Digital Transformation in Advanced Manufacturing

Training methodology

Theoretical and practical guidelines for individual and cooperative learning (for educational professionals)

DTAM

DIGITAL TRANSFORMATION IN ADVANCED MANUFACTURING

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0.2	22-03-2022	Updated draft 0.1 to reflect feedback from AM and JG. Added introduction. Rewritten chapter 2 on CAR model and hybrid/blended learning. Added 11-step challenge based learning to chapter 3.

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1. Introduction

This training methodology will offer practical and theoretical guidelines for delivering the DTAM curriculum in initial (IVET) and continuing (CVET) vocational education and training courses. The methodology is written for both VET staff and other organizations delivering the DTAM curriculum.

The curriculum contains innovative elements, both in the contents of the training materials as in the way the educators and students can work with the materials.
To achieve the desired learning outcomes while working with the curriculum, this methodology will present best practices and guidelines for a successful implementation.

Chapter 2 on theoretical guidelines provides some best-practice pedagogical and didactical models to be used with the curriculum, and an interpretation for hybrid and blended learning. The curriculum is written for collaborative-based learning, e-learning/blended learning and access to hands on learning via (remote) IoT labs (including exercises without access to an IOT lab for students who want to work on personal devices or from remote locations).

Chapter 3 contains practical guidelines, based on the 11-step “challenge-based learning” model, and will show how to organize the learning experience for (groups of) students.

Transferring knowledge to and from regional partners, and continuous development of the curriculum is discussed in the “communities of practice” chapter 4.

This is a “living” document, meant to be updated along the way.

2. Theoretical guidelines

2.1 Competence – Autonomy - Relation (CAR) model

Students can have many different reasons to decide to study a subject. Regardless of their initial motivation, the research since 2008 done by Professor Luc Stevens suggests that student motivation is highly impacted by three basis needs:

- Relationship: "*others appreciate me and want to associate with me…*"
- Autonomy: "*I can do it myself, although not always alone…*"
- Competency: "*I believe and enjoy my own abilities…*"

These needs are probably recognizable when working with students. Still, educators could ask: *how should I design my lessons to honor these concepts in a practical and concrete way?*' A valid question for many models; many models *feel* good and often have a well-founded scientific basis, but still… This methodology will further describe the three concepts and link the basic needs to pedagogical action.

2.2 Hybrid learning: simulated or real? Studying or working?

Hybrid learning [1]is a model where simulated- and realistic learning environments, and "theoretical" and participating learning activities are combined.

Learning can take place in constructed (or simulated) environments like a classroom, or in real-life environments (like a workplace). Also, learning can be an "isolated" activity where theory is acquired, and learning can also take place while being part of a working community. Many institutions work with regional partners to offer internships; often starting with "constructed participation" (someone supervises the learning process in the workplace) to "realistic participation" (the learning is working alongside other collegues).

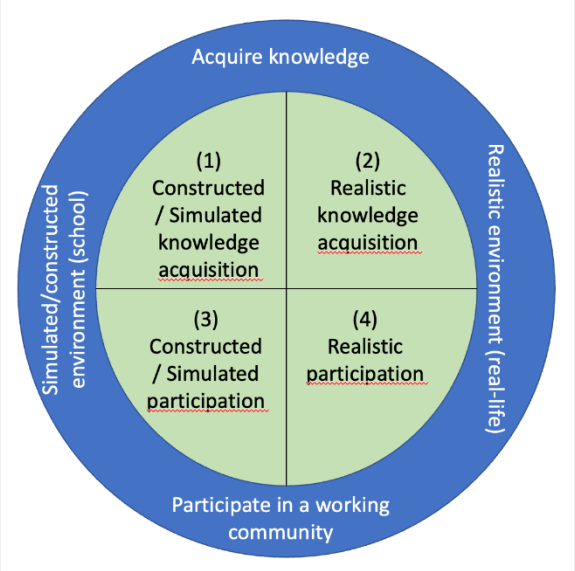


Figure 1: the four quadrants of hybrid learning

Hybrid learning environments require different, sometimes new roles from students, teachers and the business community. We see a shifting attention to the coaching, reflective and investigative role of the teacher/supervisor, but also that of the student.

