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Erasmus+ Programme
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# WORK PLANS
## for a VET student
## in a technological center

### INQUIRIES FOR INITIAL, FOLLOWING AND FINAL EVALUATION

IKASIA TECHNOLOGIES
UNIVERSITAT POLITÈCNICA DE VALÈNCIA
CHARLES UNIVERSITY
SOMATICA MATERIALS & SOLUTIONS
TEI Κρήτης
Universidade do Minho
1 ο ΕΠΑΓΓΕΛΜΑΤΙΚΟ ΛΥΚΕΙΟ ΚΑΤΩ ΑΧΑΪΑΣ

This guide is a result of the project:

**CRITICAL THINKING AS A STEP FORWARD IN VET EDUCATION: VET students immersed in high technology teams**

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**WORK PLANS FOR A VET STUDENT IN A TECHNOLOGICAL CENTER. INQUIRIES FOR INITIAL, FOLLOWING AND FINAL EVALUATION**
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Coordinator:
IKASIA TECHNOLOGIES SL
C/ Jesús y María, num 26 - bajo - 46008 (Spain)

mail: info@ikasia.es
Web: www.ikasia.es

Chief editor:
Luis Gómez Estrada, CEO Ikasia Technologies sl

Written by:
José Luis Gómez Estrada
Concha Solano Martínez
Maria Teresa Guillot-Ferriols
Sandra Clara Trujillo
Jivago Nunes
Senentxu Lanceros
Pedro Martins
Panagiotis Chatzipapas
Panagiotis Karampelas
Dimitrios Fligkos
Ioannis Kaliakatsos
Konstantinos Petridis
Ivan Krakovski

# 1 TUTOR'S NOTEBOOK

## AN AID TO THE PROGRAMMING OF THE WORK OF A VET STUDENT TO STRENGTHEN CRITICAL THINKING SKILLS IN HIGH-TECH COMPANIES OR RESEARCH CENTRES

The following pages include our proposal for a template to help the tutor of a trainee student prepare the work plan focused on the development of critical thinking skills that we have explained in chapters 5 and 6 of this guide. It can also be helpful to organize the monitoring of the student's progress. As you can see in the notebook itself, it is proposed to start by presenting the student with the work as a whole, to make him understand the objectives, hypotheses and what is expected from his contribution to the achievement of the overall objectives of the project. As in all the development of the practice one of the fundamental aspects is that the student is the one who with his own words write down in his laboratory notebook these aspects, requesting the clarifications he /she needs from the tutor himself or from other members of the group.

The next step would be to entrust the student with a task as concrete as possible, that includes an experimental part that can be carried out in a reduced period of time, perhaps of the order of 10 to 15 days. The aim is to evaluate the students' abilities in relation to certain aspects of critical thinking, but above all to guide them from the first moment in a reflective way of working. The notebook suggests different components that should be included in the task, such as the search for specific information, the understanding of an experimental protocol, the presentation of experimental data, participation in group meetings and the way in which he/she collects all this in his/her laboratory notebook.

To analyze with the student after this first task the results obtained, assessing his/her strengths and guiding the way in which the different aspects of the analysis can be improved can be very effective for the further development of the internship.

Then, it is proposed that the tutor take certain notes about the reorientation of the work plan to the extent that is relevant or the evolution of the student in relation to critical thinking skills, but without forget that it is the student who should collect in his/her notebook everything related to the description of the purpose of the work, concrete objectives, hypotheses, results and assessments.

This notebook is designed to be independent of the rest of the guide, as a working document that is particularized for each situation and that the tutor manages throughout the practice, although, obviously, reference is made to the other sections of the guide.

## 1.1 BASIC INFORMATION IN TUTOR'S NOTEBOOK:

**Tutor's notebook: suggestions to program the work of a VET student to strengthen critical thinking skills in high-tech companies or research centres**

**Worker or student internship:**
**Supervisor:**
**Notebook starting date:**
**Date of completion and file in the company:**

| The tutor who delivers the notebook: | Received by the CBIT: |
|---|---|
| Date and signature | Date and signature |

This template for the tutor notebook was developed by the team of the Centre for Biomaterials and Tissue Engineering of the Universitat Politècnica de València during the implementation of the Erasmus + project 2017-1-ES01-KA202-038469 *CRİTİCAL THİNKİNG AS A STEP FORWARD İN VET EDUCATİON: VET students immersed in high technology teams.*

## 1.2 AIM

The vision of the project CRİTİCAL THİNKİNG AS A STEP FORWARD İN VET EDUCATİON: VET students immersed in high technology teams (2017-1-ES01-KA202-038469) is that the training of professionals in critical thinking skills is a trigger for acquire the skills that the technology of this century will require of the professionals in the companies. The work of the team that has developed the project has focused on the training of VET students during the performance of an internship or in general during their work immersed in the team of a high-tech company or a research centre. But it is clear that the mere fact that the student works in a team that has well-established methodologies that employ group work, discussion and criticism, which value the creativity of each member of the group and uses the scientific method it is not enough for the formation of the student. It is necessary that his/her activity in the company be programmed carefully, so that certain strategies of critical thinking that do not appear spontaneously be trained. Also in a creative group the work of a technician or a trainee can consist of routine tasks, following established protocols, that the technician himself does neither need to analyze nor have the ability to introduce changes in them. The feeling that one does not have the possibility of introducing changes in the work that he / she is doing is discouraging in order to go further in the training with respect to everything that surrounds the tasks entrusted to him / her. On the contrary, it encourages simply to comply with the routine.

The role of the tutor of the student, in particular, and of the team in which he/she is immersed in general, is to guide the student's work so that it contributes to his / her own training in certain critical thinking skills, in the conviction that this it is the way to contribute most effectively to achieving the company's objectives.

It is necessary to assume that those of us who can take charge of tutoring the work of a technician in the company will not perform a good role in the training of the student intuitively, nor will the tutors in scientific research teams go to do it for the fact of carrying time immersed in the working methods of the university or of the higher research institutes. Apply critical thinking skills is also necessary when preparing the student's work program, it is necessary to set realistic goals, designed for each student taking into account their characteristics and interests and flexible, modifiable throughout the internship and in function of the evolution of work.

One must formulate hypotheses about what activity can favour the formation of each capacity in which one wishes to influence, to self-evaluate the criteria on which we base ourselves to establish these hypotheses, that is, to plan those activities, and the methods to evaluate the student's evolution in each capacity. With this we do not invent anything, it is something a thousand times repeated in any study about the educational process. We want to apply those general reasonings dealing to the formation of critical thinking capacities (about which there is also abundant literature) in the formation of VET students immersed in teams of high-tech companies or in research centres.

This document aims to be an aid for the tutorto program the VET student internship in the company. Obviously its content must adapt to the work of the company or the line of research and development of the group.

We start with some initial suggestions, debatable, but that could be general lines to focus the training process. In section 3, above, we proposed to focus the training in a series of critical thinking skills during the internship practice, being aware of the limited time available and thinking about developing skills that are triggering the continuation of student training during all his working life. Finally, we elaborate a template for the tutor in which to elaborate the programming in a self-critical way.

## 1.3 OUTLINES

From the literature on Critical Thinking it can be deduced that the development of critical thinking skills requires, or at least will be favoured by, an environment with certain general characteristics:

1 The training in critical thinking skills has to be centred on the student.

2 The training plan should be based on problem solving.

3 The student's activity must have a large component of group work. The student must be integrated into the group work routines of the company's work team or the research group: periodic meetings, digital data storage tools, etc.

4 The student must see clearly the possibility of introducing changes in the tasks assigned to him in the work plan of the group based on the results obtained or the information that can be collected. In this sense, there must be clear channels for the student to present, if possible, to the work team their results and evaluations.

5 The programming of the internship must be personalized for each student, for that it is necessary to program the way to evaluate the competences of the student at the beginning of the internship. We suggest carrying out this evaluation through the programming of certain initial tasks, corresponding to the work of the internship, but which can be evaluated very quickly, in the first 10 or 15 days of work, so that the programming can be revised accordingly.

The company must be aware that receiving a VET student in an internship involves an important effort that must be compensated, both for the company as a whole and for the tutor himself, by the student's contribution to the company's objectives. It may be important to consider this balance as an objective and to be demanding in this sense, that is, to develop a method of evaluating the effort devoted to student training and the student's contribution to the team. In the same way, the student must make an assessment of the training that he/she considers he/she has received in relation to the effort he/she has devoted to it. The process feeds back: we trust that by dedicating the necessary effort to the programming of the work and its follow-up, great results can be obtained for the student in his training and for the company in the effective realization of a work plan. On the contrary, if programming is lacking or a lax or undemanding pursuit of the student's activity is carried out, the results may be poor and lead to the disinterest of the company or the research group in these internship programs.

## 1.4 CRITICAL THINKING SKILLS

The critical thinking competencies in which this Project is focusing are defined in some detail in section 6 of the guide "METHODOLOGICAL GUIDE FOR HIGH TECH CENTERS TO HOST VET STUDENT INTERNSHIPS". We include here only the list in order to be able to link the elements of both the programming and the evaluation contained in this notebook with the competences that they intend to help develop in the student.

In our proposal we seek to contribute to the VET student being convinced of the importance and acquire skills to:

C1.- Self examination. Reflection of one's own reasoning.

C2.- Formulate objectives. Identify problems.

C3.- Raise fundamental questions.

C4.- Formulate hypothesis.

C5.- Learning to learn, searching for information.

C6.- Have an open mind.

C7.- Have intellectual integrity.

C8.- Express yourself well, effectively, both orally and in writing.

C9.- Be persevering.

The following pages contain a template that can be useful when programming the internship and monitoring the student progress.aluation of the way in which one comes to convictions, poses problems and solves them.

## 1.5.- CONTENTS

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| PART 1.- Global approach to the internship. | | |
| Title | Student folder | Dates of the internship: |
| Brief description: | | |
| Area of the company or project in which the internship is framed: | | |
| Problem statement: | | |
| Hypotheses, solutions that can be anticipated and expected results. | | |
| Initial information given to the student.<br><br>*Add as many pages as necessary* | | |

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 2. - Work plan. Initial tasks.** | | |
| **Task:** | **Student folder:** | **Dates:** |

**Brief description**

It is suggested to program an initial task, which can be completed in a short time and that serves both the student and the tutor to be oriented in relation to the way of approaching the work. This task could have some of the sections that are exposed in the following cells that would be dedicated to the assessments of the tutor on each of the activities. They refer to a task that contains an experimental part.

**Understanding of the experiment to be performed and assessment during its execution.**

The student should read the instructions for the operation of the equipment to be used. Then the student will be present while a technician of the company performs an experiment explaining to him/her the different operations to be performed. The student could be asked to reflect the following points in his laboratory notebook:

- What had you studied in your formative cycle related to this phenomenon or this technique?
- Indicate those parts of the written documentation that has made available to you by the company that you have found difficult to understand as it was written.
- If you have already managed to understand all the content, asking your tutor, other colleagues or looking for information, correct or add what you consider necessary in the protocol to facilitate understanding to the next recipient.

