The Physics of Everyday Life (classical and quantum)

[I semester 6 CFU]

Marilù Chiofalo
Department of Physics «Enrico Fermi»

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29 SETTEMBRE 2023

BRIGHT NIGHT

Notte europea
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e dei ricercatori

PIAZZE DELLA RICERCA
e PASSEGGIATE DELLA
SCIENZA

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Antonio Romano

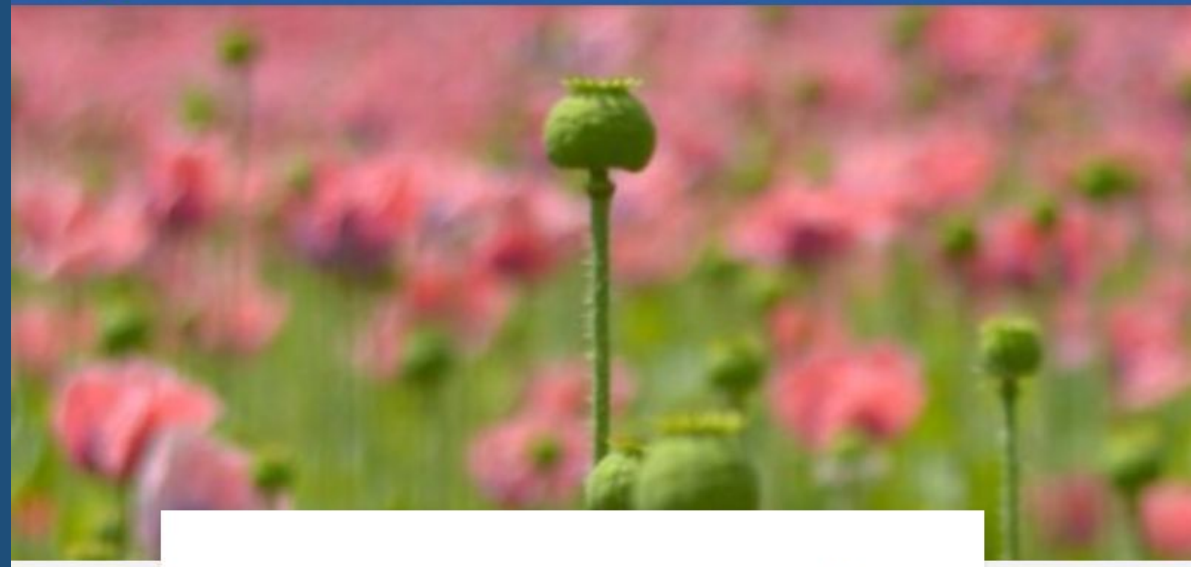
