

Reflections and Recommendations on Design, Implementation of Learning Activities and Assessment of Target Competences in Educational Robotics Contexts



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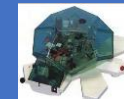
Educational Robotics, a long story...



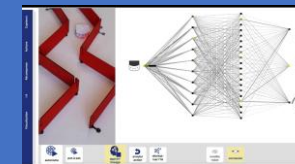
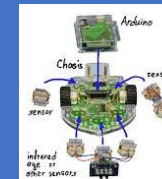
- * 60's & 70's: already present in schools, main focus on technological aspects, different disciplines
- * 70-80's: emergence of micro-computers, LOGO Microworlds (constructivism), floor turtles ... robots and programming languages
- * training, research, international conferences ...



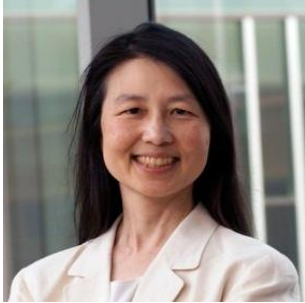
- * 90's: Various target publics and approaches (e.g. Denis & Baron, 1994)
- * (1) technocentric, (2) microworlds' exploitation, (3) simulation to learn scientific notions (computer assisted experimentation, « cognitive spectacles ») and (4) programming
- * Cross disciplinary skills: problem-solving, formalizing thought, socialization (cooperation and socio-cognitive conflicts), and acquiring certain concepts.
- * Different methodological approaches



- * > ~2005: « Revival »
- * Equipment, software...
- * More explicit links with curricula (e.g DigComp 3.0)
- * Artificial intelligence
- * Computational Thinking



Computational Thinking (CT)

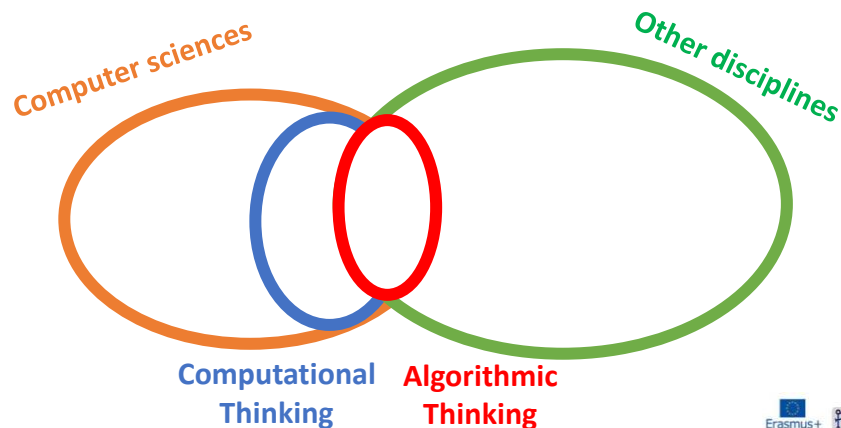


Jeannette Wing

Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability.(...)

Computational thinking involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science. Computational thinking includes a range of mental tools that reflect the breadth of the field of computer science.

(ACM vol. 49, n° 3, March 2006)



Intersections between different domains

- The set of skills involved in representing and manipulating information (particularly for problem-solving).
- Transversal, fundamental skills that can be applied with or without computer hardware or programming languages (cf. plugged or unplugged activities - Romero et al, 2018)



Many definitions, no real consensus (see Sigayret & Tricot, 2025)

‘Exploratory study’

Sustain training teachers students to produce and
field test educational scenarios related to CAT
competences development

