

# VET STUDENTS INTO TECHNOLOGY COMPANIES: A MICROLEARNING DIGITAL COURSE TO TRAIN CRITICAL THINKING SKILLS

L. Gómez Estrada<sup>1</sup>, L. Pietra<sup>2</sup>, S. Randaccio<sup>2</sup>, A. Soriano Martínez<sup>3</sup>, P. Karampelas<sup>4</sup>, A.M. Almeida<sup>5</sup>, J.S. Nunes<sup>6</sup>, J.M. Martínez Ardil<sup>7</sup>, M.T. Guillot-Ferriols<sup>8</sup>, S. Clara-Trujillo<sup>8</sup>, C. Solano-Martínez<sup>1</sup>, L. Gómez-Estrada<sup>1</sup>, J.L. Gómez Ribelles<sup>8</sup>

<sup>1</sup>*Ikasia Technologies SL (SPAIN)*

<sup>2</sup>*Smallcodes SRL (ITALY)*

<sup>3</sup>*IES Politécnico de Cartagena (SPAIN)*

<sup>4</sup>*1st Epalgematiko Lykeio Kato Achaia (GREECE)*

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

<sup>6</sup>*Somatica, Materials & Solutions (PORTUGAL)*

<sup>7</sup>*CIPF Hespérides (SPAIN)*

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

## Abstract

This microlearning course is designed to support VET graduates or students, especially those with fewer opportunities, who join a technology company at the beginning of their professional career. It has been developed within the framework of the Erasmus + 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”. This is an initiative co-financed by the Erasmus + Programme, with a personalized digital course format, to take into account both the previous training of the VET student or graduate and the type of company they will join. The course has in its sights to develop in the VET student the specific competences required by the technology company to address the problems typical of fields of leading technology innovation, as well as fitting in multidisciplinary teams. To do this, this course generates an innovative methodology in which the education itinerary is built based on previous knowledge of the student and the needs and work field of the technology company. Besides its contents strengthen critical thinking as an essential mechanism for work in both dynamic and technology sectors. For that purpose, the student is asked a series of questions in the form of problems that, in addition to being related to the study plans of VET studies, require for their solution the search for information, its analysis and many times the making of a decision or adopting a personal position on it.

We aim with our training projects, within the Erasmus + program, to convince students that they are capable of going further and further in the development of their professional skills being the technology sector an acceptable option for them, making their work increasingly valuable for their inclusion, for their own personal development, for that of the company in which they work and for society. But for this certain skills are required, and one of the most important is learning to learn autonomously and to accurately analyse the information received and the decisions that are made from it.

It is generally true that the problems that one encounters in professional practice are not going to be the ones that you were taught in your VET studies. Vocational training has to head for equipping students with the necessary tools to face the new problems that they will face in their job and to grow professionally every day. We intend to show how valuable critical thinking skills are in analysing our way of thinking and making decisions.

In this paper we present examples of the exercises included in the course, how their approach and the processes that have led to a solution relate with the standards of critical thinking and the different levels of help that are offered to the student for their solution.

The course is accessible from a digital educational software “ON YOUR SIDE: VIRTUAL ASSISTANT FOR EUROPEAN MOBILITIES IN TECHNOLOGICAL CENTERS” developed in the framework of this Erasmus+ project in order to develop cooperative work between students with fewer opportunities doing their internships in technology companies and their inclusion in new job posts. We will also present this software in a very summarized way in this article.

Keywords: VET, technology company, microlearning, critical thinking.

## 1 INTRODUCTION

In this paper we want to present the objectives, methodology and content of a course aimed at VET students or graduates who are going to start their professional career in a technology company, perhaps through their curricular internships or with a first employment contract. We want to put ourselves in the place of this professional who has a background in which they have studied different subjects, some of a general nature and others more specialized in a specific area (for example, among the most technological, electricity and electronics, energy and water, mechanical manufacturing, image and sound, computing and communications, installation and maintenance, chemistry, transport and maintenance of vehicles, glass and ceramics).

