Università degli Studi di Padova

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The CALOHEE project

Ornella Pantano

Dipartimento di Fisica e Astronomia "G.Galilei"
Università di Padova

PLS - FISICA MEETING NAZIONALE

Piano nazionale Lauree Scientifiche Fisica

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The Project

Co-funded by the Erasmus+ Programme of the European Union

CALOHEE - Measuring and Comparing Achievements of Learning Outcomes in Higher Education in Europe

https://www.calohee.eu

Coordinator: Robert Wagenaar (University of Groningen)

Co-coordinator: University of Deusto, Bilbao

(International Tuning Academy)

Group teams: Representatives from 28 countries and more than 80 HE institutions

Physics SAG - Participants

Co-ordinators	
Italy Ornella Pantano - University of Padova	**Spain** Fernando Cornet - Universidad de Granada
Inner Circle	
Belgium Katrien Strubbe - Ghent University	**Denmark** Ian Bearden - University of Copenhagen
Finland Inkeri Kontro - University of Helsinki	**France** Pierre Désesquelles - Université Paris-Sud
Greece Evangelos E. Vitoratos - University of Patras	**Ireland** Eileen Armstrong - Higher Institute of Technology, Sligo
Germany David Buschhüter - University of Potsdam	**Hungary** István Groma - Eötvos Loránd University
The Netherlands Hay Geurts - Radboud University Nijmegen	**The Netherlands** Gerard Barkema - Utrecht University
Portugal Maria-José BM de Almeida - Coimbra University	**Romania** Sebastian Popescu - Alexandro Ioan Cuza University of Iasi
United Kingdom Peter Main - King's College London	**EU** Adam Harchi - European Students' Union

Research questions

- Do students enrolled in higher education in Europe develop the competences they need?
- Can higher education learning be improved and the improvement evidenced?
- How can this be diagnosed and the diagnosis used to enhance learning and better prepare all students for their future roles in society?

The project covers five subject areas, representing five significant academic domains: Civil Engineering (Engineering), Nursing (Health Care), History (Humanities), **Physics** (Natural Sciences), Education (Social Sciences)

Project goals

- Develop a multi-dimensional instrument to measure and compare levels of learning across Europe
- Develop transnational qualification frameworks for five academic domains and five related disciplines
- Develop subject-specific assessment frameworks with measurable Learning Outcomes

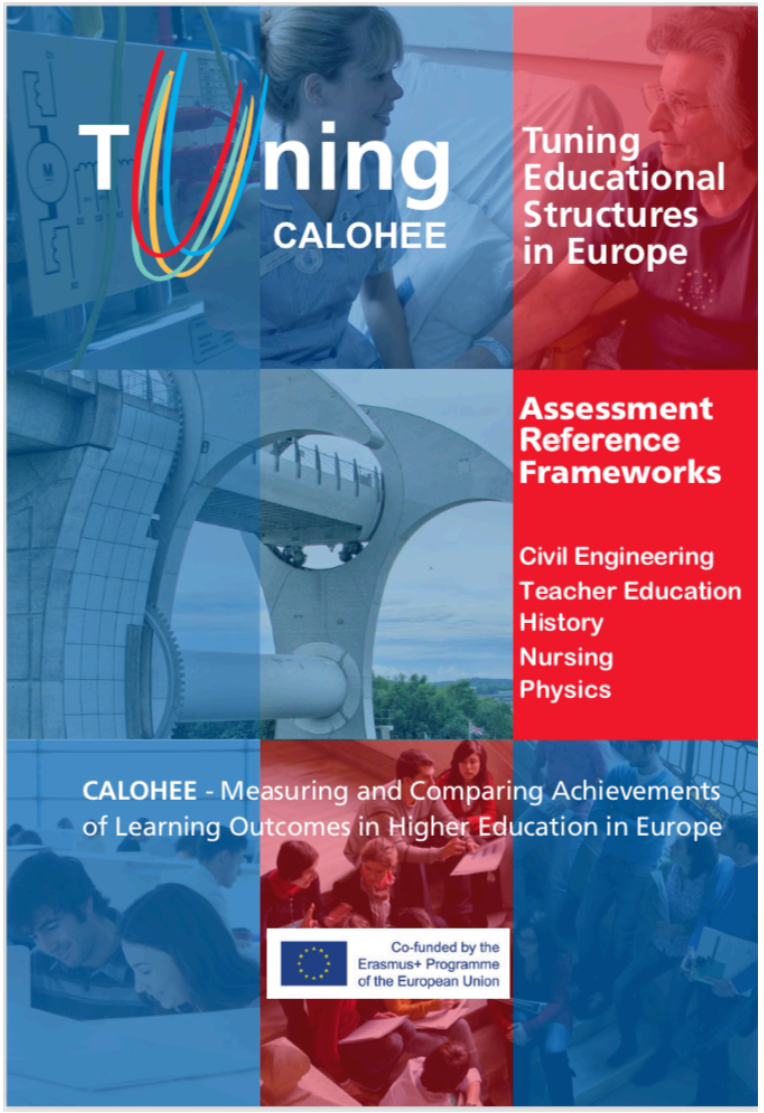
Subject Area Qualifications Reference Frameworks