Hybrid learning environments have added value for the student, vocational education and partners from professional practice:

- More meaningful learning, by interweaving professional practice with education,
- A powerful learning environment in which (elements of) theory and practice are meaningfully connected, which aids in the process of 'what you learn in one place, can also be applied in another place, at another time' . In other words: being able to make a transfer, which we see as a skill.

[1] ROC Da Vinci College – "Education for the future – our educational vision" – 2021-july-08.

- Challenging learning environments where breaking boundaries takes place by actively connecting theory and experiences & school and professional practice. It is precisely on these boundaries that the learning potential for our students, our partners from the professional field and our teachers is increased.
- New insights, innovations and working methods for the professional field, our students and vocational education, by working on issues from professional practice together with the professional field, students and teachers:
- An incentive towards cooperation in the vocational column IVET-CVET-higher vocational education and professional practice, which makes the education richer and the transition more gradual.
- Responsiveness to developments in our society and the labor market.

2.2 Blended learning

Blended learning is about when you learn, where you learn, and with who you learn.
A mixture of learning strategies in which choices can made for students to…

- study with and without teacher
- study both synchronous and asynchronous
- study Online and Offline
- study with and without the help of technology

… to provide optimal support in his/her learning task and at the same time to effectuate efficient and effective use of scarce resources such as time and space for the student and the teacher.

Blended learning in hybrid learning environments, developed for and together with our students and professional practice, can be recognized in our by:

- Learning environments that connect environments, where professional practice and education are intertwined, with people from multiple disciplines and levels. Flexible education logistics to achieve this.
- The vocational process and the vocational context as the backbone of the learning process and the learning context for all students.

- Learning environments that are aimed at continuous connection of work and learning processes.
- Education that comes about in co-creation or collaboration with the professional field and the world around us.
- Learning environments as a safe place with a positive learning climate to experiment, learn from mistakes and where the work process can be stopped if the student's learning process requires it.
- Learning environments and associated educational activities using an optimal mix of didactic teaching methods.
- Offering space to the student to take control of his/her personal and professional development and learning process.
- An environment where practice-oriented research also takes place, supported by a PhD and professional learning communities.
- Situational forms of guidance for steering, coaching, supporting and/or delegating, making use of scaffolding and formative action.

In practice, blended learning means “combine both real work context with the educational context” which can be done by working in companies, or have companies come to your institution to work with students and teachers.

3. Practical guidelines

3.1 Challenge based learning (11-step process)

When groups of students work on challenges to prove their mastery of the learning outcomes, a specific process is used, consisting of the following 11 steps[2].