Target Public & course organisation

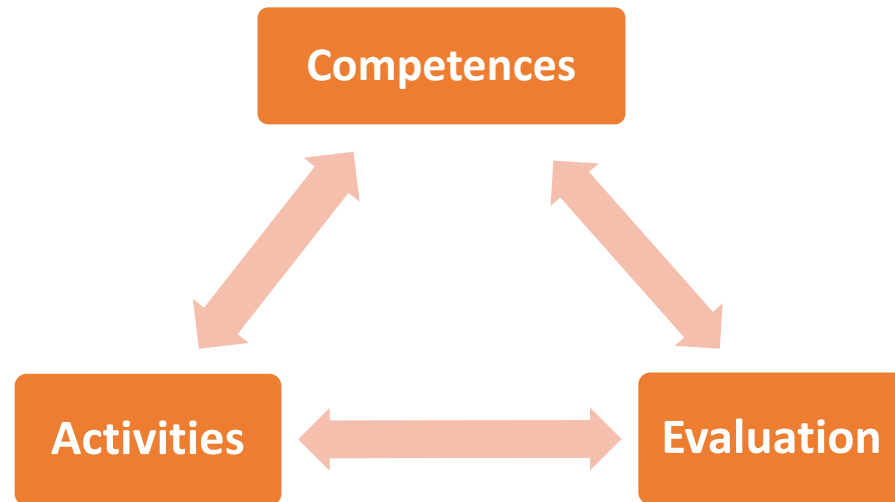
- Optional course « Introduction to CAT » (3 credits)
- Blended learning (*f2f-distance-f2f*)
 - Students: master in educational sciences (N=26)
 - 7 duos and 4 trios *
 - Professor + 2 assistants (*face-to-face activities*)
 - 3 e-tutors (*follow-up of the educational scenario design*)



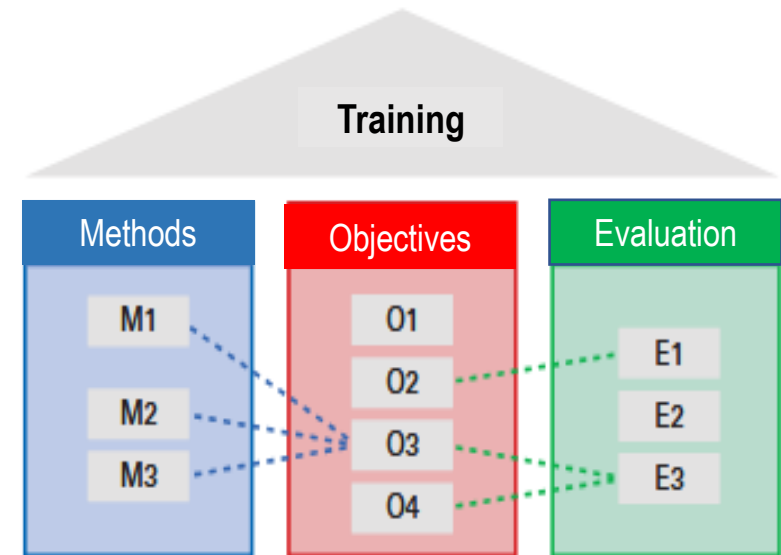
! Limits !