In this box the tutor can add notes about whether the student.

| | |
|---|---|
| ...is interested in understanding the documentation in depth (C1). | |
| ...ask clarifying questions (C3). | |
| ...dare to suggest changes in the protocol that has the research centre (C6). | |
| ... explains his ideas clearly orally (C8). | |

| **Search for information.**<br>It is suggested to include in the task the search of some data as concrete as possible, for example, if it is a question of making a measurement of liquid densities, you could be asked to look for the density value of analogous liquids that serve as reference for your test.<br><br>In this box the tutor can add notes about whether the student. | |
|---|---|
| ... has difficulty with English and if in spite of it, he is aware that it is necessary to resort to information in that language (C5). | |
| ... search several alternative sources of information (C5). | |
| ... establishes a hypothesis about his essay (C4). | |
| | |
| **Experimental results.**<br>The student will have been asked to make the measurements and then report the results in writing in his or her laboratory notebook and prepare it for presentation.<br><br>In this box the tutor can add notes about whether the student. | |
| ... assesses the quality of the results obtained in terms of reproducibility and detects the points of subjectivity in the essay (C1, C7). | |
| ... assesses if the results obtained coincide or not with his hypothesis and seek explanation to the differences (C4). | |
| ... organize and clearly present the results (C8). | |
| ... explains his ideas clearly in writing (C8). | |
| | |

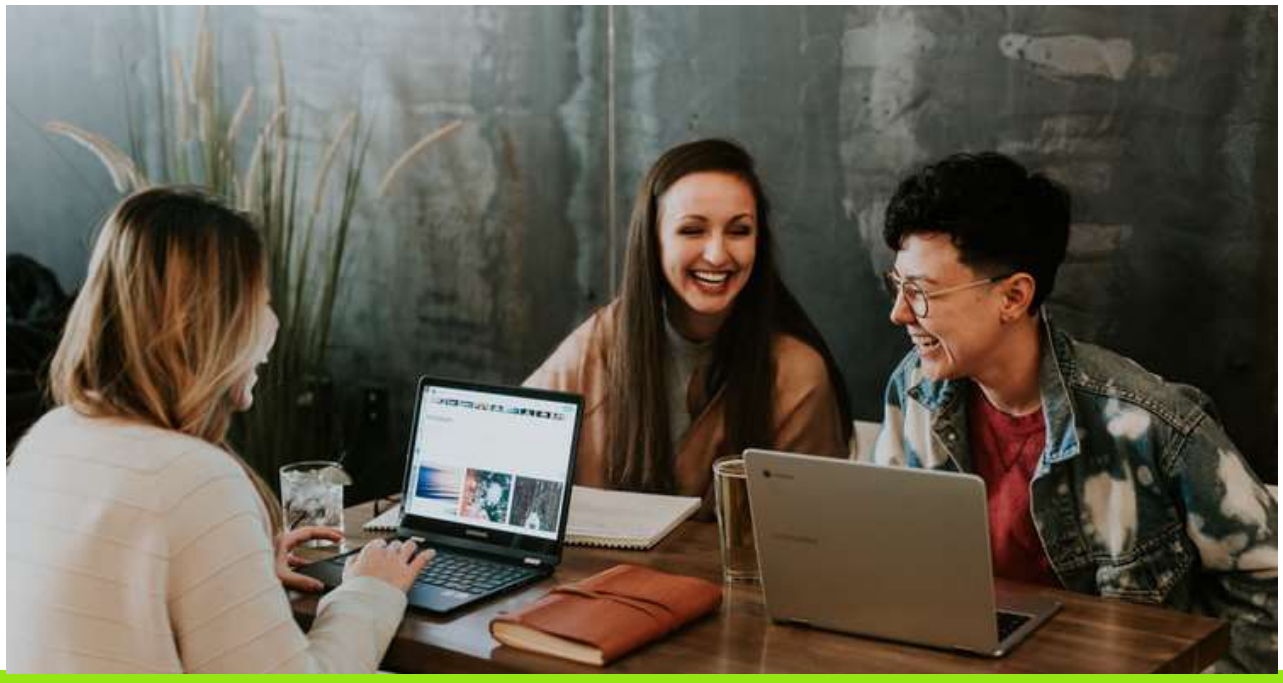
| | |
|---|---|
| **Attitude in group meetings.**<br>The tutor's impression of the participation of the student in the group meetings can be noted here if at the time of this first stage there has been any.<br><br>In this box the tutor can add notes about whether the student. | |
| ... presents his results clearly (C8). | |
| ... defend his ideas and accept criticism (C6). | |
| | |
| **Laboratory notebook.**<br><br>In this initial stage it is important that the tutor assesses the way in which the student collects in his or her laboratory notebook both the results obtained and their assessment and the purpose of their task and the comments of other team members.<br><br>In this box the tutor can add notes about whether the student. | |
| ... collect in the notebook the global objectives of the research line in which its project is framed and those of his concrete tasks (C2). | |
| ... gathers clearly enough his results and protocols used thinking that others will have to understand them later (C6, C8). | |
| ... assess the quality of the results obtained (C1). | |
| | |
| **Joint analysis of this initial task with the student.**<br><br>For the rest of the internship, this first impression of how the student develops in the company should be discussed with him in order to guide his training. The analysis should both motivate him by highlighting the results obtained in terms of immersion in a new method of work in the short time elapsed, and also suggesting ways to improve in the different sections of the notebook. | |

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 3.- Development of the internship.** | | |
| **Title:** | **Carpeta/servidor:** | **Fecha:** |
| **Changes in plan of work or new tasks.**<br><br>The tutor could briefly note here the changes that are made in the conception of the task as a function of the development of the work. It must really be the student who writes down in his /her notebook the description of the tasks entrusted to him /her. | | |
| **Methodology and work plan**<br>In the same way, the work plan should be discussed with the student and it should be he or she who writes it down in his / her laboratory notebook with his / her words | | |
| **Ratings**<br>The tutor could be taking notes of the evolution of work in relation to critical thinking skills raised. In section 6 of the guide we suggest certain critical thinking results that the student should achieve over time. | | |
| **C1.- Self examination. Reflection of one's own reasoning.** | | |
| **C2.- Formulate objectives. Identify problems.** | | |
| **C3.- Raise fundamental questions.** | | |
| **C4.- Formulate hypothesis.** | | |
| **C5.- Learning to learn, searching for information.** | | |
| **C6.- Have an open mind.** | | |
| **C7.- Have intellectual integrity.** | | |
| **C8.- Express yourself well, effectively, both orally and in writing.** | | |
| **C9.- Be persevering.**<br><br>*Include as many pages as necessary* | | |

# 2 EXAMPLES OF WORK PLANS BASED ON CRITICAL THINKING FOR A VET STUDENT INTERNSHIP IN A HIGH-TECH CENTER

Here we present a series of examples made by the project partners, belonging to the different companies or university research centres. The thematic of the projects is focused in the research and development lines of each group while the work plans have been programmed thinking about VET students eventually incorporated to the Centre. Some of these internship programs have been carried out in pilot tests with real students, this is the case of the work plan presented by the Centre for Biomaterials and Tissue Engineering of the Universitat Politècnica de València. It does not include, however, results of practice, or assessments of student work and the names of students and their tutors have been changed to protect their privacy.

The aim of this section is to provide ideas on some details that seem important to consider concerning the student's first contact with the work in an unknown environment. On the other hand, we draw attention to the need for dynamic work plan scheduling, adapted to the progress of the student and including the aspects that we have been highlighting in this guide for the formation of critical thinking



## 2.1. Work Plan for a VET student internship in IKASIA TECHNOLOGIES

# Tutor's notebook: suggestions to program the work of a VET student to strengthen critical thinking skills in high-tech companies or research centres

**Worker or student internship: LG**
**Supervisor: LGE**
**Notebook starting date: 01-01-2019**
**Date of completion and file in the company: 01-05-2019**

| The tutor who delivers the notebook: | Received by the CBIT: |
|---|---|
| Date and signature | Date and signature |

This template for the tutor notebook was developed by the team of the Ikasia Technologies SL during the implementation of the Erasmus + project 2017-1-ES01-KA202-038469 *CRİTİCAL THİNKİNG AS A STEP FORWARD İN VET EDUCATİON: VET students immersed in high technology teams*.

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 1.- Global approach to the internship** | | |
| **Title:**<br><br>**CHARACTERIZATION PROCESS OF INNOVATIVE MATERIALS FOR 3D PRINTING OF HAUTE CUISINE** | **Student folder**: | **Dates of the internship**:<br><br>01/01/2019 to 01/02/2019 |
| **Brief description:**<br><br>The objective of the work is to develop innovative materials to create haute cuisine dishes through additive manufacturing.<br>Ikasia Technologies SL is developing a 3D printing technology that converts printable dishes with the flavours of traditional cuisine, but above all opens the way to a new haute cuisine.<br>For this purpose, a 3D printing machine specially designed for this application has been developed that will use cartridges that contain the components of a recipe. These cartridges will be distributed vacuum-packed in long-term storage conditions that do not require refrigeration. You just have to press a button so that the machine prints the recipe on the plate. | | |
| **Area of the company or project in which the internship is framed:**<br><br>The characterization of the materials is the field where the Vet student have been work. The correct definition about the characteristics (especially the rheological characteristics, the processes of cooking and degradation of the materials to be printed) of the materials is basic to be able to print a cooked dish. | | |
| **Problem statement**<br><br>The material must adjust its rheological characteristics to each of the cooking processes linked to the material's printing processes. In this way, the degradation processes related to the chemical composition of the food during the preparation of the dish, as well as its stiffness and density are of special importance. | | |
| **Hypotheses, solutions that can be anticipated and expected results.**<br><br>We need a correct reaction between the food material and the cooking methods. To do that we must define a specific composition of the food material including additives capable of reacting with heat and conveniently modifying the density of the material. | | |

**Initial information given to the student.**

Protocol to use the characterization machine (Spanish).
Protocol for the warm procedures and cooking methods used (Spanish).
Food additives description (Spanish).
Food safety manual (Spanish).
Manual of prevention and safety in the workplace (Spanish).
Summary of the research project in which the work is framed (English).
Safety sheets of all the reagents to use in his work (English and Spanish).

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 2.- Work plan. Initial tasks** | | |
| **Task:**<br><br>**Characterization of a specific food material for 3d printing** | **Student folder**: | **Dates**:<br><br>01/02/2019 to 01/04/2019 |

**Brief description**

The objective of the task is to characterize a food material that it would be cooked at the time is printed in an innovative 3d Printer patented by Ikasia.

The work method will include several stages, all of them assisted by a partner of the research team:

1. Understanding of safety measures in the using of the characterization machine. Individual protection elements required. Reflect all this in the laboratory notebook.

2. Understanding the risks for the person and for the beneficiary preparing the food material. Reflect them in the lab notebook.

3. Prepare the protocol to prepare the food material including all the steps and measurements she must do to the final characterization of the food material. Reflect all this in the laboratory notebook.

4. Prepare the experimental assembly: reactor, agitation system.

5. Prepare the food material and perform the measurements.

6. Detect the errors in the protocol and include modifications on it.

7. Repeat step 5 and 6 as many times as needed.

8. Validate the protocol and show it to the research team.

9. After each step, cleaning the workplace and waste management following the established protocols.

10. Acquisition of images and make proposals for the improvement of the food material.

11. Written report of the results obtained.

**Understanding of the experiment to be performed and assessment during its execution.**

*There are a series of questions that must appear in the process*, raised either by the student or by his tutor, for example:

1. What must the food material do in each moment of 3D printing?

2. How can I make sure he does it?
3. What kind additives can give the food material the characteristics I need?
4. Which additives can contribute to the printing procedure and Wich no?
5. If the taste is modified because of the additives. How can I achieve the taste I need?
6. How is the material degraded? Will it still be healthy after printing?
7. What should I do to prepare the material safely and without creating risks to the consumer?
8. How do I save the material to preserve it?