- They describe the main feature of individual degree programmes of the first and second cycle (Bachelor and Master)
- They allow to take into account the diversity of missions, orientations and profiles of universities in Europe and their various degree programmes
- Making the distinction between knowledge, skills and autonomy and responsibility, they offer clear indicators for the alignment with the (potential) workplace and for active civic, social and cultural engagement

Assessment Reference Frameworks

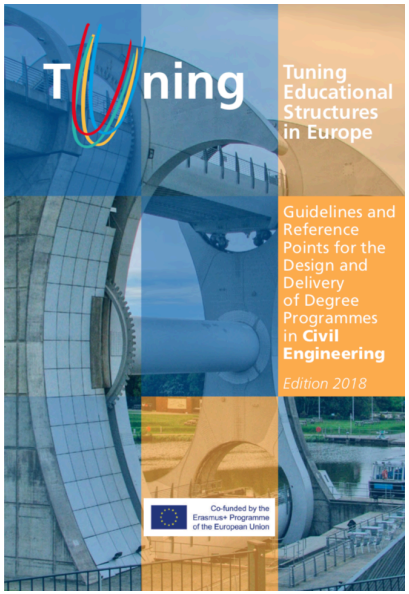
Overview of the outcomes of the project

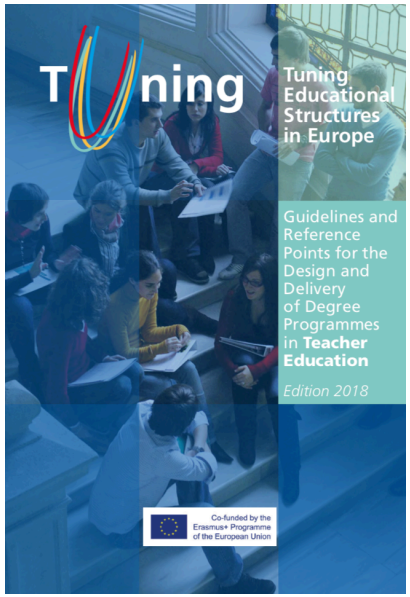
- explains the methodology
- presents the subject area descriptors in terms of measurable learning outcomes
- contains examples of good practice of learning, teaching and assessment methods and approaches to achieve the level of competence indicated

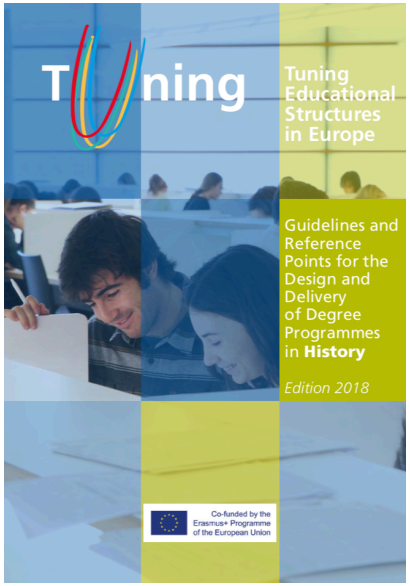


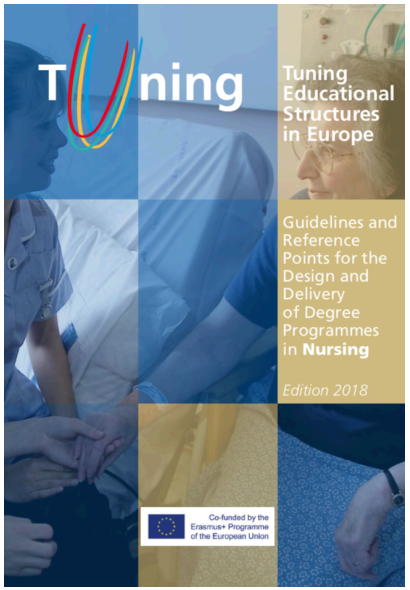
Guidelines and Reference Points Brochures