* *At the end, a duo gave up, one member of a trio left*

Pedagogical Alignment



Leclercq , 1995

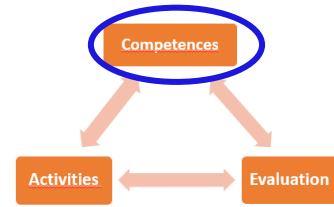


Leclercq , 2020

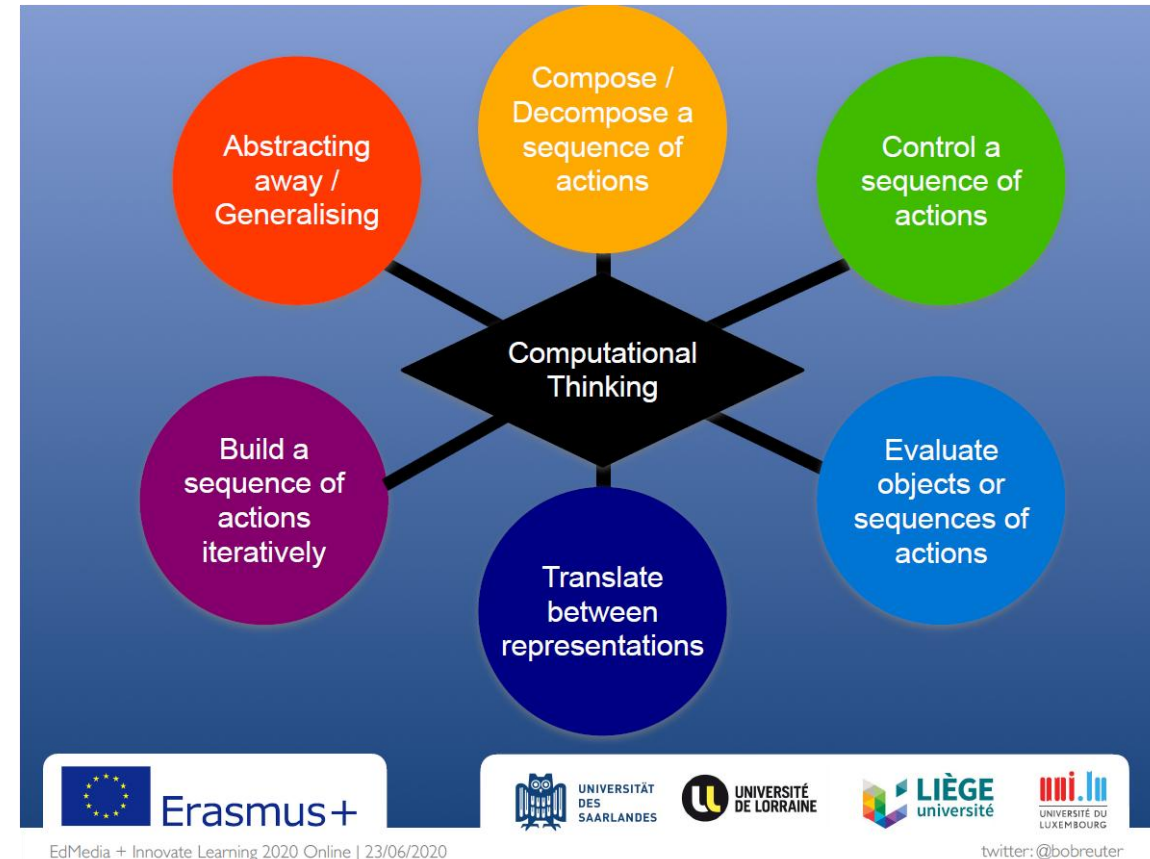
Organisation and Planning



Course general objective: Train in the design, implementation and analysis of teaching and learning methods aiming at developing CAT in pupils from preschool to secondary school



1. Define Computational Thinking (CT)
2. Appropriate a competence framework related to CT development by young people of different age groups
3. Understand complex problems; break them down into sub-problems, and propose solutions that can be partially or fully automated; analyze different existing activities, particularly from the perspective of the relationship between targeted skills, learning activities and assessment.
4. Design an educational scenario (ES) aiming at developing CT competences
5. Implement the ES in a given context
6. Make connections between these activities and the training of teachers/trainers





1 Abstracting away / generalising

- 1.1 Name objects and (sequences of) actions
- 1.2 Differentiate (i) objects and actions, (ii) atomic and non-atomic actions
- 1.3 Identify the input parameters of a sequence of actions
- 1.4 Describe the outcome of a sequence of actions
- 1.5 Describe the outcome of a sequence of actions
- 1.6 Predict the outcome of a sequence of actions
- 1.7 Using objects whose value can change
- 1.8 Recognize existing objects and (sequences of) actions that can be used to reach a similar goal

Foundational (5-8)

Advanced (9-12)

2 Compose / decompose a sequence of actions

- 2.1 Order a sequence of actions to reach a goal
- 2.2 Complete a sequence of actions to reach a simple goal
- 2.3 Create a sequence of actions to reach a simple goal
- 2.4 Create a sequence of actions to reach a complex goal
- 2.5 Combine sequences of actions to reach a goal
- 2.6 Decompose goals into simpler subgoals

Foundational (5-8)

Advanced (9-12)

3 Control a sequence of actions

- 3.1 Repeat a sequence of actions a given number of times
- 3.2 Repeat a sequence of actions until a goal has been reached
- 3.3 Integrate simple conditions within a sequence of actions
- 3.4 Integrate complex conditions within a sequence of actions

Foundational (5-8)

Advanced (9-12)

4 Evaluate objects or sequences of actions

- 4.1 Compare two objects according to a given criterion
- 4.2 Compare two sequences of actions according to a given criterion
- 4.3 Improve a sequence of actions according to a given criterion