This student gets their first job in a small or medium-sized company in a technology sector, to be able to speak specifically, let's say it is a company that uses additive manufacturing and is open to production in different industrial sectors. Among the functions of the job, this professional will find themselves with the production and characterization of materials from different families: polymers, metals, ceramic materials, they will handle 3D printing machines, which implies the management of machine control software, they will have to make specific formulations in solutions and reagent systems, will perform quality control tasks and many others and in any of them they will work in a team to which will inform orally and in writing of their results, and they will listen and propose solutions to problems that appear every day. It is easy to accept that depending on their VET studies, perhaps 90% of the concepts and technologies will be the first time they are found. It is logical that it should be so since it is not possible for the study center to foresee the first job that each student will have and even less the following ones to which they will access in their professional life. On the other hand it would be absurd to try to put in the heads of students all the possible range of professional jobs to which they can choose, just as absurd as to pretend that studies have to train only to a small window of professional activities in such a way that what they decided to study (they or their parents and teachers) at age 14 has to mark their entire professional life.

When our student who has studied VET in the family of electricity and electronics (for example) finds the job that we have described, with these functions, in this technology company, should they say: I cannot accept this job, I have not studied materials, I have not handled 3D printing machines, , I have no experience in numerical control machines, I have never seen three-dimensional design software ..? Obviously the answer is that they shouldn't think about it that way.

The first objective of our course is to convince our student that, just as they has passed dozens of different subjects throughout their studies, now they has to study other new subjects. Everything studied so far must serve to be able to overcome these new subjects. But the way to study, learn new concepts, use new technologies, react efficiently to problems that arise, is not like in previous studies. Now it's time to learn in a different, autonomous way and that requires technique. It is necessary to learn to learn autonomously and that is what this course is about.

We are going to propose about a hundred exercises, which place the student or professional in specific situations or specific problems that have to be analyzed and solved if it is the case. We classify them into three blocks: the first is about critical thinking skills, the second is how to apply those skills to scientific or technical issues, and the third one is about how to apply them to specific technology company situations. The exercises are examples chosen for the possibilities that we believe they have of teaching to learn, analyzing situations and solving problems. They are not intended to cover a syllabus, they deal with scattered topics and others could have been chosen. The examples we give should not be expected to teach, for example, electromagnetism. We would fall just the opposite of what is our intention. No matter how broad we would make the course, how many exercises we would put, the problem that our student would have to face in the company would be a different one. We propose exercises thinking that what the student is going to acquire with them is a series of skills to face new situations and problems.

## 2 METHODOLOGY

In the day-to-day work in a technology company, new situations will constantly appear to which you have to react positively to get the most out of them. Sometimes they will have to do with a problem that has to be solved, other times it is a new idea that arises from carrying out an experiment or reading a document or observing a commercial product, others it will be an order from a client with a specific need and others a legal or administrative procedure.

The company's team is made up of people with different training, knowledge and experience who can contribute their skills to the challenge that arises, and situations are, in general, complex and requiring the contribution of more than one. Moreover, it is more than likely that facing a new problem requires learning new concepts, techniques or tools because the previous knowledge and experience of the components of the company's team is not enough. Contributing effectively to this work and enjoying it requires a particularly positive attitude and a combination of communication skills and autonomous learning, of basic knowledge that allows understanding new information and new concepts and communicating effectively with the group and specific knowledge of the area in which one has specialized within the company.

To contribute to the achievement of these skills and knowledge, this course uses concepts and tools for the development of critical thinking. By critical thinking we mean here stopping to think every time a decision is made or something is accepted as true in the reasons that have led us to it, in line with Ennis's definition: "*Critical thinking is reasonable and reflective thinking focused on deciding what to believe or do.*" [1] or that of Paul and Elder "*Critical thinking is the process of analyzing and assessing thinking with a view to improving it*" [2]

Our methodology aims to approximate the company environment. It is based on a long series of examples or situations about which one has to think, seek information, face a problem and make decisions. Above all, we intend to induce a reflection on the way in which one has come to take a position on the case and evaluate one's own thinking, the sources of information and the chain of reasoning that they have developed. We hope that this objective, which we recognize, is now rather abstract, will become clearer as we move forward. As in real work, many problems do not have a single solution, and the contrast and discussion of the result with other participants in the course or with tutors can be extraordinarily rich for the training and objectives of the course.

Each example begins with a statement or an approach that requires making a decision, taking a position, or presenting a state of the art. The resolution of the case presented must be expressed clearly many times in a few lines, in other cases they require the elaboration of a more extensive document. If help is required to advance in the understanding of the case or problem raised and in the elaboration and evaluation of the answer, it is possible to go to different pieces of additional information that appear when the student requests it and it is suggested not to do so at first. The development of one's own reasoning is the richest part for training, rather than knowing the "correct" answer (apart from as mentioned before, in many cases there will not be a "correct" answer but rather an opinion or taking a position).