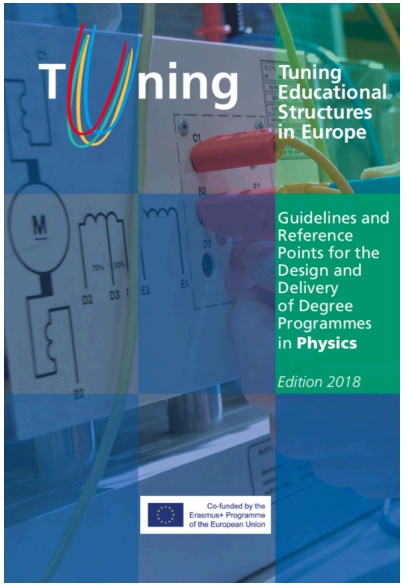
for each of the five pilot subjects





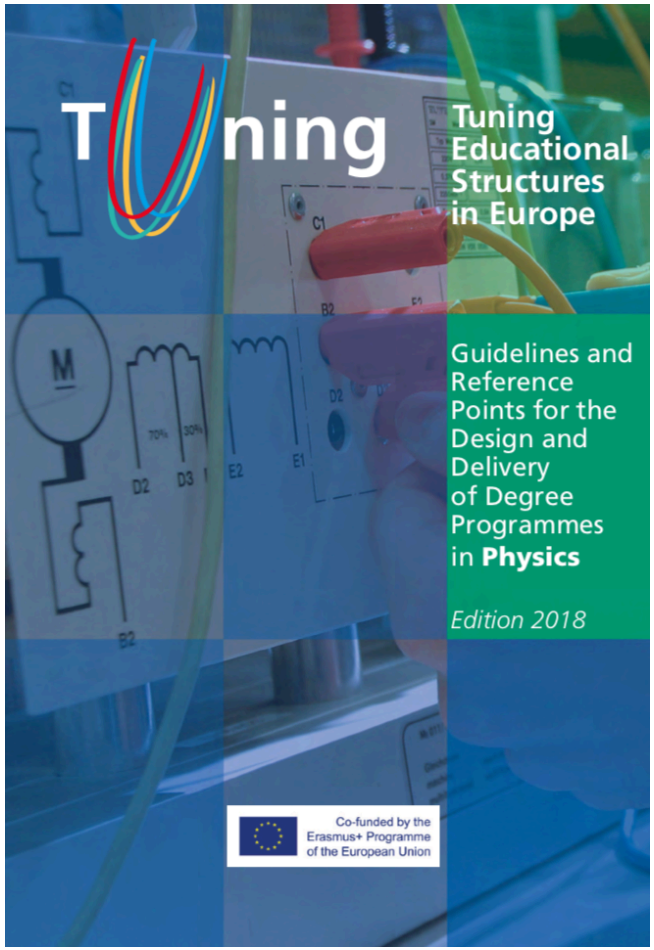






Guidelines and Reference Points Brochure

- Contains analysis of the subject area, of the typical degree programmes and of the profile of graduates
- Contains detailed level descriptors according of European qualification frameworks in terms of measurable learning outcomes
- Provides educators, administrators, students and quality assurance experts with tools for understanding how degree programmes can be most effectively organised, evaluated and improved



Methodology

Each Subject Area Group (SAG) has analysed the general descriptors of 5 subject areas in the context of a merger of the two main European qualification frameworks

- **QF-EHEA** Qualifications Framework for the European Higher Education Area
- **EQF-LLL** European Qualification Framework for LifeLong Learning

Qualification Framework for European Higher Education Area

- elaborated and adopted within the Bologna process of reform of the European High Education Area
- provides an overarching framework for curriculum design and assessment organized in three cycles: Bachelor, Master and Doctorate
- *Dublin Descriptors* for each cycle are organized in 5 dimensions

EUROPEAN Higher Education Area

European Commission

bologna process

European Commission/EACEA/Eurydice, 2018. The European Higher Education Area in 2018: Bologna Process Implementation Report. Luxembourg: Publications Office of the European Union.