Foundational (5-8)

Advanced (9-12)

5 Handling formal representations

- 5.1 Represent objects or sequences of actions using a formal representation
- 5.2 Translate objects or sequences of actions between formal representations

Foundational (5-8)

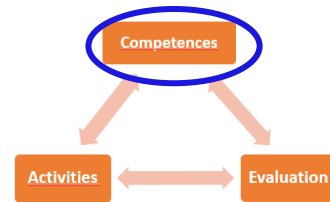
Advanced (9-12)

6 Build a sequence of actions iteratively

- 6.1 Test a sequence of actions with respect to a given goal
- 6.2 Spot errors in a sequence of actions with respect to a given goal
- 6.3 Correct a sequence of actions with respect to a given goal
- 6.4 Extend or modify a sequence of actions to reach a new goal

Foundational (5-8)

Advanced (9-12)



Competencies Framework

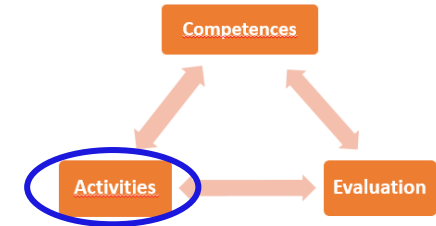
+ Glossary

+ Background information

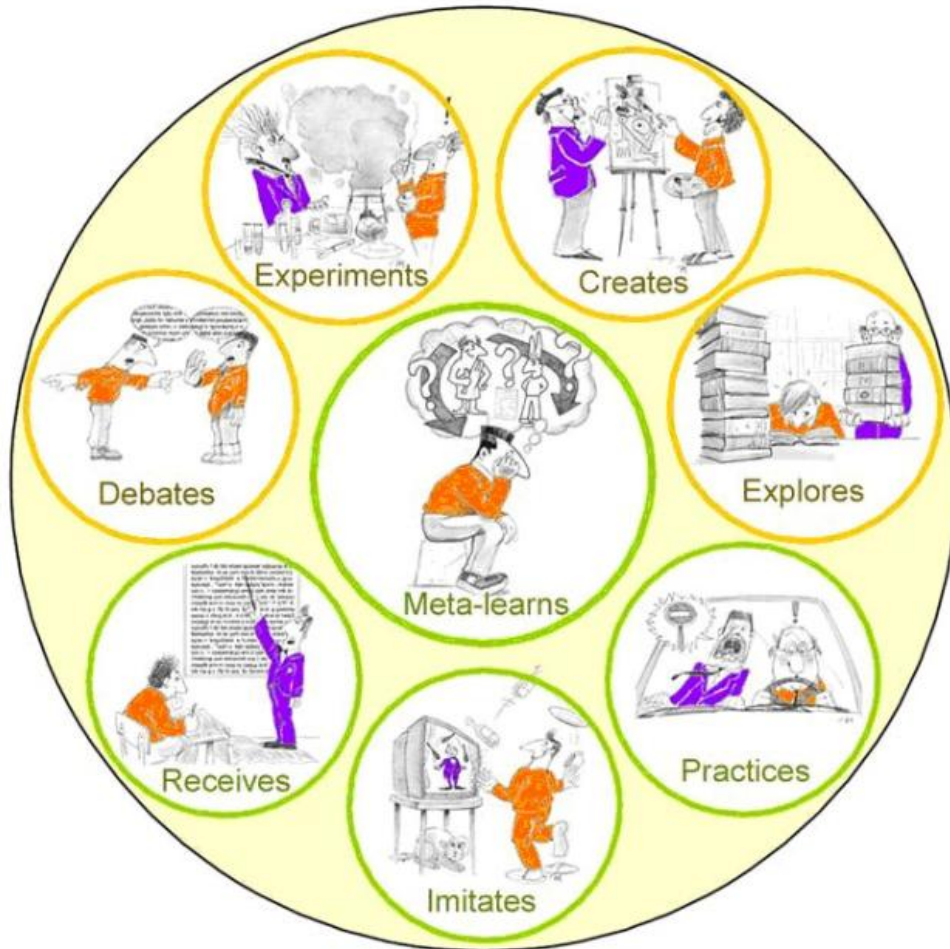
+ Examples / Illustrations

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<https://piaf.loria.fr/index.html%3Fp=507.html>

