

EDUCATION AND INNOVATION - VET STUDENTS INTO TECHNOLOGY COMPANIES

Laura Gómez Estrada¹, L. Pietra², C. Zoli², A. Soriano Martínez³, P. Karampelas⁴, A.M. Almeida⁵, J.S. Nunes⁶, J.M. Martínez Ardil⁷, M.T. Guillot-Ferriols⁸, S. Clara-Trujillo⁸, C. Solano-Martínez¹, Luis Gómez-Estrada¹, J.L. Gómez Ribelles⁸

¹*Ikasia Technologies SL (SPAIN)*

²*Smallcodes SRL (ITALY)*

³*IES Politécnico de Cartagena (SPAIN)*

⁴*1st Epalgematiko Lykeio Kato Achaia (GREECE)*

⁵*Centro de Física das Universidades do Minho e do Porto (CF-UM-UP) (PORTUGAL)*

⁶*Somatica, Materials & Solutions (PORTUGAL)*

⁷*CIPF Hespérides (SPAIN)*

⁸*Universitat Politècnica de València, Centre for Biomaterials and Tissue Engineering (SPAIN)*

ABSTRACT

VET education is an effective and accessible way for students to improve their employability and inclusion possibilities. It allows them to train technically in a short time to do a job and try to access the labor market. However, not even obtaining a qualification aimed at vocational training ensures access to the labor market or real possibilities of emancipation.

The success of VET graduates in their first work experience when joining technology companies requires not only the development of many skills that are common to all professional careers, but also specific skills that derive from the innovative nature of the work method and objectives of these companies.

For this reason, within the framework of the Erasmus + Program, the project *VET STUDENTS INTO TECHNOLOGY COMPANIES: A VET students mobility network in the technological sector through a virtual environment with specific materials for critical thinking* is being developed with the aim of promoting employability and inclusion of VET students at risk of exclusion. The project focuses on the creation of virtual tools, collaborative work methodologies and virtual training materials that allow these young people to improve their critical thinking capacity and their technological and digital skills. The project's methodology combines the creation of training materials and a network of mobility in high-tech centres, where students will carry out a first work experience.

Regarding training materials, one of the main results of this project is *PERSONALIZED DIGITAL COURSE FOR LABOR TRAINING IN A TECHNOLOGICAL CENTER*. This course generates personalized learning based on the student's previous knowledge and the characteristics of the technological company in which they will carry out their internship. The course follows an innovative methodology based on micro learning, small exercises (pills) to develop technical and work skills and reinforce critical thinking as a fundamental mechanism. The objective of this course is not so much to provide new knowledge as to develop specific skills for innovative work. The course aims at allowing the students to face problems or tasks unknown to them until then. Critical thinking skills that will be addressed are self-training, assess their own way of reasoning, set objectives, raise relevant questions, state hypothesis, search for information, intellectual integrity, oral and written communication, work in multidisciplinary teams. Also, within the framework of this project we are developing the App *ON YOUR SIDE*. This is a digital educational software available for mobile devices, which will accompany the student throughout the mobility process, providing useful information such as specific training resources focused on the company where they will carry out their mobility, linguistic resources, collaborative work tools, as well as social integration resources in the destination country, among others. From this App, students will be able to access the aforementioned course.

In this paper we present how, through micro learning methodology and critical thinking, students can solve the content pills through their autonomy and self-discovery.

Keywords: VET, technology company, microlearning, critical thinking

1 INTRODUCTION

In this article we present the objectives, methodology and contents of the "*PERSONALIZED DIGITAL COURSE FOR LABOR TRAINING IN A TECHNOLOGICAL CENTER*", aimed at VET students from technological professional families (electronics and electricity, mechanics, computer science, chemistry ...). This course is the result of the Erasmus Plus project "*VET STUDENTS INTO TECHNOLOGY COMPANIES*". This project aims to prepare VET students or graduates, especially those at risk of exclusion, in order to develop their professional careers in innovative companies. Both teaching centers and technology-based companies where students will carry out internships participate in the consortium.

Throughout their vocational studies, these students have taken a variety of subjects and have acquired a range of knowledge that they can apply to their professional careers. However, when facing the problems that arise in professional life, they find a multitude of situations that do not correspond to any of the lessons they have previously studied.

We intend to give another point of view on how to approach problems in the company through critical thinking, because throughout the work in technology companies, students will continually encounter new situations and problems that require a solution.

