a greater connection with the reality of the course, to consolidate their knowledge on the thematic of Safety and Hygiene in the laboratory and learn in a contextualized way.

It should also be noted that the difficulties felted by the students can be an important source of learning, as long as they are aware of them and seek to acquire the necessary knowledge to overcome them. It also has the advantage that students experience difficulties in environments that are as close as possible to the professional reality of the course they attend, because as stated by Mendes [15] "the formation and context of the company represents an added value for learning because allows the contextualization of theoretical and practical knowledge directly into the work environment, facing the challenges of the specificity of each activity "(p. iv).

Thus it will make sense that the contexts of teaching and learning enhance "the active involvement of students in their own learning process. Not only are students the agents of their own transformation, but higher education institutions and teachers have an essential role in mediating such processes by facilitating and moderating learning contexts that are constantly evolving, transmutation and trans (training)" (p.18, [16]).

It is considered that the learning resulting from this contextualised work can be very useful for the students in other CU of the course in which they have to use the machine-tools, in particular, they can add value in the traineeship that integrates the study plan of these courses.

In the case of groups of considerable size, the applied methodology may have some limitations due to the lack of available resources or in sufficient numbers, which would reduce the variability of different experiences that students would have access to. This aspect can be overcome if the students are allowed to visit companies in the area to choose their work focus, as did Nascimento [17].

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