Learning Activities and Resources



8 Learning Events (Leclercq & Poumay, 2005)



Learning activities and didactical resources

Reception

- Course supports
- Teacher's presentation of a canvas and examples of [ES](#)
- Guides – tutorials (see [link](#))

Practice

- Activities analysis
- Quizz

Experiment/create/debate/ imitate

- Live plugged and unplugged activities

Exploration

- Other external documents
- Personal research

Debate/ imitate

- Interactions with peers, group members, e-tutor, teacher

Roadbook

Metalearn / Reflexivity

Roadbook

Introduction to Computational Thinking

!! Rename this document (RB surname first name) before you start filling it in !!

Surname:

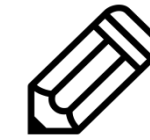
First name:

This logbook is a notebook in which you will write down your thoughts as you go through the activities in the course and as you design and test activities aimed at developing computational thinking in the field.

In addition to this reflective aspect, it also serves as a communication tool between you and your trainers (e-tutors). They will consult it regularly in order to provide you with support (answering your questions, monitoring your work carried out remotely, etc.).

It is structured in ten parts:

1. My expectations
2. Definition of Computational Thinking (CT)
3. Competency frameworks
4. Workshops experienced during the session
5. Educational scenario
6. Pedagogical alignment (Concordance C -A/M-E)
7. Creating an educational scenario
8. Testing an educational scenario
9. Reflection after experimenting with the educational scenario
10. My representation of the CT at the end of the course



Roadbook sustains

- Learning process
- Reflexivity
- Self-assessment
- Formative evaluation (e-tutoring*)

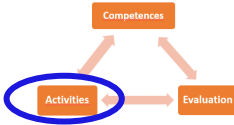
Effect on the final score/20

Bonus (0.5, 1, 1.5) / «Neutral» (0) / Malus (-0.5, -1, -1.5, -2) on the score

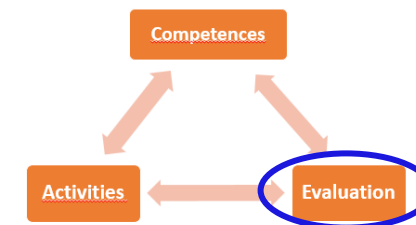
! Climate of trust between students, student(s) and e-tutor

! Regular concertation of all eTs and the teacher

* e-tutor's profile



Final learners' assessment based on a set of criteria related to ...



Final production (cf. ES canvas – written work)

Introduction

Practical information (*complete*)

Title (*present, short, original*)

Description (*clarity, length*)

Target competences

(*accurate, clear, operational, reference*)

CAT (*PIAF referential or relevant one*)

Other (*source*)

Prerequisites (*presence if any*)

Digital and/or didactical resources

Digital resources description (*if any*)

Didactical resources (*relevance, if any*)

Class organization (e.g. map)

Scenario outline (activities)

ES (*coherent, playable, complete*)

Description of the steps

Clarity of roles

Activity instructions

Alignment activities - competences

Assessment (alignment)

Originality

Areas for improvement (+ revisions highlighted)

Form and structure (*layout, structure, clarity of wording, spelling*)

Oral presentation

- Quality of the presentation (format): usability, originality
- Structure
- Inclusion of illustrations/tracks + relevance
- Vocabulary (accuracy)
- Oral expression (phrasing)
- Content (accuracy and understanding of the concepts covered (ES, competencies, methodology, assessment, pedagogical alignment, CAT))
- Overall reflective feedback (from the group)
- Answers to questions about the presentation (if additional information is requested to clarify the points)
- Speaker rotation
- Respect of time limits (20–25 min)
- Submission of the presentation material by the deadline

Individual “reflective feedback”

Set of questions to be asked to get a personal point of view (particularly if no yet present in the roadbook)

- What about going further?
- What did you find the most difficult? Easiest ? Why? Explain
- And you, what was your role (or roles) in creating the SP? And during the experiment?
- Did the experiment reinforce your views or lead you to change your perspective?
- What did you take away from this course (types of activities conducted) in terms of personal learning and the teaching/learning process?
- Were there any elements that caught your attention, made you think, changed your mind, or reinforced your opinion/approach?