*In this initial task a series of experimental techniques has been used*:

- Safety measures in the handling of organic solvents. Individual protection elements. Waste management.
- Preparation of solutions: weighing in precision balances, use of micropipettes, concentration calculations.
- Characterization machine.
- Freezer
- Oven and microwave oven
- Image Analysis

*and several basic concepts appeared:*

- Food additives
- Density and rheological characteristics
- Diffusion, solubility

In this box the tutor can add notes about whether the student

| | |
|---|---|
| …is interested in understanding the documentation in depth (C1). | |
| …ask clarifying questions (C3). | |
| …dare to suggest changes in the protocol that has the research centre (C6). | |
| … explains his ideas clearly orally (C8). | |

| | |
|---|---|
| **Search for information**<br><br>In this box the tutor can add notes about whether the student. | |
| … has difficulty with English and if in spite of it, he is aware that it is necessary to resort to information in that language (C5). | |
| … search several alternative sources of information (C5). | |
| … establishes a hypothesis about his essay (C4). | |
| **Assessment of the experimental results.**<br><br>The student will be asked to reflect his results in his laboratory notebook. Several questions should arise:<br>1. How the results should be presented?<br>2. To what extent should the procedures and incidents that have appeared during the experiment be explained in the notebook?<br>3. How the tables and figures should be prepared?<br>4. Is it interesting to include pictures of the experimental assemblies in the notebook?<br>5. Should all the images obtained in the microscope be included in an annex or in a folder in the server?<br>6. Point out in the experimental protocols that you have used what you have struggled to understand and try to explain it better according to your experience.<br><br>In this box the tutor can add notes about whether the student. | |
| … assesses the quality of the results obtained in terms of reproducibility and detects the points of subjectivity in the essay (C1, C7). | |
| … assesses if the results obtained coincide or not with his hypothesis and seek explanation to the differences (C4). | |
| … organize and clearly present the results (C8). | |
| … explains his ideas clearly in writing (C8). | |

| | |
|---|---|
| **Attitude in group meetings.**<br>The tutor's impression of the participation of the student in the group meetings can be noted here if at the time of this first stage there has been any.<br><br>In this box the tutor can add notes about whether the student**.** | |
| … presents his results clearly (C8). | |
| … defend his ideas and accept criticism (C6). | |
| **Laboratory notebook.**<br><br>In this internship, the laboratory notebook will be the medium where all the reports of the results of the experiments carried out will be collected. In this initial stage it is important that the tutor assesses the way in which the student collects in his laboratory notebook both the results obtained and their assessment, the purpose of his task and the comments of other group members.<br><br>The writing of the laboratory notebook should help the student to organize his reflection on the new concepts and techniques with which he meets in his work.<br><br>In this box the tutor can add notes about whether the student. | |
| … collect in the notebook the global objectives of the research line in which its project is framed and those of his concrete tasks (C2). | |
| … gathers clearly enough his results and protocols used thinking that others will have to understand them later (C6, C8). | |
| … assess the quality of the results obtained (C1). | |
| **Joint analysis of this initial task with the student.**<br><br>For the rest of the internship, this first impression of how the student develops in the company should be discussed with him in order to guide his training. The analysis should both motivate him by highlighting the results obtained in terms of immersion in a new method of work in the short time elapsed, and also suggesting ways to improve in the different sections of the notebook. | |

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 3.- Development of the internship** | | |
| **Title:**<br><br>**Preparation of microspheres made of acrylic copolymers by emulsion processes** | **Student folder**: | **Dates of the internship**:<br><br>01/04/2019 to 01/05/2019 |

**Changes in plan of work or new tasks**

Based on the assessment of the initial task, all the changes deemed necessary to achieve the best results in terms of student training and their contribution to the work of the research team will be made.

**Methodology and work plan**

The work must be organized from here dynamically, according to the results that are obtained and the interests of the student and the group.

In an initial estimate, the following tasks can be programmed:

1. Repetition of the initial task to analyze the reproducibility of the result. The moment in which the student can be authorized to work on their own in each of the specific tasks will be assessed.

2. Study of the rheological characteristics of the food materials.

3. Study of the cooking procedures in a 3d printing machine.

4. Analysis of the food material properties after the printed food machine with the assistance of a team member. The moment in which the student can be authorized to do it independently will be assessed.

5. Quantification of the amount of additives. Reproducibility study.

6. Surface characterization by layering, tasting procedures, and compression tests and density measurement. The student will attend the work sessions and later will work on the treatment of the images and the elaboration of conclusions.

7. Oral presentation in the research group of the progress of the results in several moments of the internship, informally, but using means of presentation such as PowerPoint.

8. Final presentation of the work in a seminar meeting of the Ikasia Technologies sl.

**Ratings**

The tutor could be taking notes of the evolution of work in relation to critical thinking skills raised. In section 6 of the guide we suggest certain critical thinking results that the student should achieve over time.

| |
|---|
| **C1.- Self examination. Reflection of one's own reasoning.** |
| **C2.- Formulate objectives. Identify problems.** |
| **C3.- Raise fundamental questions.** |
| **C4.- Formulate hypothesis.** |
| **C5.- Learning to learn, searching for information.** |
| **C6.- Have an open mind.** |
| **C7.- Have intellectual integrity.** |
| **C8.- Express yourself well, effectively, both orally and in writing.** |
| **C9.- Be persevering.**<br><br>*Include as many pages as necessary* |

## 2.2. Work Plan for a VET student internship in the Centre for Biomaterials and Tissue Engineering. UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Centre for Biomaterials and Tissue Engineering
Universitat Politècnica de València

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Centre de Biomaterials i Enginyeria Tisular
Universitat Politècnica de València

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

# Tutor's notebook: suggestions to program the work of a VET student to strengthen critical thinking skills in high-tech companies or research centres

**Worker or student internship: SF**
**Supervisor: JLGR**
**Notebook starting date: 20-3-2019**
**Date of completion and file in the company:**

| The tutor who delivers the notebook: | Received by the CBIT: |
|---|---|
| Date and signature | Date and signature |

This template for the tutor notebook was developed by the team of the Centre for Biomaterials and Tissue Engineering of the Universitat Politècnica de València during the implementation of the Erasmus + project 2017-1-ES01-KA202-038469 *CRİTİCAL THİNKİNG AS A STEP FORWARD İN VET EDUCATİON: VET students immersed in high technology teams*.

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# Template of the plan of work and evaluation of the internship.

## PART 1.- Global approach to the internship

| Title: | Student folder: | Dates of the internship: |
|---|---|---|
| **Preparation of microspheres made of acrylic copolymers by emulsion processes** | | 20/3/2019 to 30/6/2019 |

**Brief description:**

The objective of the work is to obtain microspheres to be used as a 3D environment for cell culture. The microspheres will be made of a copolymer that combines different monomeric units and the surface of these particles will be coated with a protein of interest for the interaction with the cells. The polymer has been previously synthesized by other colleagues in the research team. The first step of the process for obtaining the microspheres consists in dissolving the polymer in a suitable organic solvent. This solution is dripped into a flask in which an aqueous solution of polyvinyl alcohol, which acts as an emulsifier, is kept stirred. As a consequence, an emulsion is formed in which the polymer solution forms small droplets suspended in the aqueous medium. Stirring is maintained while slowly the organic solvent diffuses into the water and evaporates. When dried the microdrops form the microspheres. Then, different washings with water are made, they are filtered between filters with 5 and 15 microns mesh size and finally they are lyophilized for storage. The characterization consists in the acquisition of binocular magnifying images and the measurement of the diameters with an image analysis to perform a histogram. The surface of the microspheres is observed with an electron microscope.

In a second step, the collagen is grafted onto the surface. First, the amount of reactive groups present on the surface of the microspheres is quantified by staining. The collagen is dissolved in an aqueous medium at acidic pH. The collagen grafting protocol consists of the suspension of the microspheres in the collagen solution and the reaction at room temperature with the appropriate catalysts. Finally, the necessary washings are carried out in water to eliminate the non-chemically bonded collagen and the amount of collagen present on the surface is quantified. The topography of the surface is observed again in the electron microscope.

**Area of the company or project in which the internship is framed:**

This material in the form of microspheres is being used as a support for the development of an artificial analogue of the bone marrow, within the framework of the project: Artificial bone marrow to personalize the treatment of patients with blood cancers. Project PROMETEO / 2016/063 of the Generalitat Valenciana.
Different cell types are grown in a suspension of microspheres in the liquid culture medium, studying the effect of the protein grafted on the microspheres on the biological response, in particular on the generation of drug resistance by the tumour cells.

**Problem statement**

The production of microspheres presents as the main challenge their agglomeration in certain stages of the process. Another problem that can appear is that the yield could be very low because part of the polymer present in the starting solution adhere to the walls of the flask, also the filtrate is a source of material loss if the emulsion has produced a significant fraction of particles larger or smaller than desired. On the other hand, it is necessary to be able to ensure that the particles obtained finally present a continuous coating of the protein.

**Hypotheses, solutions that can be anticipated and expected results.**

It is expected that the emulsion process be sufficiently reproducible with the conditions of the protocol provided to the student by CBIT colleagues for the production of these microspheres. However, there are a number of factors that can affect the result (flask size and stirring blade, agitator position, room temperature and others) but it is expected that these parameters can be controlled enough so that the effect on the morphology of the microspheres morphology be relatively little.
In the same way it is expected that the amount of reactive groups on the surface of the microspheres and their reactivity with the collagen be reproducible.

**Initial information given to the student**

Protocol for the preparation of microspheres (Spanish).
Protocol for the quantification of acid groups on the surface of microspheres (Spanish).
Collagen graft protocol (Spanish).

Chapter of a book on the emulsion process (Spanish).
Summary of the research project in which the work is framed (English).
Safety sheets of all the reagents to use in his work (English and Spanish).

# Template of the plan of work and evaluation of the internship.

## PART 2.- Work plan. Initial tasks

| Task: | Student folder: | Dates: |
|---|---|---|
| **Production of an emulsion of copolymer A following an established protocol** | | 25/3/2019 to 5/4/2019 |

**Brief description**

The objective of the task is to prepare a first emulsion and includes the following stages, all of them being assisted by a partner of the research team:

1. Understanding of safety measures in the handling of organic solvents. Individual protection elements required. Reflect all this in the laboratory notebook.
2. Understanding of waste management procedures. Reflect them in the lab notebook.
3. Prepare a solution of copolymer A in chloroform. Prepare the dissolution of polyvinyl alcohol, PVA, in water with the specified concentrations.
4. Prepare the experimental assembly: reactor, agitation system.
5. Perform the emulsion following the protocol.
6. Washing the microspheres in water with intermediate centrifuges.
7. Filtering.
8. After each step, cleaning the workplace and waste management following the established protocols.
9. Acquisition of images in an optical microscope. Obtaining the particle size histogram by measuring microsphere diameters with image analysis software.
10. Written report of the results obtained.