QF - EHEA - Dublin Descriptors

QF-EHEA	2nd cycle - Master Level
I. Knowledge and understanding	Have demonstrated knowledge and understanding […] that provides a basis or opportunity for originality in developing and/or applying ideas, …
II. Applying knowledge and understanding	Can apply their knowledge and understanding, and problem solving abilities in new or unfamiliar environments […]
III. Making judgement	Have the ability […] to formulate judgements with incomplete or limited information, but that include reflecting on social and ethical responsibilities […].
IV. Communication skills	Can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and nonspecialist audiences […]
V. Learning skills	Have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous.

European Qualification Framework for LifeLong Learning

EU Council Recommendation of 23 April 2008 and 22 May 2017

- Developed in the EU context as an overarching qualifications framework for **vocational education and training for lifelong learning**
- Expanded to encompass general and higher education: levels 6, 7 correspond to 1st (Bachelor) and 2nd (Master) HE cycles
- Descriptors are structured in the three categories

new release:
Council Recommendation of
22 May 2017

EQF-LLL: level descriptors

EQF categories	Knowledge	Skills	Responsibility and autonomy
level 7 Master	Highly specialised knowledge , some of which is at the forefront of knowledge in a field of work or study, […]	Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge […].	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches. Take responsibility for contributing to professional knowledge and practice and/ or for reviewing the strategic performance of teams.

Multi-dimensional qualification framework obtained by merging QF-EHEA dimensions and EQF-LLL categories

QF-EHEA … cycle descriptors	EQF dimensions Level …	EQF category Knowledge	EQF category Skills	EQF category Responsibility and autonomy
I. Knowledge and Understanding	Subject-specific dimensions identified by each SAG			
II. Applying Knowledge and Understanding				
III. Making Judgement				
IV. Communication Skills				
V. Learning skills				

Methodology

Steps followed by the Physics SAG in the development of the AF for Physics:

- Analysis and discussion on the outcomes of the CALOHEE questionnaire on
  - typical physics degree programmes
  - typical occupation and task of physics graduated
- Analysis of previous works on benchmarks and learning outcomes for physics degrees (previous Tuning works, EPS specifications fo Bachelor and Master degrees, QAA for Higher Education, …)
- Identification of subject-specific and more general (civic, social and cultural) competences relevant in the context of physics
- Identification of the dimensions characterizing the physics subject in relation to the QF-EHEA dimensions
- Formulation of level descriptors according of the EQF-LLL categories (knowledge, skills, and responsibility and autonomy) in terms of measurable learning outcomes (suitable sub-dimensions were introduced at this stage for better describe learning outcomes)

Physics SAG - Results

Dimensions QF - EHEA	Dimensions of the CALOHEE Qualification Framework for Physics
I. Knowledge and Understanding	1.Theories and models 2.Mathematical methods
II. Applying Knowledge and Understanding	3.Experimental design and scientific inquiry 4.Problem solving
III. Making Judgement	5.Scientific culture 6.Work ethic and integrity
IV. Communication Skills	7.Communication 8. Project management and teamwork
V. Learning skills	9.Professional development

Physics SAG - Results

1.Theories and models	1.1 Theories and phenomena 1.2 Applications of theories and models
2.Mathematical methods	2.1 Mathematical tools 2.2 Computational tools
3.Experimental design and scientific inquiry	3.1 Experimental design and methodology 3.2 Instrumentation 3.3 Data analysis 3.4 Experiment documentation 3.5 Safety
4.Problem solving	4.1 Problem framing 4.2 Analytical thinking 4.3 Solution procedure and execution 4.4 Validation of results 4.5 Creative and innovative thinking

Physics SAG - Results

5.Scientific culture	5.1 History of physics 5.2 Epistemology 5.3 Sources of scientific information
6.Work ethic and integrity	6.1 Ethical rules in the profession 6.2 Awareness of professional actions impact 6.3 Governance and decision making
7.Communication	7.1. Information sources 7.2 Data representation 7.3 Means of communication 7.4 Technical English
8. Project management and teamwork	8.1 Project management tools 8.2 Teamwork 8.3 Organisations, societies and cultures
9.Professional development	9.1 Professional requirements 9.2 Personal capacities and attitudes