Keeping the roadbook

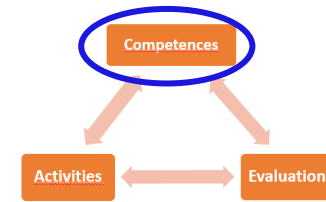
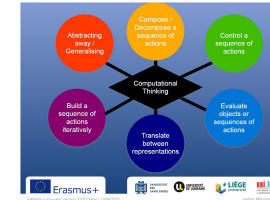
(Presence of reflections, taking into account comments, regularity...)

Some results

Educational Scenarios

- Collaborative design by the group: negotiation on topics, target public, etc.
 - ✓ *“This job offers a certain amount of freedom of choice: in terms of tools (online or offline), the year/class, the skills being worked on, the creation of the teaching scenario, the constitution of working groups, etc. All this freedom means we have to be creative, which makes the work extremely interesting and motivating.”*
- Comply with the various sections of the ES canvas necessitates clarification
- Anticipation or solving practical, conceptual, organizational problems, etc.
- Understandable and playable by other teachers
 - ⇒ ES sequence is (must be) formalized and concrete
 - ✓ *“Explaining the facts precisely was also a difficulty we encountered. To remedy this, we consulted examples of activities on the PIAF website. This helped us in writing our activity sessions. We will also have an outsider read it to ensure that these activities are clearly understood. In addition, our tutor will also be able to give us advice.”*
- Field testing => ES adaptation, reflections for future ES users

ES - Competence framework adoption



- Ongoing process. Gradual familiarization with its structure and the resources enabling students to select/define the target competences. Presence of reflections on competences concerning lived activities during the course. Frequent consultation of the provided documents or support from the tutor or teacher.

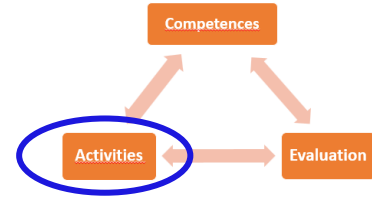
- ✓ *" I started the activity [Scratch] by observing the different blocks and understanding the objective of this program. I worked by trial and error and used various skills from the reference framework, such as skill 3.2 to create the pentagon and repeat a sequence of actions, and skill 2.3, in which I defined a sequence of actions to draw the octagon. With each exercise, the skills became more complex, adding to the skills I had already used.*
- ✓ *(...) In carrying out our teaching scenario, I found that it was mainly Appendix 1 and the explanatory videos that helped me the most."*
- ✓ *Our tutor was a "great help to us throughout our teaching scenario. (...) She also helped us to better understand certain skills that seemed very similar to us."*

- Adaptation of the list of target competences during ES development (additions, corrections)

!! Mastery of a mandatory set of target competences not addressed during the activities (course sessions or designing ES).

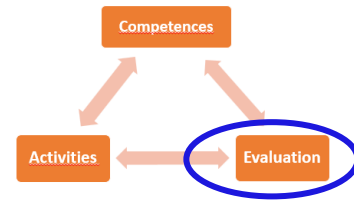
- At a minimum, students should master those used in the ES they have created.
- No assessment made before or after the course, f.i. via a test. This is not the purpose of this work.

ES - Activities



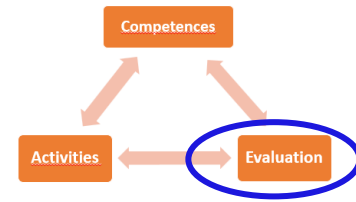
- Structured activities proposed, giving more or less way to problem-solving tailored to the target audience (aged 5 to 18)
- Sometimes several strategies acceptable for achieving the objective
This does not involve pupils' creative process (strictly speaking)
- Fair adequacy to target competences

ES - Evaluation



- Taking into account the achievement of the targeted learning competences is not immediately obvious
- Criteria generally based on observable elements and same kinds of tasks as in the activities