**Understanding of the experiment to be performed and assessment during its execution.**

*There are a series of questions that must appear in the process*, raised either by the student or by his tutor, for example:

1. What is a polymer? What structure has the molecule of a copolymer? What has the student learn on polymer structure and properties in his VET studies?
2. How is it known that the polymer has completely dissolved?
3. It is quite difficult for the polymer to dissolve, can the process be accelerated?

4. Where can one find information about these aspects?

5. How do the micro-droplets of the emulsion dry to form the dried microspheres? How is it that chloroform escapes from micro-droplets in the emulsion? Is chloroform soluble in water?

6. A polymer mass in the form of microspheres is obtained that is smaller than that of the polymer that was initially dissolved. Where has the difference been lost? Is the yield achieved what could be expected or something has failed in the process? It can be improved?

7. What would happen if the emulsion were stirred faster? And if it slows down?

8. Microspheres of variable diameters between the mesh size of the two filters used are obtained. Is the size dispersion acceptable for the following stages of the investigation?

9. How do I evaluate to what extent the microspheres stick together? If agglomerates are formed, can they be dispersed again?

*In this initial task a series of experimental techniques has been used*:

- Safety measures in the handling of organic solvents. Individual protection elements. Waste management.
- Preparation of solutions: weighing in precision balances, use of micropipettes, concentration calculations.
- Microparticle washing and filtering system.
- Optical microscopy
- Image Analysis

*and several basic concepts appeared:*

- Polymer and copolymer
- Oil in water emulsion
- Diffusion, solubility

In this box the tutor can add notes about whether the student

| | |
|---|---|
| ...is interested in understanding the documentation in depth (C1). | |
| ...ask clarifying questions (C3). | |
| ...dare to suggest changes in the protocol that has the research centre (C6). | |
| ... explains his ideas clearly orally (C8). | |

| **Search for information**<br><br>In this box the tutor can add notes about whether the student. | |
|---|---|
| … has difficulty with English and if in spite of it, he is aware that it is necessary to resort to information in that language (C5). | |
| … search several alternative sources of information (C5). | |
| … establishes a hypothesis about his essay (C4). | |
| | |
| **Assessment of the experimental results.**<br><br>The student will be asked to reflect his results in his laboratory notebook. Several questions should arise:<br>1. How the results should be presented?<br>2. To what extent should the procedures and incidents that have appeared during the experiment be explained in the notebook?<br>3. How the tables and figures should be prepared?<br>4. Is it interesting to include pictures of the experimental assemblies in the notebook?<br>5. Should all the images obtained in the microscope be included in an annex or in a folder in the server?<br>6. Point out in the experimental protocols that you have used what you have struggled to understand and try to explain it better according to your experience.<br><br>In this box the tutor can add notes about whether the student | |
| … assesses the quality of the results obtained in terms of reproducibility and detects the points of subjectivity in the essay (C1, C7). | |
| … assesses if the results obtained coincide or not with his hypothesis and seek explanation to the differences (C4). | |
| … organize and clearly present the results (C8). | |
| … explains his ideas clearly in writing (C8). | |
| | |

| | |
|---|---|
| **Attitude in group meetings.**<br>The tutor's impression of the participation of the student in the group meetings can be noted here if at the time of this first stage there has been any.<br><br>In this box the tutor can add notes about whether the student**.** | |
| … presents his results clearly (C8). | |
| … defend his ideas and accept criticism (C6). | |
| | |
| **Laboratory notebook.**<br><br>In this internship, the laboratory notebook will be the medium where all the reports of the results of the experiments carried out will be collected. In this initial stage it is important that the tutor assesses the way in which the student collects in his laboratory notebook both the results obtained and their assessment, the purpose of his task and the comments of other group members.<br><br>The writing of the laboratory notebook should help the student to organize his reflection on the new concepts and techniques with which he meets in his work.<br><br>In this box the tutor can add notes about whether the student**.** | |
| … collect in the notebook the global objectives of the research line in which its project is framed and those of his concrete tasks (C2). | |
| … gathers clearly enough his results and protocols used thinking that others will have to understand them later (C6, C8). | |
| … assess the quality of the results obtained (C1). | |
| | |
| **Joint analysis of this initial task with the student.**<br><br>For the rest of the internship, this first impression of how the student develops in the company should be discussed with him in order to guide his training. The analysis should both motivate him by highlighting the results obtained in terms of immersion in a new method of work in the short time elapsed, and also suggesting ways to improve in the different sections of the notebook. | |

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| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 3.- Development of the internship** | | |
| **Title:**<br><br>**Preparation of microspheres made of acrylic copolymers by emulsion processes** | **Student folder:** | **Dates of the internship:**<br><br>20/3/2019 to 30/6/2019 |

**Changes in plan of work or new tasks**

Based on the assessment of the initial task, all the changes deemed necessary to achieve the best results in terms of student training and their contribution to the work of the research team will be made.

**Methodology and work plan**

The work must be organized from here dynamically, according to the results that are obtained and the interests of the student and the group.

In an initial estimate, the following tasks can be programmed:

1. Repetition of the initial task to analyze the reproducibility of the result. The moment in which the student can be authorized to work on their own in each of the specific tasks will be assessed.

2. Study of the collagen graft protocol.

3. Study of the collagen quantification protocol by BCA analysis.

4. Coating of the particles obtained in (1). Initially with the assistance of a team member. The moment in which the student can be authorized to do it independently will be assessed.

5. Quantification of the amount of grafted collagen. Reproducibility study.

6. Surface characterization by scanning electron microscopy FESEM. A selected sample will be included in one of the trials in the FESEM of the microscopy services of the University. The student will attend the work sessions and later will work on the treatment of the images and the elaboration of conclusions.

7. Oral presentation in the research group of the progress of the results in several moments of the internship, informally, but using means of presentation such as PowerPoint.

8. Final presentation of the work in a seminar meeting of the Centre for Biomaterials and Tissue Engineering.

| **Ratings**<br><br>The tutor could be taking notes of the evolution of work in relation to critical thinking skills raised. In section 6 of the guide we suggest certain critical thinking results that the student should achieve over time. |
|---|
| **C1.- Self examination. Reflection of one's own reasoning.** |
| **C2.- Formulate objectives. Identify problems.** |
| **C3.- Raise fundamental questions.** |
| **C4.- Formulate hypothesis.** |
| **C5.- Learning to learn, searching for information.** |
| **C6.- Have an open mind.** |
| **C7.- Have intellectual integrity.** |
| **C8.- Express yourself well, effectively, both orally and in writing.** |
| **C9.- Be persevering.**<br><br>*Include as many pages as necessary* |

# 2.3. Work Plan for a VET student internship in the Department of Macromolecular Physics, Faculty of Mathematics and Physics, CHARLES UNIVERSITY

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# Tutor's notebook: suggestions to program the work of a VET student to strengthen critical thinking skills in high-tech companies or research centres

**Worker or student internship: XX**
**Supervisor: Ivan KRAKOVSKY**
**Notebook starting date: June 3rd, 2019**
**Date of completion and file in the company:**

| The tutor who delivers the notebook: | Received by the CBIT: |
|---|---|
| Date and signature | Date and signature |

This template for the tutor notebook was developed by the team of the Department of Macromolecular Physics, Faculty of Mathematics and Physics, Charles University during the implementation of the Erasmus + project 2017-1-ES01-KA202-038469 *CRİTİCAL THİNKİNG AS A STEP FORWARD İN VET EDUCATİON: VET students immersed in high technology teams*.

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| **Template of the plan of work and evaluation of the internship.** | | |
|---|---|---|
| **PART 1.- Global approach to the internship** | | |
| **Title**<br><br>**Preparation of thermosensitive epoxy-based hydrogels and study of their swelling behavior.** | **Student folder** | **Dates of the internship:**<br><br>**3/6/2019 to 30/8/2019** |

**Brief description:**

The aim of the work is to prepare a series of thermosensitive epoxy-based hydrogels to be used in sensor applications and investigate their swelling behavior.

Epoxy networks are usually prepared by reaction of compounds containing two or more epoxy groups with compounds having amine, anhydride or other suitable groups capable to open the epoxy ring. If one or both compounds are hydrophilic, epoxy network able to uptake water is obtained. Swelling of such epoxy network in water give rise to epoxy-based hydrogel. If one or both compounds used in the network synthesis are thermosensitive, volume of the hydrogel exhibits a strong dependence on temperature.

In the first step, mixtures of reagents necessary for synthesis of epoxy networks are prepared. As their miscibility is usually not sufficient at room temperature, it is improved by heating to a higher temperature for a time short enough to prevent gelation of the mixtures. The mixtures are then transferred into moulds for curing in an oven at a proper temperature. At a certain time (gel time), a single molecule of macroscopic dimensions (polymer network) is formed by the reaction. The reaction is allowed to proceed further for a time long enough to achieve a high conversion.

The samples obtained contain a small fraction of reaction products which is soluble in a proper solvent. For sensor applications this fraction is unwanted and has to be removed. Therefore, in the second step, the samples prepared are extracted using toluene at room temperature. The rests of toluene are removed from the samples prepared by drying at room temperature, first in open air, then in vacuum oven.

Finally, the extracted samples are cut into small specimen of disk or prisma shape and swollen in water at room temperature.

Swelling behavior (water uptake) is determined by temperation of hydrogel specimen at progressively increasing temperatures and measuring their dimensions or mass.

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**Area of the company or project in which the internship is framed:**

The materials prepared are used in subsequent research projects of Department of Macromolecular Physics. Hydrophilic epoxy networks are synthesized using combinations of hydrophilic reagents of different chemical structure and structure, thermal and swelling properties of resulting hydrogels are investigated using combination of physico-chemical methods, such as infrared spectroscopy, X-ray and neutron scattering, differential scanning calorimetry etc.

**Problem statement**

The preparation of homogeneous reaction mixtures for curing of epoxy networks represents an important step and requires due care. A proper mixing temperature and time have to be chosen. Sufficient extraction of soluble products from the network samples prepared by a proper solvent is necessary. Precise determination of dimensions and mass of hydrogel specimen is another very important step, too.

**Hypotheses, solutions that can be anticipated and expected results.**

Conditions specified by synthesis and measurement protocols elaborated by Charles University workers are expected to be sufficiently understandable to the student to prepare reproducible samples and obtain reliable results. Of course, there is always a number of important factors to achieve these goals, such as careful work with laboratory balance, analytical equipment, stirrers, ovens and optical devices.

**Initial information given to the student**

Protocol for the determination of concentration of amine and epoxy groups in reagents used for epoxy curing.
Protocol for the synthesis of epoxy networks.
Protocol for the determination of swelling degree of hydrogels.

Chapter of a book on epoxy resins.
Chapter of a book on polymer networks and hydrogels.
Chaper of a book on sensor applications of hydrogels.

Summary of the research projects in which the work is framed.
Safety sheets of the reagents used and precautions for the work in chemical laboratory.
*Add as many pages as necessary*

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| **Template of the plan of work and evaluation of the internship.** | | |
|---|---|---|
| **PART 2.- Work plan. Initial tasks** | | |
| **Task:**<br><br>**Synthesis of hydrophilic epoxy network and hydrogel following an established protocol.** | **Student folder:** | **Dates:**<br>**10/6/2019**<br>**to**<br>**20/6/2019** |

**Brief description**

It is suggested to program an initial task, which can be completed in a short time and that serves both the student and the tutor to be oriented in relation to the way of approaching the work. This task could have some of the sections that are exposed in the following cells that would be dedicated to the assessments of the tutor on each of the activities. They refer to a task that contains an experimental part.