Physics SAG - Results

MASTER - Dimension 3: Experimental design and scientific investigation			
	Knowledge	***Skills***	***Responsibility and autonomy***
	Describe standard and advanced experimental methods, instrumentation, techniques, theories and regulations used in experimental physics.	**Design a complete physics experiment, using standard and advanced instrumentation safely and applying a wide range of methods, techniques and theories for data collection, analysis and reporting.**	**Set up and carry out scientific investigations independently and safely.**
3.1 Experimental design and methodology	Name and describe basic and advanced aspects of a scientific investigation as well as the physical quantities involved in a situation, and describe the inherent physical models or theories.	Formulate articulated hypotheses and devise an experimental plan to test them, also using modelling tools to design/model the experiment when necessary, and estimate the nature and order of magnitude of the results of an experiment.	Conduct investigations independently, identifying the relevant theoretical framework and the process(es) required to obtain consistent results.
3.2 Instrumentation	Name and describe standard and some examples of advanced instrumentation, its characteristics and specifications.	Set up different experimental arrangements, including some examples of non-standard/complex ones; identify the specifications of advanced instrumentation, use it and apply complex experimental procedures to gather data.	Identify, arrange and employ advanced instrumentation to carry out an investigation, also in some complex situations and evaluate the correctness and significance of the measurement process and of the obtained data.

Physics SAG - Results

MASTER - Dimension 3: Experimental design and scientific investigation			
	Knowledge	***Skills***	***Responsibility and autonomy***
3.3 Data analysis	Name and describe basic and advanced methods and techniques for the processing of experimental data.	Organise and analyse experimental data (including big data) using a variety of tools and techniques including basic and advanced software, identify sources of error and correctly apply them to the measurements, critically evaluate the reliability of experimental results and relate them to the initial hypotheses.	Process complex sets of experimental data, evaluate the reliability of the results, draw sensible conclusions and use them to reformulate the hypotheses if necessary.
3.4 Experiment documentation	Describe a wide range of methods for recording the details of an experimental activity, storing and representing data (tables, different kinds of graphs, words, equations).	Keep a record of the details and steps of an experiment, including the acquisition of data, also in complex experimental situations; use different representations to display data and results and write a complete and accurate laboratory report.	Identify the appropriate method(s) to report on an investigation, communicate the results and debate on its outcomes.
3.5 Safety regulation	Describe the safety issues, equipment, procedures, behaviour, persons-in-charge and regulations of a specialised physics/science laboratory.	Follow the safety regulations and procedures of a specialised physics/ science laboratory, including using specialised protection equipment.	Evaluate risk factors in an experimental environment, gather information about safety regulations in a working environment and operate accordingly, including the choice and use of appropriate protection equipment.

Physics SAG - Results

MASTER - Dimension 3: Experimental design and scientific investigation		
Knowledge	***Skills***	***Responsibility and autonomy***
Describe standard and advanced experimental methods, instrumentation, techniques, theories and regulations used in experimental physics.	**Design** a complete physics experiment, using standard and advanced instrumentation safely and **applying** a wide range of methods, techniques and theories for data collection, analysis and reporting.	**Set up** and **carry out** scientifi c investigations **independently** and **safely**.

MASTER - Dimension 3: Experimental design and scientific investigation			
	Knowledge	***Skills***	***Responsibility and autonomy***
3.1 Experimental design and methodology	**Name and describe** basic and advanced aspects of a scientifi c investigation as well as the physical quantities involved in a situation, and describe the inherent physical models or theories.	**Formulate** articulated hypotheses and **devise** an experimental plan to test them, also **using** modelling tools to design/model the experiment when necessary, and **estimate** the nature and order of magnitude of the results of an experiment.	**Conduct** investigations independently, **identifying** the relevant theoretical framework and the process(es) required to obtain consistent results.

MASTER - Dimension 3: Experimental design and scientific investigation			
	Knowledge	***Skills***	***Responsibility and autonomy***
3.2 Instrumentation	**Name** and **describe** standard and some examples of advanced instrumentation, its characteristics and specifications.	**Set up** different experimental arrangements, including some examples of non-standard/complex ones; identify the specifications of advanced instrumentation, **use** it and **apply** complex experimental procedures to gather data.	**Identify**, **arrange** and **employ** advanced instrumentation to carry out an investigation, also in some complex situations and **evaluate** the correctness and significance of the measurement process and of the obtained data.

Physics SAG - Results

BACHELOR - Dimension 8: Project Management and Teamwork			
	Knowledge	***Skills***	***Responsibility and autonomy***
EQF categories *general level descriptors*	**Describe** strategies for project work and demonstrate attitude to work collaboratively.	**Organize** and **complete** a simple project individually or in team.	**Identify and implement** an appropriate strategy to carry out a simple individual or group project, collaborate constructively, exercise some initiative and acknowledge accountability for the assigned tasks.