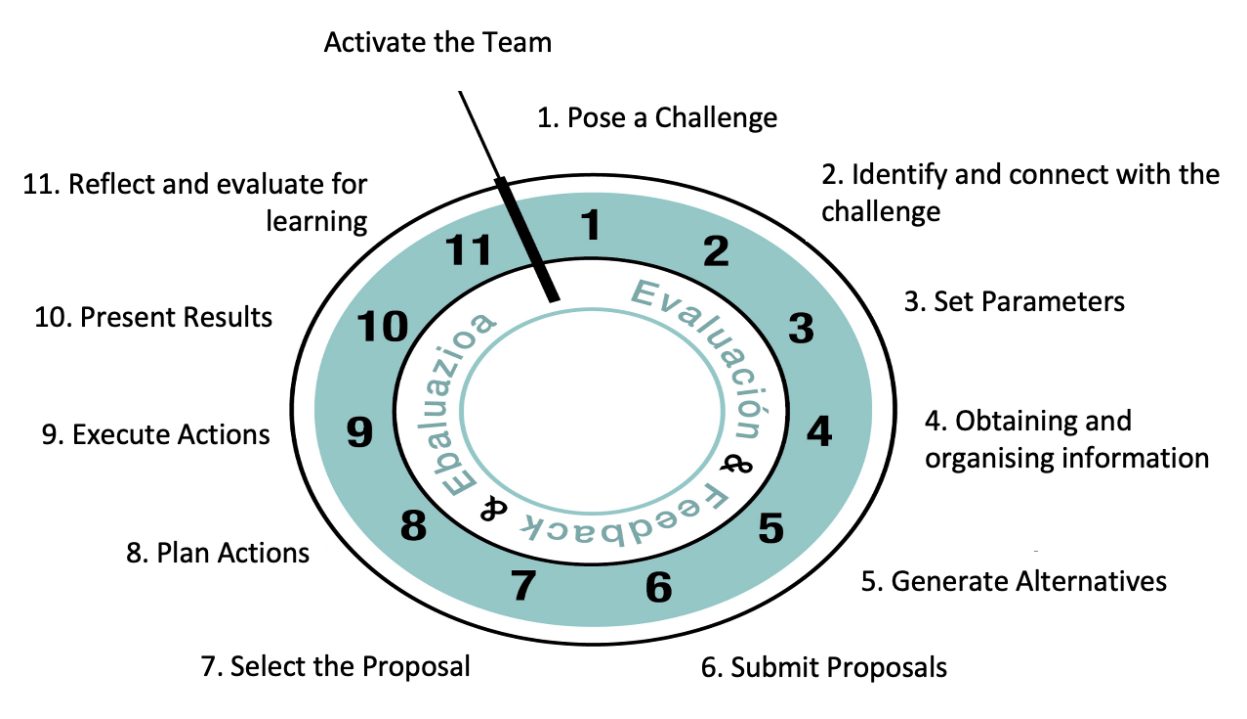


Figure 2: steps in challenge based learning

As a teacher, you will need to guide your students through the process by:

- Starting up the teams
- Present and identify the challenge
- Inform teams about feasibility parameters and help them collect information
- Have teams show their proposals
- Have teams organize actions and carrying them out

[2] INCOBOTICS – Ready for Industry 5.0, "CHALLENGE BASED LEARNING 11-step process"

- Have teams present results
- Analyze and evaluate the teaching process with the teams

Each step serves multiple goals:

GOALS of activating the team:

- Create/reinforce the collaborative environment
- Starting the teaching process
- Getting to know the students and their profiles
- Establish/agreement on operating rules
- ACTIVATE the team and prepare it for action

GOALS of presentation: posing a challenge, identify and connect to it

- Present the tasks to the students in an attractive way
- Give them a picture of what you are about to start
- Explain the new scenario to them
- Understanding the problem and what needs to be done
- Identify previous knowledge
- Motivate students and turn problem solving into a challenge for them.

GOALS of setting parameters, obtaining, and organizing information

- Create questions
    - What do I have to study?
    - What do I have to learn to do?
    - What information do I need?
- Split the challenge into areas of expertise
- Create research

GOALS of Proposals

- Each student has to bring at least one solution to the problem (DIVERGENCE)
- Working on creativity
- The more solution ideas the better
- Presentation and defence of the student's solution

- Learning from others
- Working on communication
- The group of students has to choose one of all the solutions (CONVERGENCE)
- Decision-making: individual and group.
- Searching for a common solution through teamwork

GOALS of organizing actions

- Structure how they will take the proposal forward.
- Use of **planning** tools
- Timing, sequencing, responsibilities, risk agreement.

GOALS of carrying actions out

- Carry out what they have identified, enhancing specific skills and abilities
- Develop what they have learned in the process
- Follow up on what has been done by correcting deviations.

GOALS of the analysis:

- Refining the teaching process
- To offer tools to see and improve the level they have in the different competences through feedback
- Become aware of how far they have come, where they want to go, and what commitments they will make
- Making compromises

3.2 Design criteria for challenges

Students need to work on challenges, and follow the 11 steps, described above.

Design criteria for suitable challenges are:

- Problems should be “real-world”, preferably explained to the students by someone from a regional organization/company;

- Many different “solutions” should be possible and it’s up to the students to research multiple possible solutions (with regards to feasabile in terms of available materials, costs, time, teacher knowledge, lab availability);

When developing the different steps for a challenge, ask yourself these questions:

- Does each of the 11 phases apply to our challenge? What for?
- How do we do the work groups? Do we use any dynamics?
- Is it written in such a way that the whole faculty understands it?
- Should we identify and distribute roles?
- Is it written down in the teacher's challenge?
- Should we activate the team in every challenge? How? With what dynamics?
- Is the contract drawn up and reviewed/reinforced at each challenge?

Presenting the problem

- What is the problem we propose? Is it real? Is it an everyday occurrence in the student's life?
- Is it confusing? Can it have more than one solution?
- Have you taken into account the profile of the student? (High/medium, ½,...)
- Do you have dynamics to identify what needs to be done/worked on?
- Are you going to work on transversal competences? Which ones? How? What evidence are you going to collect?
- How will students connect with the problem and accept it as a challenge? (What is the dynamic?)