The objective of this task is to prepare first polymer network and hydrogel. It includes the following stages, all of them being assisted by a partner of the research team:

1. Understanding of safety measures in the handling of all chemicals used with proper individual personal protective equipment. Reflect all this in the lab notebook.
2. Understanding of waste management procedures. Reflect them in the lab notebook.
3. Weigh proper amounts of reagents for epoxy network synthesis into a glass jar of a proper volume.
4. Prepare the experimental assembly: electromagnetic stirrer, stirring chips, curing moulds, preheat the oven to carry out the epoxy curing.
5. Prepare the curing mixture from the reagents following the protocol.
6. Transfer the curing mixture into reaction mold.
7. Close the mold and fasten it. Install it into oven preheated at reaction temperature specified in the protocol.
8. After each step, clean the workplace and handle waste following the established protocols.
9. Let the curing reaction proceed for specified time.
10. Then, take out the mould from the oven. Open the mould and take out carefully the sample of epoxy network prepared.
11. Cut the sample into smaller pieces and put them into closed bottles with toluene for extraction at room temperature. Extract the samples three times using fresh toluene. The used solvent transfer to a bottle for its later redistillation.
12. Dry carefully the epoxy network samples at room temperature. Avoid tearing of the samples by too fast drying.
13. Dry the epoxy network samples in vacuum oven at room temperature for one day.
14. Cut the extracted epoxy network samples into small pieces (specified by the protocol). Measure their dimensions and mass. Then, transfer them into bottles with water for swelling to obtain hydrogels. Place the bottles into the thermostat kept at 20 $^{o}$C. Temper the hydrogel samples for one day.
15. Measure dimensions and mass of the hydrogel samples. Calculate swelling degrees at 20 $^{o}$C.
16. Written report of the results obtained.

**Understanding of the experiment to be performed and assessment during its execution.**

The student should read the instructions for the operation of the equipment to be used. Then the student will be present while a technician of the company performs an experiment explaining to him/her the different operations to be performed. The student could be asked to reflect the following points in his laboratory notebook:

- What had you studied in your formative cycle related to this phenomenon or this technique?
- Indicate those parts of the written documentation that has made available to you by the company that you have found difficult to understand as it was written.
- If you have already managed to understand all the content, asking your tutor, other colleagues or looking for information, correct or add what you consider necessary in the protocol to facilitate understanding to the next recipient.

*There are a series of questions that must appear in the process*, raised either by the student or by his tutor, for example:

1. What is polymer network? What is epoxy network? Which curing reaction is used in its preparation? What is gelation time?
2. How is it known that polymer network has been already formed?
3. Sometimes it is quite difficult to obtain homogeneous reaction mixture. Why is the homogeneity important?
4. How can be the mixing process accelerated and improved?
5. Why is necessary to extract the polymer networks prepared? Why a multiple extraction is necessary?
6. How is polymer hydrogel obtained from a polymer network? Why when immersed in water the sample of a polymer network swells but not dissolves?
7. When is the polymer hydrogel thermosensitive?
8. In which applications the thermosensitive hydrogels can be used?
9. Where is it possible to find information about all these aspects?
10. What has the student learn on formation, structure and properties of polymer networks and hydrogels in his VET studies?

*In this initial task a series of experimental techniques has been used*:

- Safety measures in the handling of chemicals. Personal protective equipment. Waste management.
- Preparation of reaction mixtures: reagents amounts calculations, weighing in precision balances, use of volumetric devices, electromagnetic stirrers.
- Swelling and extraction of prepared networks.

*and several basic concepts appeared:*

- Curing reaction, gelation time, polymer network.
- Rubber elasticity, miscibility, swelling of polymer networks.

In this box the tutor can add notes about whether the student.

| | |
|---|---|
| …is interested in understanding the documentation in depth. (C1). | |
| …ask clarifying questions (C3). | |
| …dare to suggest changes in the protocol that has the research centre (C6). | |
| … explains his ideas clearly orally (C8). | |

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| | |
|---|---|
| **Search for information.**<br>It is suggested to include in the project seeking of the most specific data, for example, if a determination of density of liquids is intended, the student can be asked to find densities of liquids analogous to those being referenced for his/her project.<br><br>In this box the tutor can add notes about whether the student. | |
| … has difficulty with English and if in spite of it, he is aware that it is necessary to resort to information in that language (C5). | |
| … search several alternative sources of information (C5). | |
| … establishes a hypothesis about his essay (C4). | |
| | |
| **Experimental results.**<br>The student will have been asked to make the measurements and then report the results in writing in his or her laboratory notebook and prepare it for presentation.<br><br>In this box the tutor can add notes about whether the student. | |
| … assesses the quality of the results obtained in terms of reproducibility and detects the points of subjectivity in the essay (C1, C7). | |
| … assesses if the results obtained coincide or not with his hypothesis and seek explanation to the differences (C4). | |
| … organize and clearly present the results (C8). | |
| … explains his ideas clearly in writing (C8). | |
| | |

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| | |
|---|---|
| **Attitude in group meetings.**<br>The tutor's impression of the participation of the student in the group meetings can be noted here if at the time of this first stage there has been any.<br><br>In this box the tutor can add notes about whether the student. | |
| … presents his results clearly (C8). | |
| … defend his ideas and accept criticism (C6). | |
| | |
| **Laboratory notebook.**<br><br>In this initial stage it is important that the tutor assesses the way in which the student collects in his or her laboratory notebook both the results obtained and their assessment and the purpose of their task and the comments of other team members.<br><br>In this box the tutor can add notes about whether the student**.** | |
| … collect in the notebook the global objectives of the research line in which its project is framed and those of his concrete tasks (C2). | |
| … gathers clearly enough his results and protocols used thinking that others will have to understand them later (C6, C8). | |
| … assess the quality of the results obtained (C1). | |
| | |
| **Joint analysis of this initial task with the student**<br><br>For the rest of the internship, this first impression of how the student develops in the company should be discussed with him in order to guide his training. The analysis should both motivate him by highlighting the results obtained in terms of immersion in a new method of work in the short time elapsed, and also suggesting ways to improve in the different sections of the notebook. | |

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# Template of the plan of work and evaluation of the internship.

**PART 3.- Development of the internship**

| **Title:** | **Student folder**: | **Dates of the internship:** |
|---|---|---|
| **Preparation of thermosensitive epoxy-based hydrogels and study of their swelling behavior.** | | **3/6/2019 to 30/8/2019** |

**Changes in plan of work or new tasks**

The tutor could briefly note here the changes that are made in the conception of the task as a function of the development of the work. It must really be the student who writes down in his /her notebook the description of the tasks entrusted to him /her.

**Metodology and plan of work**

In the same way, the work plan should be discussed with the student and it should be he or she who writes it down in his / her laboratory notebook with his / her words

The work has to be carried out flexibly, according to the results obtained and the interest of the student and research group.

In the beginning, the following tasks can be suggested:

1. Study of the epoxy curing protocol.
2. Study of the hydrogel swelling protocol.
3. Determination of the concentration of reactive groups (amino, epoxy) in the reagents to be used in curing reaction.
4. Calculation of reagent amounts for all systems to be synthesized.
5. Synthesis of the first epoxy network and hydrogel with the assistance of a team member. Later, self-reliant synthesis of the remaining networks and hydrogels.
6. Check of the reaction conversion (curing degree using infrared spectroscopy).
7. Determination of the mass fraction of extractable fraction from the networks synthesized.
8. Determination of the swelling degree of the networks at 20 $^{o}$C.
9. Temperation of hydrogel specimen at various temperatures in increasing and decreasing order. Determination of the swelling degrees at various temperatures.
10. Informal oral presentation of the progress of the research work for colleagues.
11. Final presentation of the research work in a seminar of the Department of Macromolecular Physics.

**Ratings**

The tutor could be taking notes of the evolution of work in relation to critical thinking skills raised. In section 6 of the guide we suggest certain critical thinking results that the student should achieve over time.

| |
|---|
| **C1.- Self examination. Reflection of one's own reasoning.** |
| **C2.- Formulate objectives. Identify problems.** |
| **C3.- Raise fundamental questions.** |
| **C4.- Formulate hypothesis.** |
| **C5.- Learning to learn, searching for information.** |
| **C6.- Have an open mind.** |
| **C7.- Have intellectual integrity.** |
| **C8.- Express yourself well, effectively, both orally and in writing.** |
| **C9.- Be persevering.**<br><br>*Include as many pages as necessary* |

## 2.4. Work Plan for a VET student internship in SOMATICA, MATERIALS & SOLUTIONS LDA

SOMATICA
MATERIALS & SOLUTIONS

SOMATICA
MATERIALS & SOLUTIONS

# Tutor's notebook: suggestions to program the work of a VET student to strengthen critical thinking skills in high-tech companies or research centres

**Worker or student internship: JN**
**Supervisor: TS**
**Notebook starting date: 02-01-2019**
**Date of completion and filed in the company: 02-05-2019**

| The tutor who delivers the notebook: | Received by *Somatica*: |
|---|---|
| Date and signature | Date and signature |

This template for the tutor notebook was developed by *Somatica, Materials & Solutions, Lda.* during the implementation of the Erasmus + project 2017-1-ES01-KA202-038469 *CRİTİCAL THİNKİNG AS A STEP FORWARD İN VET EDUCATİON: VET students immersed in high technology teams*.

SOMATICA
MATERIALS & SOLUTIONS

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 1.- Global approach to the internship** | | |
| **Title:**<br><br>**Development of a customized piezoelectric keyboard** | **Student folder:** | **Dates of the internship:**<br><br>02/01/2019 to 02/05/2019 |
| **Brief description:**<br><br>The goal of the work is to develop different architectures to build a customized keyboard with piezoelectric technology. | | |
| **Area of the company or project in which the internship is framed:**<br><br>The company have different areas of competence, such as Physics, Materials engineering and Electronics. The Vet student must have one of these competences in order to make some experimental work and tests. | | |
| **Problem statement:**<br><br>Piezoelectric materials are very sensitive to small vibrations. When pressing a key in the keyboard, the vibration of one key must not interfer with the other ones. A good architecture and a precise assembly of all parts must be taken in account. | | |
| **Hypotheses, solutions that can be anticipated and expected results:**<br><br>There are several ways to isolate the vibrations from each keys, in order to avoid signal interferences. So, it is expected to have clear and distinguish signals from each keys. | | |
| **Initial information given to the student:**<br><br>Protocols about piezoelectric materials and signal acquisition.<br>Summary of the research project in which the work is framed. | | |

SOMATICA
MATERIALS & SOLUTIONS

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 2.- Work plan. Initial tasks** | | |
| **Task:**<br><br>**Create different keyboard architectures and their assembly** | **Student folder:** | **Dates:**<br>18/03/2019<br>to<br>29/03/2019 |

**Brief description**

The work plan will be made according to student knowledge and competence, in order to obtain the maximum effort and dedication from him/her. A short conversation will be made to understand what areas he/her dominate and after a short task will be requested to be done by themselves.

These procedures will help the tutor to understand students reasoning and to adjust it to the correct path.