Edoardo Leandri

Gabriele Cidonelli

Maria Sonetto

Mirko Del Cimmuto

Valeria Cangialosi



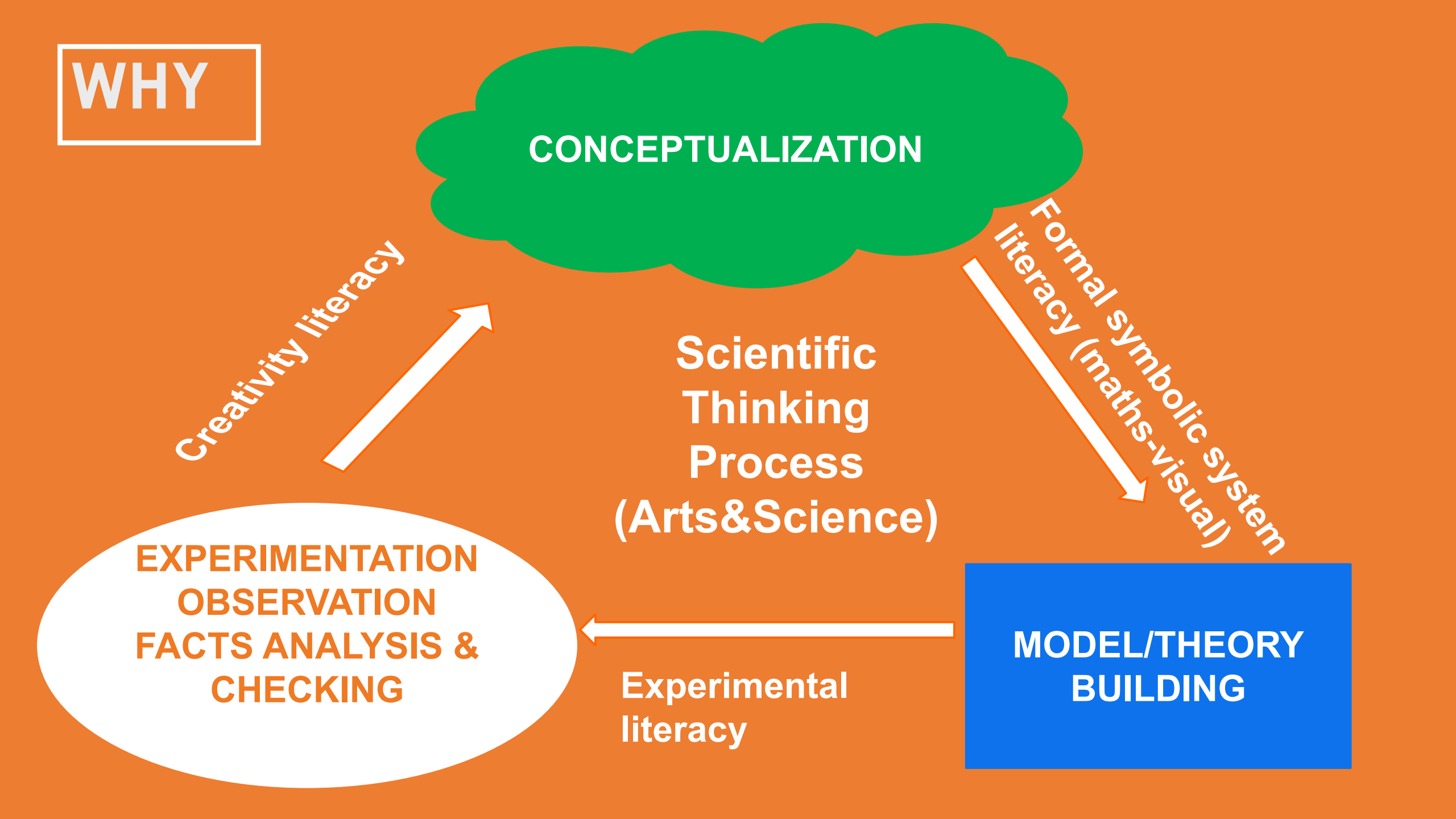
Prosperity – Piazza della Ricerca

Data: 27/09/2024
Ora: 16:30
Luogo: Pisa
Indirizzo: Piazza dei Cavalieri, Pisa

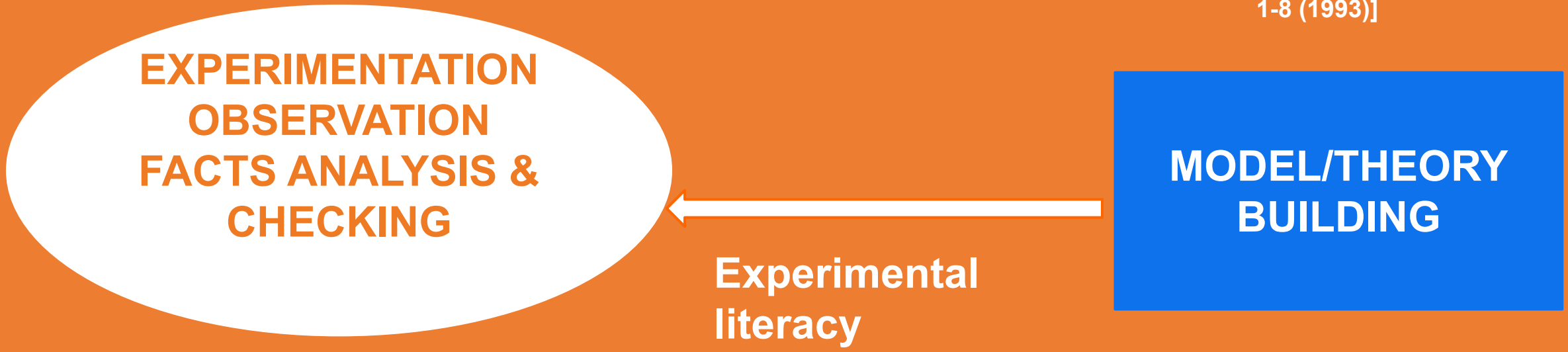
Nella Piazza saranno presentati studi e ricerche su tecnologie, su modelli economici e sull'importanza della formazione per una crescita sostenibile della società.