We will follow this scheme in the section corresponding to the basic competences that are essentially critical thinking competencies, but we also consider that it is a very appropriate methodology for the acquisition of basic knowledge and specific knowledge that will be organized in the same way.

We classify the examples in different sections, but, as will be seen in a moment, each of them could fit well in several of them, even in a mixture of basic critical thinking skills and basic scientific and technical knowledge or in specific knowledge, for example: for addressing the knowledge about the properties of the filaments used in three-dimensional printing that we would classify within a specific competence, will require the search for conceptual information, of a basic nature about the polymers from which they are made, and technical data that are really more specific. It will also require the understanding and evaluation of the information found and the effective written expression of the conclusions, which are basic critical thinking skills. In this sense, it is not necessary to go through the course from beginning to end in an orderly manner, you can jump forward or backward to address the examples that you find most attractive or suggestive.

We will not stop in this course in the writing of large texts to study, not even for the general or specific contents of a specific area, we will base ourselves on the existing and accessible information through digital means and on developing effective routines to find the information that is needed, understand it, elaborate it and draw conclusions from it.

### 3 RESULTS

In this section we include an example of each of the sections of the course, as a way to clarify our methodology and the intention of the course. They are examples that aim to start from the level of training of VET graduates, understood in a generic way, but go further, raising ideas and concepts that require the student to face new things, search for information in digital media, and elaborate and understand it.

#### 3.1 Contents for the development of critical thinking

In this course we have chosen to focus in a reduced series of critical thinking standards (Evaluate one's way of reasoning, set objectives, ask relevant questions, pose hypotheses, learn to learn, seek information, have an open mind, have intellectual integrity, express oneself well orally and in writing) and adapt the examples to the age and background of the students.

Next, we propose a problem related to the formulation of a hypothesis. There are several examples on this topic in the course. Before making a calculation, the student is asked to make an estimate of the result based on their intuition their previous knowledge or simply on common sense. It is not important to get the hypothesis right, simply the fact that it has been raised causes the result to be critically analyzed. If something unexpected comes up, they will ask themselves if they were wrong with their first ideas or have made a mistake in the calculations and also will make them look for a physical meaning of the result.

##### ***Lengthening of a thread when hanging a weight.***

We want to hang a piece from a thin thread, 500 *microns* in diameter and 1 *m* long. The piece weighs 1 *kg*. When hanging the piece the thread lengthens, we can allow it to lengthen a maximum of 1mm. Can we put a nylon or polyester wire or do we have to put an aluminium or steel wire? Before doing any calculations, try to answer based on intuition and what you know about these materials, for example, fishing lines are made of nylon, many fabrics are made of polyester. Then do the math and see if you were right or not.

**Help 1.** The question is what parameter of the material determines how much the thread will deform when we apply a force to it. This is the elastic modulus. Find the elastic modulus values for different materials. In the case of plastics you will find approximate values because there are different types of nylon and different types of polyester, in addition, the deformation of plastics is a very complex phenomenon, they do not deform instantly when the weight is hung but they lengthen over time.

**Help 2.** If the elastic modulus of the yarn is  $E$ , its units in the international system is the Pascal or  $N/m^2$ . The elastic modulus is

$$E = \frac{\sigma}{\varepsilon}$$

where  $\sigma$  is the applied tension

$$\sigma = \frac{F}{S}$$

Where  $S$  is the cross section of the wire, in our case the area of a circle whose diameter is

$$d = 0.5 \text{ mm}, S = \pi d^2/4.$$

$\varepsilon$  is the strain

$$\varepsilon = \frac{\Delta l}{l}$$

Where  $\Delta l$  is the elongation, which we have set as  $1\text{ mm}$  and  $l$  is the initial length,  $1\text{ m}$ .

Let us put all the parameters in units of the international system:  $F = 9.8\text{ N}$ ,  $l = 1\text{ m}$ ,  $d = 0.0005\text{ m}$  and calculate the elastic modulus that the material must have.