Parameters

- Have we identified the parameters/questions to be extracted?
- Do we have in writing how we are going to make it dynamic?
- Will we do it individually, in working groups or in the whole group?
- If all the parameters are not present, how will you take action?
- Are the information gathering activities identified and planned?
- Are the activities designed to seek the answer to all parameters?
- What evidence will you collect to know where the student is with regards to the technical competences to be acquired? Will you give feedback?
- What transversal competences will you work on? What evidence will you receive?
- Will the evidences be individual or group?

Organizing actions and carrying them out

- Has the teaching team identified the following activities to be carried out?
- Have the risks been taken into account?
- Will we provide them with the necessary resources?
- Have we taken into account whether they are medium or higher grade?
- What evidence are we going to collect? Have we worked on this evidence before?
- Can they carry out what they have planned? (time, resources, responsibilities)
- Are there activities that work on competences?
- When evaluating the competences, has the necessary evidence been identified?
- Is a review of the planning foreseen?

Presenting the results:

- Should the results be presented formally? Why?
- Which competencies are we going to work on, and which ones
- are we going to evaluate?
- What will the presentation tell us about how the learning process
- went or about the information of the product produced?

Reflection and evaluation of learning

- How does the teaching team participate? And the students?
- Is there an event to celebrate what has been achieved?
- Is there a plan for who is going to give feedback?
- Will a feedback report or similar be issued?
- Will those commitments be collected? How?
- Where is it and what improvement tools have been designed? (To be offered to the learner)
- Will the student's progress be assessed?
- Is the same challenge expected to be assessed?

When students have read the training material, participated in the collaborative and individual exercises, optionally made a test, and this way showed that the learning outcomes are achieved, then the real proof will be to build a prototype in an IOT lab. Students must integrate multiple techniques and demonstrate their ability to choose the best (or the most affordable, or the fastest achievable) solution.

Collaborative based learning

Some learning outcomes are achieved reading text, while others will need to be achieved by exercises, on a laptop or in a lab (or on a laptop).
The exercises and challenges which are meant to be done in a group will be marked "collaborative".

Examples of collaborative learning:

- a group is given a number of subjects, which will need to be investigated
- the group discusses who will be doing which subject
- everyone will create their part
- the results will be put together (for example in a short presentation)
- the group will present the result back to the class

Or:

- an assignment consists of different nodes/hosts, each playing another part in the exercise
- every group member will setup and configure one of the nodes/hosts,
- the group will troubleshoot together
- the end result will be demonstrated to the instructor and/or the class

Or:

- An exercise consists of a part where a python script needs to be created (one or more software developer students will need to do this part),
- another part consists of setting up a MySQL database on a raspberry pi (one or more IT systems & devices, or networking administration, or devops students will need to do this part)
- The end result will be demonstrated to the instructor and/or the class

Or:

- A small group (1) will be given the assignment to give as many unique arguments for a given solution to a problem.
- A second small group (2) will gather arguments opposing the solution from group 1
- Groups (1) and (2) will exchange arguments / discuss in front of the class

- The class will decides which case will win.

E-learning/blended learning

The training materials should be useful in different scenarios:

- the student is using the materials individually (not in class); some self-test quizz questions should be usable for the student to determine if he/she understands the theory and knows the correct meaning of technical jargon.
- the teacher should use the training materials for classical, teacher-driven classical interactions (teachers explains / gives demo's and references the material. or : teacher assigns parts of the material as homework and does exercises with the class - or only the studentens that come prepared (flipping the classroom) can join the exercises.

Hands-on learning via (remote) IoT labs

A selected portion of the exercises / tests should be done using the IOT lab, where students need to be present in class.

Also, the "lab" exercises should be split into individual parts and group assignments.