Laboratori

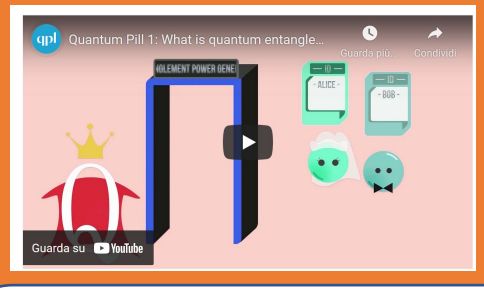
- Robotica e bioingegneria per una crescita equa e sostenibile – Centro di Ricerca "Enrico Piaggio", Università di Pisa
- Flash, una nuova tecnologia al servizio della salute – CISUP – Centro per l'Integrazione della Strumentazione dell'Università di Pisa
- Street Physics – Dipartimento di Fisica, Università di Pisa
- Matematica in gioco – Dipartimento di Matematica, Università di Pisa
- Fisica e Intelligenza Artificiale per la Salute e il Benessere – Istituto Nazionale di Fisica Nucleare e Dipartimento di Fisica dell'Università di Pisa
- Càndidati – Scuola Superiore Sant'Anna e Dipartimento di Informatica dell'Università di Pisa


WHY
CONCEPTUALIZATION
Creativity literacy
Formal symbolic system literacy (maths-visual)
Scientific Thinking Process (Arts&Science)
EXPERIMENTATION OBSERVATION FACTS ANALYSIS & CHECKING
Experimental literacy
MODEL/THEORY BUILDING

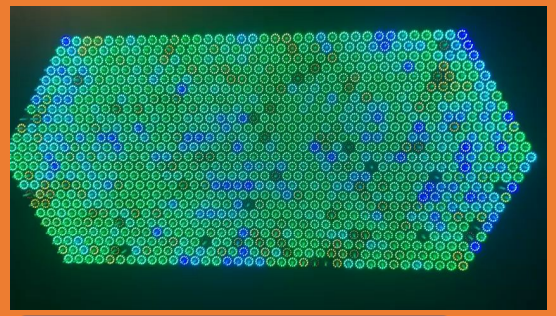
- [Wieman, C. and Perkins, K.: Transforming Physics Education. Physics Today 58, 36{41 (2005)]
- [Dorrìo, B.V., Blanco-Garca, J., Costa, M.F.M.: Hands-on Physics] Experiments for Classroom. Selected Papers on Hands-on Science II
- [Flick, L.: The Meanings of Hands-On Science. Journal of Science Teacher Education 4(1) 1-8 (1993)]



QUANTUM PHYSICS: CHALLENGE IN THE CHALLENGE!



Creative and immersive experiences
- Animations (e.g. Quantum pills)
- Art-science installations (e.g. Quantum Jungle)



Experimental toolbox:
- Virtual experimental (and conceptual) labs
- Quantum games
- Quantum algo labs
- Tangible analog objects

CONCEPTUALIZATION

Forms of Creative literacy

Forms of Symbolic/ Formal literacy (maths-visual---)

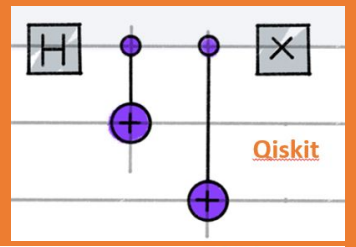
Disciplinary (scientific) thinking

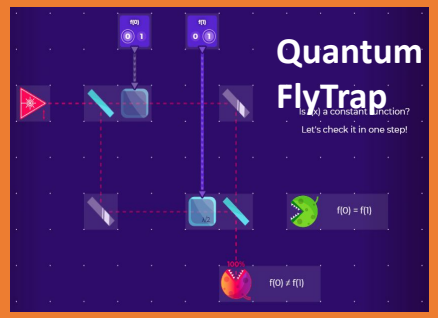
EXPERIMENT FACTS ANALYSIS & CHECKING

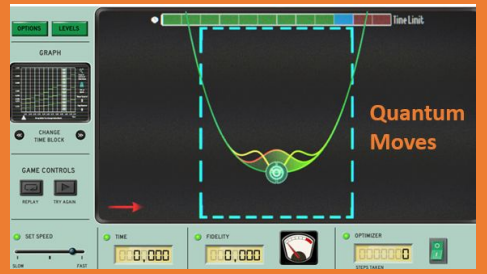
Forms of Experimental literacy

THEORY BUILDING

Math-visual toolbox:
- Virtual conceptual labs
- Quantum games
- Quantum algo labs