It turns out that  $S = 0.000000196\text{ m}^2$ , the tension applied to the wire is  $\sigma = 49900000\text{ Pa}$ ,  $\epsilon = 0.001$  (it is dimensionless) and therefore the modulus is

$$E = 49900000000\text{ Pa} = 4.99 \cdot 10^{10}\text{ Pa} = 49.9\text{ GPa}$$

**Final comments.** Do these numerical values surprise you? The Pascal is a very small unit, it is of the order of the pressure that a  $100\text{ g}$  bar of butter would make on a square table one meter on a side. That is why the tensions that appear in concrete situations are very large numbers. In any case, so that the thread does not lengthen more than  $1\text{ mm}$ , a metallic thread is necessary, the plastics are not as rigid as it is necessary in this case, their elastic moduli reach  $10\text{ GPa}$  at most, were you correct? Plastics deform a lot.

### 3.2 Scientific and technical contents

In this part of the course, examples are presented corresponding to very varied areas, they could be others, the main value that has been sought for them is the ability to provoke the application of critical thinking to problem solving and the search and analysis of information.

#### **Charts prepared with Excel**

In one of the company's machines we have a heating system that increases the temperature of a part. We want to know the effective heating rate and for this, a temperature probe has been placed inside the part, the heating element has been activated and you have noted the temperature measured at different instants of time measured from the moment the system has started to heat up. The table collects this data and with it you have to make a representation. The graphs are prepared with the Excel application, in which you enter the data in consecutive cells, choose the type of graph and automatically prepare it, then all the characteristics of the graph can be modified: character sizes, colors, scales.... With your data, the four graphs in the Figure have been prepared. They all represent the same data and yet they look very different from each other. What happens? Are there some that are right and others that are wrong? Did you make a mistake when putting the values in the table? Explain what is good and what is bad for each of the others

**Help 1.** In the graph A all the points appear perfectly aligned, in fact, the straight line that joins all the points has been represented. However, in diagrams B and D the points are not aligned but the data is the same as in Figure A, what happens? The format of chart B is that of a bar chart and D is a line chart, what does Excel represent on the x-axis of those charts?

**Help 2.** The diagram in figure C is like that of A, they are graphs of "scatter points", the content of graph C is correct, but information is missing in the axes, it is not known what is being represented, the format of the characters of the axis y has been smaller, it also seems that it could be improved.

#### **Final comments.**

Perhaps Excel is the most used application to organize calculations and prepare graphs with them that allow them to be analyzed. But, although Excel is very easy to use, you need to keep your attention. The type of graph that is chosen is not only a matter of style, they represent different things, for example, many of the graphic styles represent texts on the abscissa axis, in B and D it has taken the numbers in the column as if they were letters and he has put them at the same distance from each other regardless

of the value of each one, for those the graph comes out distorted. In Excel, the only type of graph suitable for the type of representation that interests here is the one called Dispersion xy.

The automatism of the spreadsheet are not always adequate to what one is after. The style of representation, the information it contains, the details that appear on the axes, the sizes of symbols and characters in the texts, are aspects that you have to judge yourself, in the application criteria have been introduced on how to do it that in most of the situations are not going to agree with what you need.