Therefore, the main objective of the course is for VET students to acquire the necessary skills and abilities to participate in cutting-edge innovation projects in a technology company and fit into multidisciplinary teams. All this through the development of critical thinking and skills that promote their social and labour inclusion.

In this course, we intend to review many basic questions necessary to function in the world of science and technology, focused on professional practice. Thus, through a micro e-learning methodology we will propose hundreds of micro pills that place the student in specific situations or problems that they must analyze and solve autonomously, seeking information with the means available to them. The content of the exercises has been chosen for their ability to make the students acquire a series of skills to face new situations and problems.

2 METHODOLOGY

This course uses an innovative micro learning methodology. Learning is based on solving relatively short exercises (pills) that allow the student to develop autonomy and self-discovery. It is also sought that the student adapts to situations in which they encounter concepts, situations and responsibilities that are new to them.

The objective of this methodology is for students to develop the technical and labour competencies necessary to work in a technology company through situations that induce students to reflect, evaluate their own thinking, search for information and make decisions. In this sense, critical thinking is key to learning [1-4].

However, as it happens when working in a technology company, not all problems have a single solution, so generating a debate about the result with other students of the course and with the tutors themselves is important for the training and objectives of this course.

Through this methodology, the course generates a personalized educational itinerary based on the student's previous knowledge and the needs and work environment of the technology company. We will come back to this point at the end of this section. The exercises that are proposed have the form of problems that, in addition to being related to the study plans of VET studies, require for their solution the development of critical thinking (searching for information, making a hypothesis, analyzing and assessing the problem, making decisions or taking a personal position on it).

In this course the student will not have to study large texts in any of the content blocks. We will build on existing and accessible information through digital means, as well as on developing effective routines to obtain the information that is needed, understand it, elaborate it and draw conclusions from it.

The course is classified into three content blocks, whose exercises will have the same scheme: 1) for the development of critical thinking, 2) scientific and technical, and 3) the specific contents of technology companies. It should be noted that although the exercises are classified into different content blocks, each of them could fit into several, since they require both the development of basic critical thinking skills and basic scientific and technical knowledge for their resolution.

The first block, focused on the development of critical thinking skills, will be assigned to all students.

In the second block, we intend for students to exercise how to address technical problems that may arise at work in a technology company. Our idea is to train them to face a scientific or technical concept that they do not remember or that no one has explained to them before. We hope that the student will develop their own strategies in dealing with these problems. They will have various levels of help that they can get in the course itself, as well as being able to turn to co-workers and their tutors.

Consequently, we are obviously not going to cover all aspects of vocational studies. We will concentrate on a series of concepts trying to force the student to reflect on them. The exercises are relatively simple, adapted to the level of the VET curricula. However, an important aspect of the methodology is to raise questions that are clearly not solved simply with previously memorized definitions or equations. They should also be exercises that encourage not to settle for not understanding why a specific solution has been reached in an exercise. In fact, in many of them there will not be a single solution, although in the final comments several possibilities to open a discussion can be offered.

Our starting point is the conviction that the fundamental tool at work in the innovative company is the ability to reason, whatever the level of studies of the worker. That is why it is key to insist that the student does not settle for anything that they does not understand. For this, we consider it preferable to pose a reduced number of problems or situations, but to thoroughly analyse each exercise or problem that arises. In this way the student has to make an effort to reason, seek information, understand it, and learn by himself. That is why in the exercises they will be asked to carry out calculations, but above all to interpret them, and to explain the result. The course does not contain theoretical introductions to the subject matter of the exercise, nor the equations that allow calculations to be carried out, as it will be in most cases in real work.

We also intend to escape from that way of studying that consists of following problem-solving methods and trying to fit a new problem into one of the standard methods learned. We try to convince the student that with this type of procedure something new can never be addressed. It seems that in a situation that one has not met before they are not able to do anything. We seek just the opposite. We seek to be able to grow professionally and increase our knowledge and capabilities throughout life.

As for the third block, the specific contents, it will consist of exercises proposed directly by the companies in which the students are going to carry out the internships. It is intended to facilitate, to a certain extent, the student's first contact with the company.

The resolution of an exercise involves drawing up some conclusions, which in some cases may be very short and in others it will require something more extensive and reasoned. The exercise of clearly explaining the solution found or the opinion regarding a specific case is considered essential since it forces not to settle for having vague ideas.