M. Chiofalo, C. Foti, C. Lazzeroni, S. Maniscalco, Z. Seskir, J. Sherson, C. A. Weidner, M. Michelini, Quantum Games, for Physics Education, Springer Proceedings of the World Congress on Physics Education (2021)

Z. Seskir et al. from QUTE4E, Mchiofalo, Quantum Games and Interactive Tools for Quantum Technologies Outreach and Education: Experiences from the Field, Optical Engineering (2022)

IDEA

Choosing objects/phenomena:

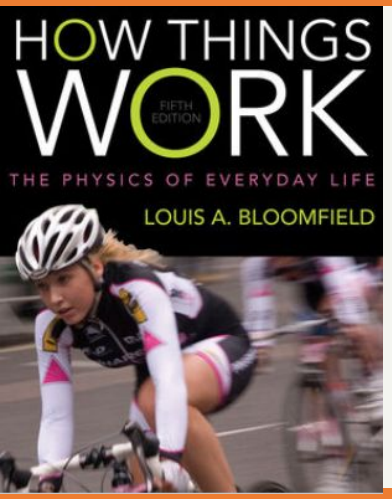
Sci agenda first, then objects

Caveats:

- **Given objects are best suited or more interesting**
- **Each object involves one central physics concept and *potentially many secondary* ones**

HIERARCHY WITH 3 LEVELS

- **L1: AREAS OF SCIENCE [FOR TEACHER]**
- **L2: EVERYDAY-LIFE OBJECTS [FOR STUDENTS]**
- ***L3: CONCEPTS OF PHYSICS [FOR BOTH]***



Chapter 9. Resonance and Mechanical Waves

Experiment: A Singing Wineglass 263

9.1 Clocks 265
(time and space, natural resonance, harmonic oscillators, simple harmonic motion, frequency)

9.2 Musical Instruments 274
(sound, music, vibrations in strings, air, and surfaces, higher-order modes, harmonic and nc harmonic overtones, sympathetic vibration, standing and traveling waves, transverse and longitudinal waves, velocity, frequency, and wavelength in mechanical waves, superposition, Doppler effect)

9.3 The Sea 286
(tidal forces, surface waves, dispersion, refraction, reflection, and interference in mechanical waves)

WHAT

How Things Work Table of Contents (Part 1)

How Things Work Table of Contents (Part 2)