**Understanding of the experiment to be performed and assessment during its execution.**

The student will receive written instructions of what to do and then must research by themselves how to achieve those tasks. The procedures must be written by the student in order to compare how the tasks were done in the future. Then, the student will be accompanied by the tutor / company worker who will show how to do a specific task, explaining the reasons of each procedures. At the end, it will be the student turn to do everything from the beginning, explaining every procedure to the tutor / company worker.

Taking this approach, the student will learn by observing and then by doing, asking all the questions needed to ensure that everything is clear to him.

In the end, the student should compare his initial written procedures with the ones performed later, and reflect the following points in his laboratory notebook:

- Indicate those parts of the written documentation that has made available to you by the company that you have found difficult to understand as it was written.
- If you have already managed to understand all the content, asking your tutor, other colleagues or looking for information, correct or add what you consider necessary in the protocol to facilitate understanding to the next recipient.

In this box the tutor can add notes about whether the student

| | |
|---|---|
| …is interested in understanding the documentation in depth (C1). | |
| …ask clarifying questions (C3). | |
| …dare to suggest changes in the protocol that has the company (C6). | |
| … explains his ideas clearly orally (C8). | |

| **Search for information.**<br>It should be requested to the student to make some specific search related to the task that he/her just made, in order to deepen his/her knowledge and question the methods used, possibly proposing other ways of doing so.<br><br>In this box the tutor can add notes about whether the student. | |
|---|---|
| … has difficulty with English and if in spite of it, he is aware that it is necessary to resort to information in that language (C5). | |
| … search several alternative sources of information (C5). | |
| … establishes a hypothesis about his essay (C4). | |
| | |
| **Experimental results.**<br>The student should register all the results obtained, as well the important notes, and create a quick presentation with the main results and comments/suggestions.<br><br>In this box the tutor can add notes about whether the student | |
| … assesses the quality of the results obtained in terms of reproducibility and detects the points of subjectivity in the essay (C1, C7). | |
| … assesses if the results obtained coincide or not with his hypothesis and seek explanation to the differences (C4). | |
| … organize and clearly present the results (C8). | |
| … explains his ideas clearly in writing (C8). | |
| | |

| | |
|---|---|
| **Attitude in group meetings.**<br>The student should present his presentation to the group, as well to participate in the meetings. In order to encourage student participation, the group should ask for the student's point of view and to make new proposals.<br><br>In this box the tutor can add notes about whether the student. | |
| … presents his results clearly (C8). | |
| … defend his ideas and accept criticism (C6). | |
| | |
| **Laboratory notebook.**<br>In the initial stage it is important that the tutor assesses the way in which the student collects the information, i.e., the tasks, procedures, results, improvements and comments in his/her laboratory notebook.<br><br>In this box the tutor can add notes about whether the student. | |
| … collect in the notebook the global objectives of the research line in which its project is framed and those of his concrete tasks (C2). | |
| … gathers clearly enough his results and protocols used thinking that others will have to understand them later (C6, C8). | |
| … assess the quality of the results obtained (C1). | |
| | |
| **Joint analysis of this initial task with the student.**<br>At his point, it is important to analyse the overall student performance and together with him discuss what improvements can be done in order to maximize his effort in a shorter period of time.<br>The analysis should be done in a way that motivate him to do more and better, by highlighting the results obtained in terms of immersion in a new method of work, and also suggesting ways to improve in the different sections of the notebook. | |

SOMATICA
MATERIALS & SOLUTIONS

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 3.- Development of the internship** | | |
| **Title:**<br><br>**Measurement of the output signals** | **Folder/server**: | **Date**:<br>13/03/2019<br>to<br>28/06/2019 |
| **Changes in plan of work or new tasks**<br><br>The tutor could briefly note here the changes that are made in the conception of the task as a function of the development of the work. It must really be the student who writes down in his /her notebook the description of the tasks entrusted to him /her. The student should also propose other changes not mentioned by the tutor, if makes sense. | | |
| **Methodology and work plan**<br>In the same way, the work plan should be discussed with the student and he/her should write it down in his/her laboratory notebook with his/her own words. This is important to ensure that the student perceives and internalize what is intended to be done. | | |
| **Ratings**<br>The tutor should take notes of the work evolution of the student in relation to critical thinking skills raised during the internship. Over time the student should achieve several critical thinking results, such as: | | |
| **C1.- Self examination. Reflection of one's own reasoning** | | |
| **C2.- Formulate objectives. Identify problems.** | | |
| **C3.- Raise fundamental questions.** | | |
| **C4.- Formulate hypothesis.** | | |
| **C5.- Learning to learn, searching for information.** | | |
| **C6.- Have an open mind.** | | |
| **C7.- Have intellectual integrity.** | | |
| **C8.- Express yourself well, effectively, both orally and in writing.** | | |
| **C9.- Be persevering.**<br><br>*Include as many pages as necessary* | | |

# 2.5. Work Plan for a VET student internship in physics department of UNIVERSIDADE DO MINHO

Universidade do Minho

Campus de Gualtar
4710-057 Braga – P

Universidade do Minho
Escola de Ciências

# Tutor's notebook: suggestions to program the work of a VET student to strengthen critical thinking skills in high-tech companies or research centres

**Worker or student internship:**
**Supervisor:**
**Notebook starting date:**
**Date of completion and file in the company:**

| The tutor who delivers the notebook: | Received by the UM: |
|---|---|
| Date and signature | Date and signature |

This template for the tutor notebook was developed by the team of the University of Minho during the implementation of the Erasmus + project 2017-1-ES01-KA202-038469 *CRİTİCAL THİNKİNG AS A STEP FORWARD İN VET EDUCATİON: VET students immersed in high technology teams*.

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| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 1.- Global approach to the internship** | | |
| **Title:**<br><br>**Preparation of polymer-based magnetoelectric composites for advanced technological applications** | **Student folder** | **Dates of the internship:**<br><br>20/3/2019 al 30/6/2019 |
| **Brief description:**<br><br>In this work it is proposed to develop new magnetoelectric devices based on polymers. These are materials that when subjected to a magnetic field respond by generating an electrical impulse. In the internship that the VET student will perform, two types of materials will be combined: a piezoelectric material (which produces an electric field in the event of deformation) and a material with magnetostrictive properties (material that deforms when it is subjected to a magnetic field). The VET student will see how these two materials can be combined to produce a flexible, composite material, in which, when subjected to an external stimulus, a series of effects take place that end in a response. These materials have many applications as sensors or as actuators. The work will include the manufacture of the material with its physical characterization with extraordinarily precise measurements of a variety of parameters that demonstrate its capacity for the intended application. | | |
| **Area of the company or project in which the internship is framed:**<br><br>Demand and interest from industry in this new type of sensing/actuation materials is so high that the market size is expected to grow to 5.4 billion US dollars by 2023, at an estimated Compound Annual Growth Rate (CAGR) of 9%. The combination of magnetic materials with printing technologies along with breakthroughs in micro-electronics and miniaturization will allow the introduction of powerful and potential analytical tools for effective device applications. The VET student's internship will focus on one of the materials that is being studied in our research lines.<br>Further, at the present stage of the research, strong international collaborations already exist (Cambridge University; University of Zaragoza; ARC Centre of Excellence for Electromaterials Science Wollongong, Australia; CIBER de Bioingeniería, Biomateriales y Nanomedicina (CIBER-BBN), Madrid, International Iberian Nanotechnology Laboratory, Portugal; University of the Basque Country, and Basque centre for materials) and are supporting the viability and success | | |

of the proposed tasks. The range of collaborations makes the work team in which the student will be integrated an interdisciplinary group composed of people from very different backgrounds and coming from different countries.

**Problem statement**

Most known magnetoelectric compounds are based on piezoelectric phase ceramics such as barium titanate (BaTiO3) or lead zirconate titanate (PZT) due to their high piezoelectric coefficients. Such high piezoelectricity allows magnetoelectric coefficients to be three orders of magnitude higher than in monophasic materials, but, on the other hand, they are limited by reactions in the interface regions, are expensive, dense, fragile and may fail during operation, hindering this way their incorporation in devices.

The problem that arises in the work to which the VET student is incorporated is the development of composite materials, consisting of a sheet of a piezoelectric polymer in which nanoparticles of Terfenol-D are dispersed, which is the material most used as a magnetostrictive phase due to its high magnetostriction. In the production of these sheets, it is necessary to face the problems of handling the nanoparticles, their homogeneous dispersion and the fact that the coupling between them and the polymer is essential so that the expected properties of the material are achieved to be able to incorporate it into a device

**Hypotheses, solutions that can be anticipated and expected results.**

It is expected that with the techniques of dispersion of the particles in a solution of the polymer followed by evaporation of the solvent at high temperature and subsequent crystallization by specific thermal treatments, it will be achieved that, when subjected to a magnetic field, the nanoparticles will deform, dragging with them a deformation of the polymer that will produce the desired electrical signal. That the signal values reach the desired levels will require very careful and reproducible manufacturing processes.

The main objective is:
- Develop a magnetic field sensor that responds to the sensitivity and reproducibility requirements demanded by the industry.

Other objectives are:
- Analyze in depth the reproducibility of the manufacturing process of the composite sheets.
- Analyze the reproducibility of the measured physical properties.
- Characterize the microstructure of the material.

**Initial information given to the student**

Protocol for the preparation of composites (Spanish / Portuguese).

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Protocol for quantification of the magnetoelectric coefficient (Spanish / Portuguese).
Application Development Protocol (Spanish / Portuguese)

A book chapter on piezoelectric properties (Spanish / Portuguese)
A book chapter on the polymer-based magnetoelectric effect (English)
Summary of the research project in which the work is framed (English)
Safety sheets of all reagents to use at work (English and Spanish)

*Add as many pages as necessary*

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| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 2.- Work plan. Initial tasks** | | |
| **Task:**<br><br>**Material processing** | **Student folder:** | **Dates**:<br><br>25/3/2019<br>al<br>5/4/2019 |

**Brief description**

The initial task will be the preparation of a composite sheet and the characterization of the magnetoelectric effect on that sheet:

The protocol includes:
-Understanding of the nanoparticle management protocol. Individual protection elements, isolated chamber, cleaning, waste management.
- Understanding of working protocols with solvents.
-Calculation of polymer and nanoparticle concentrations following a protocol available at the Research Centre.
- Preparation of a dispersion of nanoparticles of Terfenol-D in the appropriate solvent and with the desired concentration. Use of ultrasonic agitation systems
- Solution of the polymer, poly(vinylidene fluoride) in the suspension containing the nanoparticles.
-Evaporation of the solvent to form the film and heat treatments.
- Film thickness measurements. Measures of mechanical properties.
- Measurement of the magnetoelectric coefficient.

**Understanding of the experiment to be performed and assessment during its execution.**

1. What is a polymer? What has the student seen in his studies on polymers?
2. How the student knows that the polymer has been completely dissolved?
3. What size are the nanoparticles used in this work? How is this size assessed?
4. It is very difficult for the polymer to dissolve, can the process be accelerated?
5. Where can one find information about these aspects?
6. What is a magnetostrictive material?
7. What is a magnetoelectric material?
8. How many phases are in a magneto-electric material?
9. How is a magneto-electric material characterized?