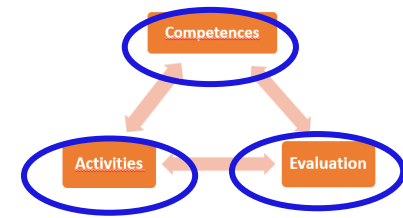
Academic results



<i>N=23</i>	μ	σ	$\mu+\sigma$	$\mu-\sigma$
Written ES	79,65%	10%	89,64%	69,65%
Oral presentation	81,33%	10,48%	91,81%	70,86%
Individual question	78,70%	11,45%	90,14%	67,25%
Total Score	79,95%	9,10%	89,04%	70,85%
Final ES Score /20	15,82	1,99	17,81	13,83

- Final scores vary from 11,4 to 17,9 /20
- 16 students received a roadbook bonus, 6 a penalty, and 1 was neutral
- Including roadbook, the final scores varied from 10,9 to 18,9/20.

Results: Evaluation and formative assessment



- Formative assessment: interactions with a dedicated tutor during completion of the roadbook and of the ES canvas helped the students to attain the objectives

✓ *“Following feedback from our tutor, I realize that the proposed evaluations do not comply with the triple concordance. However, this is a model that must be followed. Upon reviewing our work, we noticed that we are assessing skills that were not initially included in our activities. We have therefore decided to work on this skill during an activity so that it can be included in the evaluation while still adhering to the preferred methodology.”*

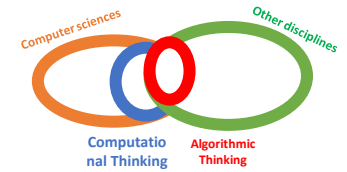
- Progress in students’ learning noticeable as they complete their roadbook and write their ES, and during the oral exam.
- Every learner has completed their roadbook, but the regularity and degree of reflection varies
- No pre-training ‘measurements’

Conclusions & Perspectives

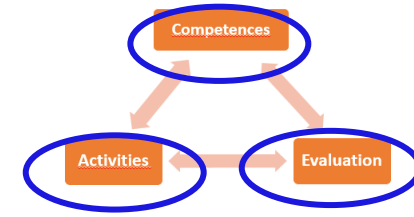


Focus on importance of teachers' training

- ER and CAT cover various fields and share learning objectives
 - Designing and implementing plugged or unplugged activities necessary to develop CAT/ER competences
 - Time and difficulty to create or to appropriate ES, especially reliable evaluation situations and indicators (cf. research)
- Different profiles (preacquisites/experience) => more or less easy to master the competences framework(s) or the available equipment and software
 - Probably depending on initial training, curricula, countries
 - But now important focus on digital competences, STEAM...



A blended learning environment, including distance tutoring relying on follow up through individual roadbook and the sharing (with a tutor) of the ES designed in small groups, can enhance the success



Planned course	Implemented course
Blended learning	Blended learning, with f2f block time seminar
Pedagogical alignment • Target competences • Learning activities & resources • Formative assesment+Evaluation	Globally well respected ✓ Communicated, linked to practical work (course + ES) ✓ Variety, in relation with target competences, availability, opportunity to deepen ✓ Mix of evaluation tools, but could be ameliorated or/and not only used for hetero-evaluation
ES collaborative design Follow up of the learning process: dedicated e-tutors + concertation	✓ Collaboration (! individuals, contextual variables..) ✓ Reflexivity, creation Importance of e-tutoring and shared tools (roadbook, ES) 

Recommendations (1/2)

- Systemic approach
- Train the trainers/animators
- Apply the principle of **isomorphism** in trainer's training
- Carefully prepare teaching/learning activities (multiple facets, pedagogical alignment...) or use/adapt existing educational scenarios
- Don't reinvent the wheel
- Products can be shared and evolve through the participation to Communities of Practice (CoP)
- Difficulty to create or propose scenarios based on personal learners' projects
 - Co-animation with an "expert" could help
- Sustain learners' personal reflection/metacognition all along the process

Recommendations (2/2)

- Research on effects of teaching/learning activities
 - Interest to take care of multiple facets:
 - What happens during the learning activity
 - Individual variables
 - Reflexivity (metacognition pre-per-post, SWOT)
 - Cognitive laboratory
 - ... not only Pre-Post tests

Pre test

???

Post test

- Collaborative research? 😊

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