In the next section we present some examples of what we have meant in this section.

3 PERSONALIZATION

The course will begin with an initial test that will allow the tutor to customize its itinerary for each student. The selection of the course contents for each of the students will be based on a self-evaluation that will allow the selection of exercises related to the second block of content: general scientific and technical knowledge, since the exercises of the first block of content will be common to all students, while those in the third block will depend on the technology company in which they will carry out the internship.

The program will automatically select the exercises based on the student answers, but the student will always have the opportunity to check with their tutor at any time if they consider that there are areas in which they have not been able to answer properly or topics that have particularly interested to them and want to expand.

To each question of the initial test, they must respond with a number between 1 and 4, according to the following classification:

I have never studied this. I would not know where to start	1
I remember studying similar things, but I don't know how to approach it	2
I have to go over it, but I'll know how to do it	3
Yes, I know how to do it	4

Throughout this short initial test, students may come across questions such as:

1. Do you remember how you prepare formulations or solutions, for example, could you calculate how many grams of sodium chloride you have to add to 25 g of water to form a 12 weight % solution?
2. Are you confident in handling the concepts and equations related to electrical installations? For example, an electrical equipment, powered at 220V, has a 10A fuse. What is the maximum electrical power it can develop?
3. You will have studied the general concepts of risk prevention at work. Do you know what the safety data sheet of a chemical product is?
4. Do you know the basics of electromagnetism? An example: A magnet adheres to a metal surface with a force of 3kg, if we separate it one millimetre from that surface, it will exert the same force on it, a slightly less force or a much less force?
5. Mechanical properties of materials Could you explain what a brittle material is?
6. Regarding computer applications, do you know how to represent data with the Microsoft Office Excel application or another similar one?
7. Some mathematical concepts. Can you explain what the slope of a function is?

4 RESULTS

In this section we are going to present examples of each of the content blocks that make up the course. The objective of these exercises is to raise ideas and concepts that require students to face new problems, analyse them and be able to solve them.

4.1 Contents

4.1.1 Contents for the Development of critical thinking

As an example, we have chosen a content pill that belongs to the didactic unit “Set hypothesis”.

Electric heating

What is the monthly cost in electrical energy of an electric radiator that has a power of 1400 W and is plugged in for 8 hours a day?

First, based on what you know about the monthly electricity bill for your house or by intuition, raise, without fear of being wrong, what you think will be the solution to this question: XXX euros per month.

Help 1: The first step is to look for the electricity rate on a receipt. Say that you read, in 2020, that the price is 0.171 euros / kWh, there is also a 5.11% tax on electricity in Spain (of course, the price is variable from one month to another, from one supplier company to another and from one country to another, but the calculation will be worth taking as a reference the data of your house). There are other expenses that are fixed in the electricity contract and that we may not have an impact here. In addition, we will have VAT of 21%. Total 0.218 euros / kWh. Notice that we settle here with three decimal places. The numbers that appear on the invoice are very precise because they apply to consumptions that can be enormous, but in our case we don't need to be so precise. Then we will analyse it based on the result.

Help 2: The kWh is a unit of work, it is the product of a power in kilowatts and time in hours. In our case, with 30 working days in a month (of course not all months are the same), our electric radiator consumes $8 \times 30 \times 1.4 = 336$ kWh and the cost of this consumption will be $336 \times 0.218 = 73.25$ euros

Final comment: Have you approached? Did you think that the price of heating was so high? In this example we want to show the role of making a first hypothesis about the result, before doing any calculations. Doing so will help us analyse the result we obtain. If it is very different from what we had anticipated, we will ask ourselves if we have not made a mistake in the calculations and we will review them. If we confirm them, it will make us think about the physical reason why that result comes out. In this case, electric radiators actually have a very high consumption, there are other heating systems that are cheaper, such as the heat pump or natural gas or butane gas boilers.

4.1.2 Scientific and technical content

As an example we have chosen a content pill that belongs to the didactic unit “Chemical elements and compounds. Formulations. Concentrations”.

Prepare a solution.

Explain in a simple protocol how you would prepare 10 ml of a sodium chloride solution in water with a concentration of 1% by weight, which has to be added in a production process: what products would you use, what amounts of salt and water, how would you measure those quantities, how would you mix to obtain a homogeneous solution, what equipment do you need to do it?. How does the protocol change if what we want is a 1% w / v solution? How does it change if what I want is a saturated solution at room temperature?