time (min)	temperature (°C)
2	302,9
6	330,3
8	336,3
17	346,6
30	349,3

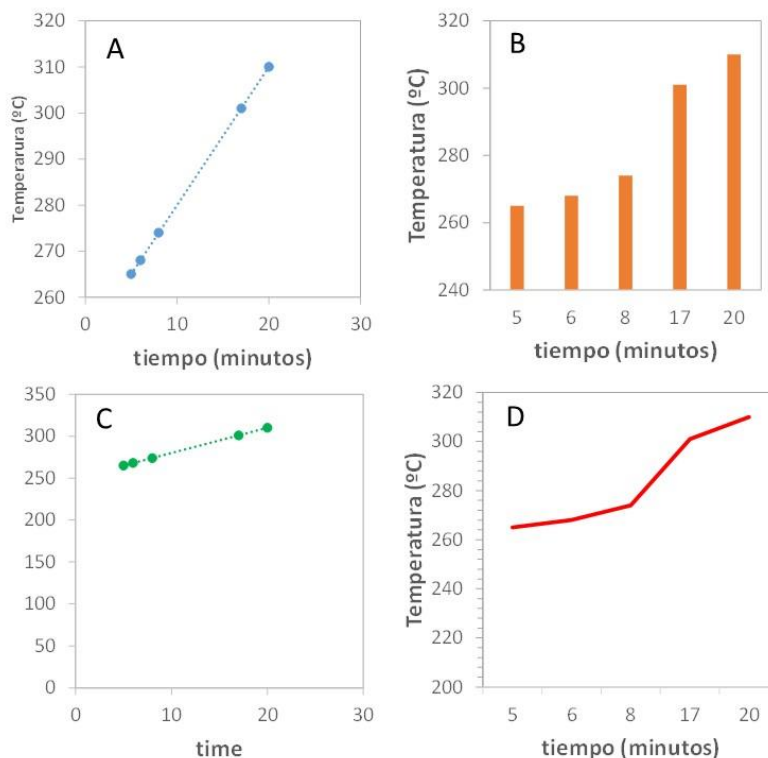


Figure 1. Different graphs prepared from the same data

### 3.3 Content related to the work in the company

#### **Safety data sheets, SDS of chemicals.**

You are going to use dimethylformamide as a solvent. Look for its safety data sheet and see if you understand its content. In particular, look at its toxicity, safe storage conditions, precautions for working with this reagent. What individual protection elements should you use when handling it?

#### **Help 1.**

The safety data sheet (SDS) can be found at any reagent supplier, enter the website of a chemical laboratory supply company and together with the characteristics of the product and its price, you can download the safety sheet on your idiom. From there you will be able to get the data that this exercise asks of you.

#### **Help 2.**

It is important to understand the terms that appear on the sheet, for example, those that define its toxicity and determine the precautions for use and storage.

#### **Final comment.**

The safety sheets of all the products handled by a company must be collected and available to the workers. The company will have its procedures to keep this file updated and to train workers before using each product.

### 3.4 Implementation

The course is free, implemented on the “virtual inclusive education” e-learning platform ([www.virtualinclusiveeducation.com](http://www.virtualinclusiveeducation.com)), aimed at helping and supporting both social and educational entities, as well as their members and beneficiaries. It is accessible from a digital educational software “ON YOUR SIDE: VIRTUAL ASSISTANT FOR EUROPEAN MOBILITIES IN TECHNOLOGICAL CENTERS” developed in the framework of this Erasmus+ project. This digital environment will accompany the VET student throughout the mobility process. It will contain useful information for students, including the centers where they can carry out mobility, the culture of the region, linguistic resources and the experiences of other students. Specific training tools for each mobility, as well as collaborative work are also available in this application. This result will allow the student to feel attended during their mobility, find resources to help them when they have problems and to feel that their teacher and their tutor are with them.

Students or professionals interested in following it will first carry out a small survey in which they are asked to answer a series of questions with a number between 1 and 4, according to the following classification:

I have never studied this. I wouldn't know where to start	1
I remember studying similar things, but I don't know how to approach it	2
I have to review it but I will know how to do it	3
Yes, I know how to do it	4

Some examples of the questions are the following:

*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% solution by weight?*

*Are you confident in handling the concepts and equations related to electrical installations? For example, an electrical equipment, powered at 220V, has a 10 A fuse. What is the maximum electrical power it can develop?*

*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?*

The application recommends, depending on the answers, a part of the exercises that make up the course to be carried out in an orderly manner. In this way, the course is personalized not so much based on the successes on previous questions but according to the previous studies or interests declared by the student.

## 4 CONCLUSIONS

The idea behind the methodology proposed in this course is to show situations in which the student needs to learn something independently. In doing so, the reader will find indications and suggestions that highlight the pitfalls that one generally encounter when have to make a technical decision or solve a problem on a subject on which they do not have sufficient prior knowledge or experience. We try to convince that the key ingredient to be successful in this learning process is critical thinking and that to develop it, it is necessary to acquire a series of skills and become aware of certain keys of how our mind works when we leave it on automatic pilot.

## **ACKNOWLEDGEMENTS**

This work has been funded by the Erasmus + program within the 2019-1-ES01-KA202-064569 project, Spanish Service for the Internationalization of Education (SEPIE)

## **REFERENCES**

- [1] R. Ennis 2011.- *Critical Thinking: Reflection and Perspective Part I, Inquiry: Critical Thinking Across the Disciplines*, F Fair Ed. Sam Houston State University 2011
- [2] R. Paul, L.Elder 2005, *Critical Thinking Competency Standards. Standards, Principles, Performance Indicators, and Outcomes With a Critical Thinking Master Rubric*. Foundation for Critical Thinking 2005, Retrieved from <http://www.criticalthinking.org/> accessed 3-3-2019