Physics SAG - Results

BACHELOR - Dimension 8: Project Management and Teamwork			
	Knowledge	***Skills***	***Responsibility and autonomy***
	Describe strategies for project work and acknowledge the characteristics of a collaborative work.	**Organize and complete a simple project individually or in team.**	**Identify and implement an appropriate strategy to carry out a simple individual or group project, collaborate constructively, exercise some initiative and acknowledge accountability for the assigned tasks.**
8.1 Project management tools	Recall some strategies for planning, organising, checking progress, and evaluating results of a project.	Use appropriate tools, set targets, and organise work to meet deadlines.	Take responsibility for contributing in a simple individual or group project.
8.2 Teamwork	Describe and characterise the different components of an effective teamwork.	Listen, share opinions and respectfully participate in conversation and/or discussion activities, and use (receive and give) feedback.	Identify own and others' competences and roles with respect to teamwork, contribute constructively and respectfully in a group, and take responsibility for own task(s).
8.3 Organisations, societies and cultures	Recognise the main differences in and between individuals, organisations, societies and cultures.	Analyse some relevant issues and/or potential conflicts in and between individuals, organisations, societies and (work) cultures.	Identify best practices and interventions in the case of tensions and conflicts.

Open questions

- Can we use the Framework for informing and checking the structure or development of physics degree curricula at the Bachelor or Master level?
- How do we identify the teaching, learning and assessment strategies most useful for favoring student achievements?

1st cycle - Bachelor 3.1 : Experimental design and methodology	
	Knowledge
	Name and describe the basic aspects of a scientific investigation as well as the physical quantities involved in a situation, and describe the inherent physical models or theories.
Teaching	Presentation of case studies and classroom demonstrations. Problem-solving recitations. Provide literature/historical readings. Prompt reflection on the links between theory and experiments, and between classroom demonstration and lab practice.
Learning	Observation of experiments and guided reflection with peers. Historical and literature readings. Describe physical situations using multiple representations.
Assessment	Require reference to relevant physical models in the lab report. Verify the correct reference to elements of the investigation (hypothesis, prediction, outcomes, etc.).

1st cycle - Bachelor 3.1 : Experimental design and methodology	
	Skills
	Formulate a simple prediction from an hypothesis and devise a plan to test it, and estimate the order of magnitude of the results of an experiment.
Teaching	Prepare handouts with scaffolding questions to help students identify the hypothesis, prediction and expected outcomes and devising a plan. Interact with groups by prompting reflection on key or critical aspects. Provide feedback.
Learning	Design a simple testing experiment for a known equation, working in small groups. Receive/give feedback.
Assessment	Short group report containing hypotheses, predictions, and plans. Group observation and interactions during the lab sessions. Self- and peer-assessment opportunities.

TLA - Teaching, Learning and Assessment

1st cycle - Bachelor 3.1 : Experimental design and methodology	
	Responsibility and autonomy
	Conduct simple investigations under supervision, identifying the relevant theoretical framework and the process required to obtain consistent results.
Teaching	Prepare handouts with scaffolding questions/hints to help students design the experiment Provide students with relevant references (software, study material). Set up an online learning environment to promote peer/instructor discussion.
Learning	Conduct simple application experiments where students are given some responsibility about the choice of variables. Guided meta-cognitive reflection (purpose of the experiment, criteria for judging the agreement between prediction and outcomes).
Assessment	Group report complemented by individual reflection describing and justifying hypotheses, predictions, expected outcomes, choices, and reference to theoretical frameworks.

Conclusions

- Frameworks could be used for developing physics degree programmes at the Bachelor or Master level
- Higher Education Institutions could revise their present programmes in order to align them with internationally developed reference points
- Quality Assurance Bodies will have access to reliable internationally agreed frameworks to assess the quality and relevance of individual degree programmes
- Faculty could be inspired by the frameworks for promoting good practices of teaching, learning and assessment methods

Phase 2

CalohE2 "Measuring and Comparing Achievements of Learning Outcomes in Higher Education in Europe - Phase 2":

- Development of an assessment instrument based on agreed dimensions and parameters.

CalohE2 Consortium consists of 42 partners and 6 associate partners;

- **32 universities** in Europe (Austria, Belgium, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Lithuania, Malta, Netherlands, Poland, Portugal, Slovenia, Spain, Sweden, Turkey)
- **16 organisations/associations** (university networks, quality assurance organisations, professional organisations and student organisations)
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CALOHEX

- Extension of CALOHEE to other subject areas: Business Administration, Information Engineering/ICG; International Relations; Medicine; Performing and Fine Arts.

THANK YOU