Help 1. The first point to pay attention is that, although it is a preparation that uses common products in everyday life, any manufacturing process needs to be reproducible and any foreign component must be avoided. This means that the necessary purity must be considered in the starting products. In our case, we will not use the salt sold in food stores as sodium chloride because we have no guarantee that it does not contain mixed salts other than sodium chloride, nor will we use tap water or mineral water because they have other salts dissolved. Look for the salt in the laboratory suppliers and see what degrees of purity of the water we can use.

Help 2.

The quantities to be measured are small, to measure them we need a balance, and pipettes, with the appropriate measurement precision for those quantities. For example, if I have to weigh 5.0 mg, I cannot use a balance that appreciates milligrams since the reproducibility will be ± 1 mg or poorer, and thus the measurement would have an uncertainty of at least $\pm 20\%$. A balance that appreciates at least 0.1mg will give an accuracy in my measurement of the order of 2%. What if the company only has a scale with a precision of 1mg available? What can you think of doing? (it is not worth saying it is not possible to prepare the solution)

Final comments. Taking into account the precision and reproducibility of everything that is done in the company is crucial. Introducing an unknown agent into the processes can make the product not have the expected characteristics and also makes it impossible to understand why it does not have them and therefore solve the problem that appears. It goes without saying that the analysis or production processes cannot depend on the person who performs them, the protocols have to be described with all the necessary details so that anyone, with the necessary training, can obtain the same results as who prepared the test protocol.

4.1.3 Specific content.

The chosen example belongs to the content prepared by a technology-based company specialized in 3D printing.

What is a polymer?

How do you imagine a molecule of a polymer? They are long chains of atoms in which a unit is regularly repeated hundreds, thousands, or hundreds of thousands of times. To know how to interpret phenomena that we find when printing parts with the polymer filament extrusion 3D printer, it is necessary to have an image of what the structure of these materials is like. Draw outlines of the different forms that the chain can take in space and explain what depends on whether it is one or the other. Identify what the chemical structure is like and how it should be the structure of polyethylene, PE, polycarbonate, PC, polylactic acid PLA and polyethylene terephthalate, PET.

Help 1. When looking for information about what a polymer is, you will have found the analogy that it is like a plate of spaghetti, the molecules curl up and intertwine with each other. But not only does this structure appear, when the chain is sufficiently regular the chains can be arranged in space forming a crystal. What are the crystals of a polymer like?

Help 2. Polymers, even those that are capable of crystallizing, do so only in part. Many times they form structures called spherulites formed by very fine sheets of glass that grow from a single nucleus forming a sphere. Identify the polymers of those in the exercise statement that can and cannot crystallize.

Final comments. There are an infinity of polymers. Chemical synthesis is capable of making really complex chemical structures to make the polymer have special properties. A few of them are used in 3D printing. Each printing filament has particular properties, some contract more and the printed parts are curved when the lower layers cool during printing, the adhesion between the layers is better or worse, the mechanical resistance is also very different from each other, there are rubbers but other are extraordinarily rigid, the maximum temperature of use can also be very variable. All these properties depend on the chemical structure and the spatial conformation of the chains. The other essential aspect for printing is the fluidity of the polymer and the temperature at which the polymer flows, also dependent on its structure.

4.2 Implementation

The course is free and freely accessible through the digital educational software "ON YOUR SIDE", one of the results developed within the framework of the Erasmus Plus project "VET STUDENTS INTO TECHNOLOGY COMPANIES". This software, available for mobile devices, will accompany the student throughout the mobility process, providing useful information such as specific training resources focused on the company where they will carry out their mobility, linguistic resources, collaborative work tools, as well as social integration resources in the destination country, among others.

Likewise, the course will also be available on the e-learning platform "Virtual Inclusive Education" (www.virtualinclusiveeducation.com), aimed at helping and supporting both social and educational entities, as well as their members and beneficiaries.

5 CONCLUSIONS

In this course we try to put the student before situations that require proposing a solution or taking a personal position. The exercises involve scientific or technical concepts that the student may not have come across before or that they have studied in a rather passive way and do not remember well. We try to convince them that the key to getting out of these situations is to train the way of reasoning, including looking for information, judging its credibility, analysing it and ordering their own ideas, expressing themselves well, and many other skills related to critical thinking.

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