Lou Bloomfield

University of Virginia

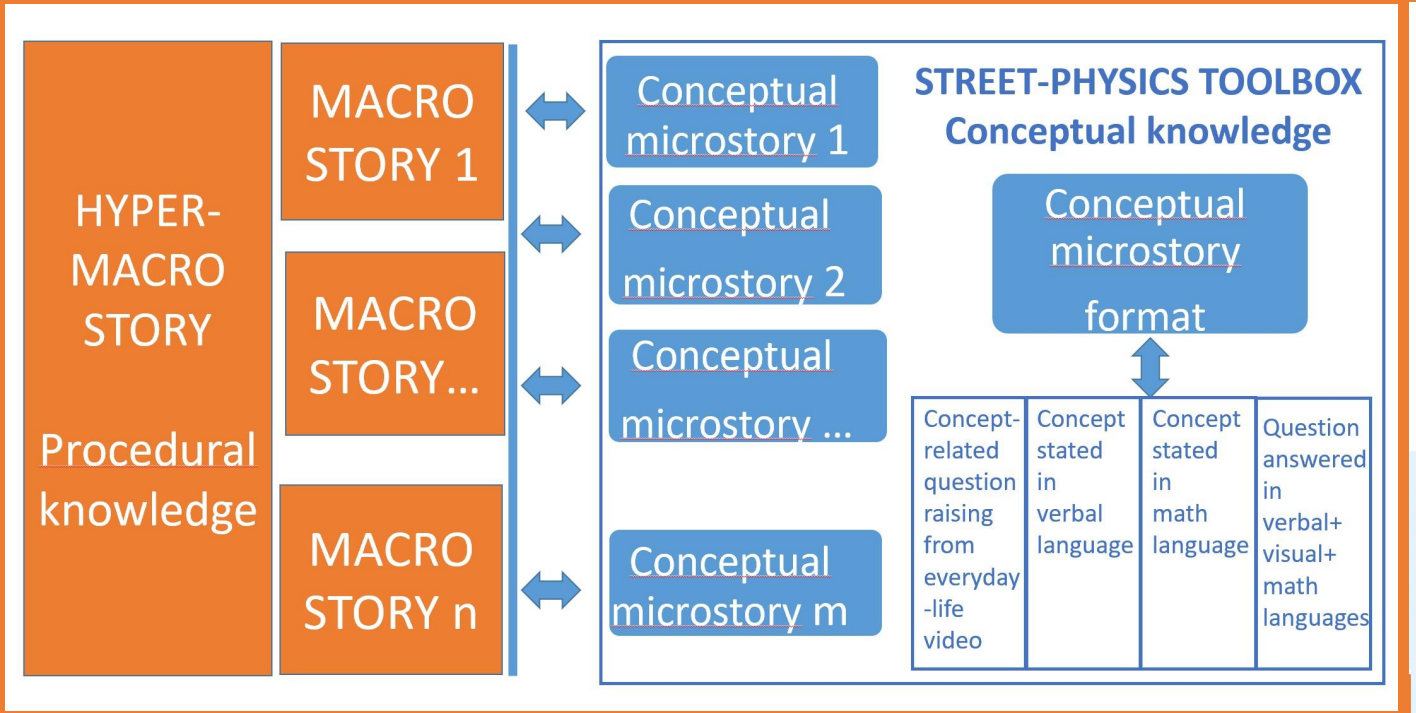
+ PHYSICS OF COOKING

+ PHYSICS OF HARRY POTTER

+ STUDENTS ASSESSMENT PROJECTS FROM PREVIOUS YEARS

- **TOPICS SELECTED WITH CLASS BASED ON NEEDS**

Physics of everyday life (PEL) + Street Physics Toolbox (SPT)