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| | |
|---|---|
| 10. What is important in a magneto-electric sensor?<br>11. What is important in a magneto-electric actuator?<br>12. What is important in a magneto-electric power collector?<br><br>In this first task a series of experimental techniques have been used:<br>- Safety measures in the management of organic solvents and nanoparticles. Individual protection elements. Waste management.<br>- Preparation of solutions: weighing in precision balances, use of micropipettes, concentration calculations.<br>- Thin films thickness measurement system. Measures of mechanical resistance.<br>- Measures of magnetoelectric effect.<br><br>and the understanding of a series of concepts:<br><br>- Polymer and copolymer<br>- Composite material<br>- Interfaces<br>- Piezoelectric, magnetostrictive and magnetoelectric effect<br><br>In this box the tutor can add notes about whether the student | |
| …is interested in understanding the documentation in depth. (C1) | |
| …ask clarifying questions (C3) | |
| …dare to suggest changes in the protocol that has the research centre (C6) | |
| … explains his ideas clearly orally (C8) | |
| | |

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| **Search for information.**<br><br>In this box the tutor can add notes about whether the student | |
|---|---|
| … has difficulty with English and if in spite of it, he is aware that it is necessary to resort to information in that language (C5) | |
| … search several alternative sources of information (C5) | |
| … establishes a hypothesis about his essay (C4) | |
| | |
| **Experimental results.**<br><br>The student will be asked to reflect his results in his laboratory notebook. They must pose a series of questions<br>1. How are the results presented?<br>2. How is reproducibility assessed?<br>3. To what extent should the procedures and incidents that have appeared during the experiment be explained in the notebook?<br>4. How are the tables and figures prepared?<br>5. Is it interesting to include pictures of the assemblies?<br>6. Point out in the experimental protocols that you have used what you have struggled to understand and try to explain it better according to your experience.<br><br>In this box the tutor can add notes about whether the student | |
| … assesses the quality of the results obtained in terms of reproducibility and detects the points of subjectivity in the essay (C1, C7) | |
| … assesses if the results obtained coincide or not with his hypothesis and seek explanation to the differences (C4) | |
| … organize and clearly present the results (C8) | |
| … explains his ideas clearly in writing (C8) | |

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| | |
|---|---|
| **Attitude in group meetings.**<br>The tutor's impression of the participation of the student in the group meetings can be noted here if at the time of this first stage there has been any.<br><br>In this box the tutor can add notes about whether the student | |
| … presents his results clearly (C8) | |
| … defend his ideas and accept criticism (C6) | |
| | |
| **Laboratory notebook.**<br>.<br><br>In this practice, the laboratory notebook will be the medium where all the reports of the results of the experiments carried out will be collected. In this initial stage it is important that the tutor assesses the way in which the student collects in his/her laboratory notebook both the results obtained and their assessment and the purpose of their task and the comments of other group members.<br><br>The writing of the laboratory notebook should help the student to organize his reflection on the new concepts and techniques with which he/she is in his/her practice.<br><br>In this box the tutor can add notes about whether the student | |
| … collect in the notebook the global objectives of the research line in which its project is framed and those of his concrete tasks (C2) | |
| … gathers clearly enough his results and protocols used thinking that others will have to understand them later (C6, C8) | |
| … assess the quality of the results obtained (C1) | |
| | |

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| **Joint analysis of this initial task with the student** |
|---|
| For the rest of the practice, this first impression of how the student develops in the company should be discussed with him/her in order to guide their training. The analysis should both motivate him/her by highlighting the results obtained in terms of immersion in a new method of work in the short time elapsed, such as showing him/her or suggesting ways to improve in the different sections of the notebook. |

| **Template of the plan of work and evaluation of the internship.** | | |
|---|---|---|
| **PART 3.- Development of the internship** | | |
| **Title:**<br><br>**Preparation of polymer-based magnetoelectric composites for advanced technological applications** | **Carpeta/servidor**: | **Date**:<br><br>5/4/2019 Hasta el final de la práctica |
| **Changes in plan of work or new tasks**<br><br>Based on the assessment of the initial task, all the changes deemed necessary to achieve the best results in terms of student training and their contribution to the work of the research team will be made. | | |
| **Methodology and work plan**<br><br>The work must be organized dynamically and according to the results that are obtained and the interests of the student and the group.<br><br>In an initial estimate, the following tasks should be programmed:<br><br>1. Repetition of the initial task to analyse the reproducibility of the result. The moment in which the student can be authorized to work on their own in each of the specific tasks will be assessed.<br>2. Study of the production protocol of the magnetoelectric material with variable nanoparticle contents. | | |

| |
|---|
| 3. Study of the correlation between the composition and the quantification of the magnetoelectric effect.<br>4. Structural, morphological, mechanical and thermal characterization.<br>5. Integration of the material into a device as a magnetic field sensor.<br>6. Oral presentation in the research group of the progress of the results at various moments of the practice, informally, but using means of presentation such as PowerPoint.<br>7. Final presentation of the work in a seminar meeting of the Center for Biomaterial and Tissue Engineering. |
| **Ratings**<br>It could be taking notes of the evolution of work in relation to critical thinking skills raised. In section 6 of the guide we suggest certain critical thinking results that the student should achieve over time. |
| **C1.- Self examination. Reflection of one's own reasoning** |
| **C2.- Formulate objectives. Identify problems.** |
| **C3.- Raise fundamental questions.** |
| **C4.- Formulate hypothesis.** |
| **C5.- Learning to learn, searching for information.** |
| **C6.- Have an open mind.** |
| **C7.- Have intellectual integrity.** |
| **C8.- Express yourself well, effectively, both orally and in writing.** |
| **C9.- Be persevering**<br><br>*Include as many pages as necessary* |

## 2.6. Work Plan for a VET student internship in physics department of TEI OF CRETE

ΤΕΙ Κρήτης
Τεχνολογικό Εκπαιδευτικό Ίδρυμα Κρήτης

Erasmus + project 2017-1-ES01-KA202-038469 *CRİTİCAL THİNKİNG AS A STEP FORWARD İN VET EDUCATİON: VET students immersed in high technology teams*.

Deliverable: **Tutor's notebook: suggestions to program the work of a VET student to strengthen critical thinking skills in high-tech companies or research centres**

Authors: Yiannis Kaliakatsos, Eleftherios Doitsidis

Version: v1

Hellenic Mediterranean University

Department of Electronic Engineering

**Department of Electronic Engineering**
**Hellenic Mediterranean University**

# Tutor's notebook: suggestions to program the work of a VET student to strengthen critical thinking skills in high-tech companies or research centres

**Worker or student internship:**
**Supervisor:**
**Notebook starting date:**
**Date of completion and file in the company:**

| The tutor who delivers the notebook: | Received by the CBIT: |
|---|---|
| Date and signature | Date and signature |

This template for the tutor notebook was developed by the team of the Department of Electronic Engineering, Hellenic Mediterranean University during the implementation of the Erasmus + project 2017-1-ES01-KA202-038469 *CRİTİCAL THİNKİNG AS A STEP FORWARD İN VET EDUCATİON: VET students immersed in high technology teams*.

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 1.- Global approach to the internship** | | |
| **Title:**<br><br>**Preparation of educational material for STEM based activities** | **Student folder**: | **Dates of the internship**: |

**Brief description:**

Education is of key interest for most of the countries since, it has a significant impact on the society overall. During the last 20 years, mainly due to the advancement of the computers and the significant cost reduction of the related technologies, STEM (Science, Technology, Engineering and Mathematics) and educational robotics have gained a lot of attention and became a significant asset in the overall education process of the primary and secondary education.

The objective of the work is to design new hardware for STEM education aiming the students of secondary education. The new educational material is aiming students of secondary education, and it consists of properly designed hardware and software. The existing hardware solution is based on the Arduino microcontroller, while the software is based on Ardublockly software which is free for educational use and it is developed by Google.

The fundamental operational characteristic is the ease of use and the unique way of implementation. This has as a result the minimization of errors due to inappropriate way of connecting the devices, resulting in the reduction of frustration that the students might have during their involvement. The educator has more time to focus to the actual context of the lesson, than get involved in timely consuming procedures related with the proper setup. Another key characteristic of the system is that it can be programmed using visual tools (visual programming) without losing the benefits of developing code in a standard programming language. It is worth mentioning that the user has access to the standard code (i.e. C) and has also the ability to use it to program the devices.

**Area of the company or project in which the internship is framed:**

The proposed internship is part of the research ongoing activities, in the field of new educational methods, STEM and educational robotics of the laboratory of Electronic Circuits and Automation of the Department of Electronic Engineering of the Hellenic Mediterranean University. In the context of these activities the laboratory is participating in a series of funded Erasmus projects as long as it develops its own small scale research projects, funded by university funds.

**Problem statement**

The adoption of new STEM oriented hardware and software from students of the secondary education is of major importance for the development of the student's skills in the areas of Science, Technology, Engineering and Mathematics. These may lead to advanced skills which will later on will help the students to develop dexterities in technology-oriented disciplines like programming and automation.

A key issue is how the devices will be appealing to the students and how they will provide maximum engagement by simultaneously keeping the frustration levels low and at the same time provide expandability and modularity.

The intern should consider the above issues and design and provide proper modifications to the existing hardware and software so that it meets the aforementioned goals.

**Hypotheses, solutions that can be anticipated and expected results.**

It is expected that the intern will initially understand the fundamental way of operation and development related with the existing devices. These devices are properly developed but lack the ability to interconnect with each other in the physical level.

The intern is expected to provide a solution based on state-of-the-art methodologies like 3d modelling and prototyping to overcome the aforementioned problem. This solution must be appealing to secondary education students and simultaneously must be functional and expandable. The final product should be tested either in the lab or idealy by the end users.

**Initial information given to the student**

Protocol of operation inside the lab (Greek)
Existing Hardware and Software with manual (Greek, English)
Manual of the 3D printer with proper instructions (Greek, English)
Manual of the 3D design software and instructions about how the intern will setup his workspace (Greek, English)
Literature on STEM education (Greek, English)

| **Template of the plan of work and evaluation of the internship.** | | |
|---|---|---|
| **PART 2.- Work plan. Initial tasks** | | |
| **Task:**<br><br>**Designing and printing 3D shells for STEM hardware** | **Student folder**: | **Dates**: |

**Brief description**

The objective of the task is to provide the initial design and manufacture functional prototypes of 3D printed shells for STEM Hardware. This procedure includes the following steps and the intern will be assisted in all the steps by members of the lab.

1. Understanding the functionality of the working prototypes. Basic principles of programming and interconnection of the existing software and hardware. Creation of simple working prototypes. Reflect all this in the laboratory notebook.

2. Understanding the principles of 3Dd printing. Reflect them in the lab notebook.

3. Understanding the principles of designing in parametric manner in a 3D environment. Preparation of sample drawings. Reflect them in the lab notebook.

4. Prepare and print a sample prototype. Reflect it in the lab notebook.

5. Perform design based on the end user needs. Reflect it in the lab notebook.

6. Written report and manual which will describe all the final products and their related functionality.

**Understanding of the procedure, way of development and assessment during its execution.**

*There are a series of questions that must appear in the process*, raised either by the student or by his tutor, for example:

1. What is STEM? How it is affecting the learning process? What are the benefits of STEM to secondary education students?