4. Communities of practice

4.1 Regional knowledge triangles

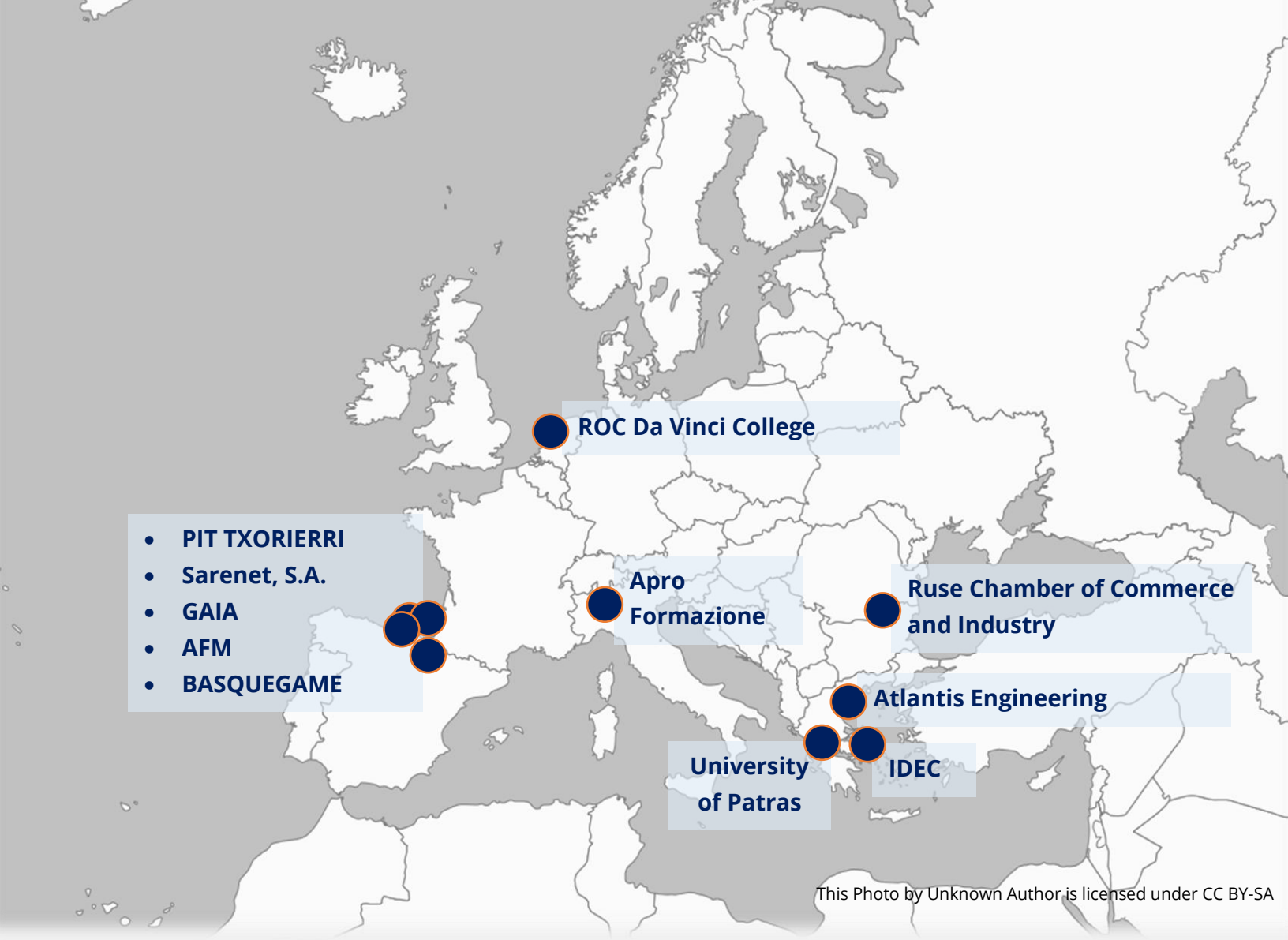
To keep the curriculum up to date and to exchange knowledge with local companies, both students, teachers and companies need to be engaged in hands-on knowledge sharing sessions. These come in many forms.
Here are some examples, as done by ROC Da Vinci College in 2022:

Organize a speed date with companies and students:

Invite companies to join the session (they will be rewarded by getting an early chance to find good interns among the student group, and will be rewarded by
have students prepare questions related to both the theory and/or exercises and to the field of work that the companies are doing).

Ask companies if they are open to host a prototyping project:

teacher will approach companies (for example, companies where interns are working or where exams are done)
teacher will ask students to create groups of 4, 5 people
each group of student will be matched to one company (or, mulptiple groups create a prototype for the same company so many solutions will be found)
students listen to the problem/request from the company;
they will research different technical approaches, from the training materials;
they'll build a prototype
the students demonstrate their prototype to their fellow students and to the companies.



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