La fisica di tutti i giorni - Youtube Channel

CLASSICAL PHYSICS

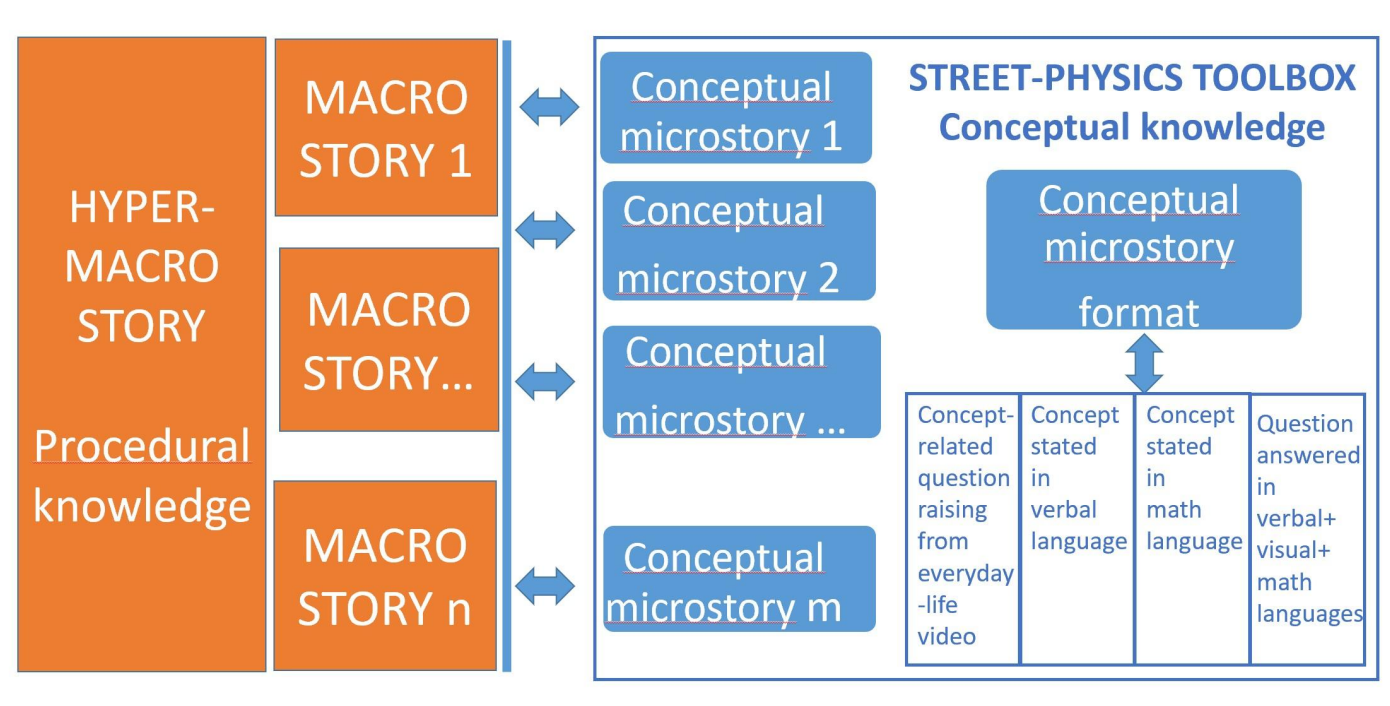
- **microstories on single concepts**

5’ videopills (IT-EN-FR) on 60 single concepts from Galileo to Maxwell: like position, velocity, acceleration, force,…

- **MACROSTORIES: sports physics, weather, aeroplanes, microwave ovens, medical imaging,…**

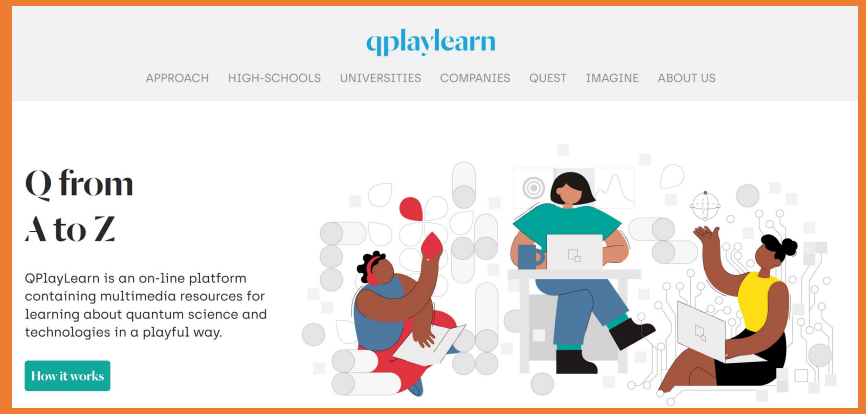
HOW

Physics of everyday life (PEL) + Street Physics Toolbox (SPT)



QUANTUM PHYSICS

- **microstories:** quantum state, superposition, measurement, spin, entanglement, Heisenberg principle, …
- **MACROSTORIES:** qubits, quantum computers, teleportation, quantum technologies,…



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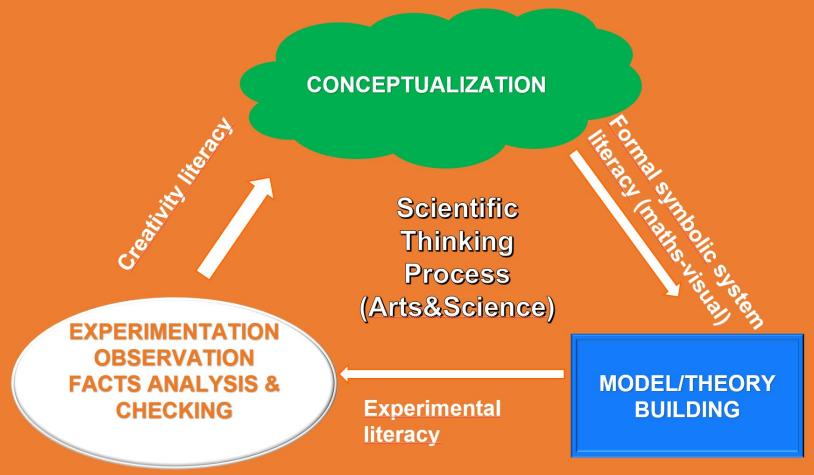