2. How rapid prototyping using 3D printing works? What are the basic advantages of the aforementioned procedure?

3. What is parametric 3D design? Why we use it?

4. Where can one find information about these aspects?

5. What is visual programming and what are the benefits comparing to the traditional approach for the students using devices programable with this approach?

| | |
|---|---|
| 6. How can we optimize the design of our prototypes in order to reduce 3D printing time?<br><br>- Safety measures during 3D printing process.<br>- Usage of 3D software<br><br>*and several basic concepts appeared:*<br><br>- 3D design<br>- Programming skills<br>- Basic Electronics<br><br>In this box the tutor can add notes about whether the student | |
| …is interested in understanding the documentation in depth. (C1) | |
| …ask clarifying questions (C3) | |
| …dare to suggest changes in the procedures currently used in the laboratory (C6) | |
| … explains his ideas clearly orally (C8) | |

| **Search for information**<br><br>In this box the tutor can add notes about whether the student | |
|---|---|
| … has difficulty with English and if in spite of it, he is aware that it is necessary to resort to information in that language (C5) | |
| … search several alternative sources of information (C5) | |
| | |
| **Assessment of the experimental results.**<br><br>The student will be asked to reflect his efforts and final product in his laboratory notebook. Several questions should arise:<br>1. How the results should be presented?<br>2. To what extent should the procedures and incidents that have appeared during the internship be explained in the notebook?<br>3. How the tables and figures should be prepared?<br>4. Is it interesting to include pictures of the prototypes in the notebook?<br>5. Should it include examples in the form of exercises for the students using the protypes developed?<br><br>In this box the tutor can add notes about whether the student | |
| … assesses the quality of the final prototype obtained in terms of functionality and detects the points of subjectivity in the essay (C1, C7) | |
| … organize and clearly present the results (C8) | |
| … explains his ideas clearly in writing (C8) | |
| | |

| **Attitude in group meetings.**<br>The tutor's impression of the participation of the student in the group meetings can be noted here if at the time of this first stage there has been any.<br><br>In this box the tutor can add notes about whether the student | |
|---|---|
| … presents his results clearly (C8) | |
| … defend his ideas and accept criticism (C6) | |
| | |
| **Laboratory notebook.**<br><br>In this internship, the laboratory notebook will be the medium where all the reports of the results of the experiments carried out will be collected. In this initial stage it is important that the tutor assesses the way in which the student collects in his laboratory notebook both the results obtained and their assessment, the purpose of his task and the comments of other group members.<br><br>The writing of the laboratory notebook should help the student to organize his reflection on the new concepts and techniques with which he meets in his work.<br><br>In this box the tutor can add notes about whether the student | |
| … collect in the notebook the global objectives of the research line in which its project is framed and those of his concrete tasks (C2) | |
| … gathers clearly enough his results and protocols used thinking that others will have to understand them later (C6, C8) | |
| … assess the quality of the results obtained (C1) | |
| | |
| **Joint analysis of this initial task with the student**<br><br>For the rest of the internship, this first impression of how the student develops in the company should be discussed with him in order to guide his training. The analysis should both motivate him by highlighting the results obtained in terms of functionality and applicability in the short time elapsed, and also suggesting ways to improve in the different sections of the notebook. | |

| Template of the plan of work and evaluation of the internship. | | |
|---|---|---|
| **PART 3.- Development of the internship** | | |
| **Title:**<br><br>**Preparation of the final protorypes** | **Student folder**: | **Dates of the internship**: |

**Changes in plan of work or new tasks**

Based on the assessment of the initial task, all the changes deemed necessary to achieve the best results in terms of student training and their contribution to the work of the research team will be made.

**Methodology and work plan**

The work must be organized from here dynamically, according to the results that are obtained and the interests of the student and the group.

In an initial estimate, the following tasks can be programmed:

1. Design of the final prototypes based on the feedback received from the laboratory members and the ideally some end users (the laboratory has a network of partners that may provide the requested information).
2. Print the final prototype shells.
3. Test the functionality of the prototypes in the laboratory.
4. Develop sample educational examples.
5. Provide manual for them.
6. Develop sample evaluation sheet of the functionality of the prototypes under the guidance of an experienced laboratory member.
7. Oral presentation in the laboratory members of the progress during and in several moments of the internship, informally, but using means of presentation such as PowerPoint (enhance soft skills of the intern).
8. Final presentation of the work, in a form of open presentation in the laboratory and interested university members as long as interested end users.

**Ratings**

The tutor could be taking notes of the evolution of work in relation to critical thinking skills raised.

| |
|---|
| **C1.- Self examination. Reflection of one's own reasoning** |
| **C2.- Formulate objectives. Identify problems.** |
| **C3.- Raise fundamental questions.** |
| **C4.- Formulate hypothesis.** |
| **C5.- Learning to learn, searching for information.** |
| **C6.- Have an open mind.** |
| **C7.- Have intellectual integrity.** |
| **C8.- Express yourself well, effectively, both orally and in writing.** |
| **C9.- Be persevering**<br><br>*Include as many pages as necessary* |

# AUTHORS

## José Luis Gómez Ribelles

José Luis Gómez Ribelles is a full professor at the Universitat Politècnica de València, carrying out his research work at the Centre for Biomaterials and Tissue Engineering, CBIT, of that university. He is currently the principal investigator of one of the research units of the CIBER-BBN of the Instituto de Salud Carlos III. His current line of research focuses on the development of biomaterials for tissue engineering and regenerative medicine.

## M. Concepción Solano Martínez

With a degree in English and German studies (University of Valencia, 1980), I have worked as a secondary school teacher (retired 2018). I have always had a strong interest in methodology and have taken more than 4000 hours of training both in the U.K and Spain. I worked for a school term in Beaconsfield grammar School as an exchange teacher. Member of the work team for the elaboration of the curriculum of the program "Integrated curriculum mec-British council". I have also been a teacher trainer for the Teaches and Resources Centre in Murcia.

# SPAIN

## Sandra Clara Trujillo

Sandra Clara is a phD student at the Universitat Politècnica de València. She received a bachelor´s degree in Biotechnology from Universitat Politècnica de València and a master's degree in Molecular Approaches in Health Sciences from Universitat de València. Currently her doctoral thesis is related with tissue engineering of the bone marrow and the study of drug resistance in mutiple myeloma.

## Maria Guillot

Maria Guillot, graduated in Biotechnology by Universitat Politècnica de Valencia, MSC in Cytogenetics and Reproductive Biology by Universitat Autònoma de Barcelona. She is currently studying a PhD at Universitat Politècnica de València, her doctoral thesis is related with bone regeneration using piezoelectric polymers for mesenchymal stem cell differentiation into osteoblasts

## Luis Gómez Estrada

Luis Gómez Estrada, was born in Valencia in 1980, with a Bachelor's degree in Industrial Design by "Universidad Politécnica de Valencia", experienced in the research field at the "Instituto de Biomecánica de Valencia" (UPV). Actually is CEO of Ikasia technologies and has experience as head of the 3D department in an engineering services companies. He has a broad experience in European and international project's management and coordination.

# GREECE

## Panagiotis Chatzipapas

Panagiotis Chatzipapas is agronomist. He studied Agricultural Biotechnology at Agricultural University of Athens and he did his Master in Applied Biology and Biotechnology at faculty of Biology in the University of Patras. He worked for the Achaia (Patras) regional agricultural service and the Greek Organization for Agriculture Insurance. He studied pedagogics and he started his VET teaching career in 2003. He teaches agriculture at 1st Epagelmatiko Lykeio Kato Achaias and he is the head of Agriculture, ICT and Economy sector. A very important part of his activity in VET, is to design and implement training projects for students and teachers in VET.

## Panagiotis Karampelas

He works as a teacher in secondary technical education with specialization in computers and design implementation circuits and also the design and development of algorithmic structures. Now days is the Headmaster in VET Secondary School. He has 2 Masters, Ecomomics in Education and In School Managment.
Also, Manage and Organize Erasmus Plus Projects (KA1-KA2) and E-Twinning

## Dimitrios Fligkos

Dimitrios Fligkos has studied IT in Athens University of Economics. He started his teaching career at 1st Epagelmatiko Lykeio Kato Achaias in 2002. He teaches IT and technology. Since 2002 he has taken part in many national and EU projects. He is responsible to organise students and teachers mobilities as well for the projects documentation. He has worked a lot to integrate ECVET system in the mobilities. He is also responsible to organise training activities for foreign students in the area. He has a key role to apply the mobility charter for vet high quality standards in projects planning and implementation.

## Yiannis Kaliakatsos

Prof. Ioannis (Yiannis) A. Kaliakatsos was professor in Electronics in TEI of Crete (now Hellenic Mediterranean University), (1986-2018). Now is Prof. Emeritus in the same University. He has a BSc in Physics, an MSc in Electronics and a PhD in Solid State Electronics, all from the University of Athens Greece.
He has a long experience in Erasmus Projects since 1991 and he was coordinator in many National & EU projects related with education.

# CZECH REPUBLIC

## Ivan Krakovski

Ivan Krakovský received his MSc degree in Chemical Physics and Biophysics from Charles University, Prague, in 1985 and PhD in Macromolecular Physical Chemistry from Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, in 1991. His main research interests focus on synthesis, structure and properties of polymer hydrogels. He is an author of 65 papers in peer-reviewed journals and 5 book chapters.

# PORTUGAL

## Jivago Nunes

Jivago Nunes have a degree on Optoelectronics and Lasers, and a Master in Materials Engineering, and worked as a scientific researcher during 5 years. After that, he has been the CTO of the company Somatica, Materials and Solutions, Lda. for the last 10 years and, as an entrepreneur, he have created 5 companies during the last 7 years.

## Senentxu Lanceros

S. Lanceros-Mendez is Ikerbasque Professor at the BCMaterials, Basque Center for Materials, Applications and Nanostructures, Leioa, Spain, where he is the Scientific Director. He is Associate Professor at the Physics Department of the University of Minho, Portugal (on leave), where also belongs to the Center of Physics. From 2012 to 2014 he was also Associate Researcher at the INL – International Iberian Nanotechnology Laboratory. He graduated in physics at the University of the Basque Country, Leioa, Spain and obtained his Ph.D. degree at the Institute of Physics of the Julius-Maximilians-Universität Würzburg, Germany. He was Research Scholar at Montana State University, Bozeman, MT, USA and visiting scientist at the Pennsylvania State University, USA and University of Potsdam, Germany, among others. His work is focused in the area of smart and multifunctional materials for sensors and actuators, energy and biomedical applications.

## Pedro Martins

Pedro Martins graduated in Physics and Chemistry in 2006 and received the PhD degree in Physics in 2012, from the University of Minho, Braga, Portugal in collaboration with Basque Country University, Spain and Cambridge University, United Kingdom. He is now a Post-Doc researcher in the Physics Center of the University of Minho, Braga, Portugal and his work is focused on polymer-based magnetoelectric/magnetostrictive materials, electroactive and multifunctional polymers for advanced applications. He collaborates with the Basque Country University, Spain; Wollongong University, Australia and Cambridge University, United Kingdom, among others.

IKASIA TECHNOLOGIES

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Centre for Biomaterials and Tissue Engineering
Universitat Politècnica de València

CHARLES UNIVERSITY

INSTITUTE OF MACROMOLECULAR CHEMISTRY
CZECH ACADEMY OF SCIENCES

Universidade do Minho

SOMATICA
MATERIALS & SOLUTIONS

ΤΕΙ Κρήτης
Τεχνολογικό Εκπαιδευτικό Ίδρυμα Κρήτης

1 ο ΕΠΑΓΓΕΛΜΑΤΙΚΟ ΛΥΚΕΙΟ ΚΑΤΩ ΑΧΑΪΑΣ