HOW

Horizons

ENGAGEMENT & HAVE FUN [STUDENTS & TEACHERS]

CREATE MATERIAL FOR NEXT YEAR FROM STUDENTS PROJECTS: SUSTAINABILITY

- Learn how things work in Science & Technology

Learn tools & guidelines for:
- teaching
- outreaching

physics in any environment

- Focus on basic concepts & basic operations of exp method
- Learn how to apply them
- Learn how to combine them for more complex problems
- Develop intuition & creativity
- Practice & reinforce physics thinking

Assessment

DESIGN A LEARNING PATH IN HOW-THINGS-WORK STYLE:
- **WITH OBJECTS NOT DISCUSSED IN THE COURSE**
- **USING CONCEPTS AND TOOLS LEARNED IN THE COURSE**

Assessment is competences-based

- ❑ Up to 24 points for conceptual and factual knowledge of specific physical mechanisms
- ❑ Up to 6 points for cross-competences, e.g.:
  - *scientific thinking and method*
  - *autonomy*
  - *team working*
  - *communication*
  - *degree of awarness of conceptual maps and tools*

Fisica, l'arte del pensiero scientifico.
imparadigitale.nova100.ilsole24ore.com/2021/08/31/fis... @PhysicsUnipi @Unipisa @Unipisa

Fisica, l'arte del pensiero scientifico
Contributo di Marilù Chiofalo Professoressa di Fisica della materia al Dipartimento di Fisica dell'Università di Pisa, componente dell'Associazione ...
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↳ HELMeTO 2021: **Higher Education Learning Methodologies and Technologies Online** pp 100–114

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The Physics of Everyday Life Toolbox for Basic Physics Courses

Marilú Chiofalo

Conference paper | First Online: 06 March 2022

330 Accesses | 1 Citations

Part of the Communications in Computer and Information Science boo

!!!!
This is a
Research-based
Teaching/learning
Course/environment

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1 July 2022

Quantum games and interactive tools for quantum technologies outreach and education

Zeki C. Seskir, Piotr Migdał, Carrie Weidner, Aditya Anupam, Nicky Case, Noah Davis, Chiara Decaroli, İlke Ercan, Caterina Foti, Paweł Gora, Klementyna Jankiewicz, Brian R. La Cour, Jorge Yago Malo, Sabrina Maniscalco, Azad Naeemi, Laurentiu Nita, Nassim Parvin, Fabio Scafirimuto, Jacob F. Sherson, Elif Surer, James R. Wootton, Lia Yeh, Olga Zabello, Marilù Chiofalo

Author Affiliations +

Optical Engineering, 61(8), 081809 (2022). https://doi.org/10.1117/1.OE.61.8.081809

Open Access | Article

Quantum Physics Literacy Aimed at K12 and the General Public †

by Caterina Foti [1,2,*], Daria Anttila [3], Sabrina Maniscalco [1,2,4] and Maria Luisa Chiofalo [5,*]

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5 Dipartimento di Fisica Enrico Fermi, Università di Pisa and INFN, Largo B. Pontecorvo 3, I-56127 Pisa, Italy
* Authors to whom correspondence should be addressed.

education sciences | MDPI

Article

Games for Teaching/Learning Quantum Mechanics: A Pilot Study with High-School Students

Maria Luisa Chiofalo [1,*], Caterina Foti [2], Marisa Michelini [3], Lorenzo Santi [3] and Alberto Stefanel [3,*]

education sciences | MDPI

Article

Culturo-Scientific Storytelling

Simon Goorney [1,*], Caterina Foti [2], Lorenzo Santi [3], Jacob Sherson [1], Jorge Yago Malo [4] and Maria Luisa Chiofalo [4,*]

qplaylearn

Demos creation and realizations:
Massimiliano Labardi, *IPCF-CNR and Dept. Physics UNIPI*
Giorgio Ciocca, MD student @UNIPI

SPT realization with UNIPI MediaEventi
Chiara Cini, *50 Canale*
Ian Carlos Trujillo Duran, *BSC Physics Student*

Enlightening discussions:
Dianora Bardi, *Association ImparaDigitale*
Marisa Michelini, University of Udine & President of GIREP
Simon Goorney & Jacob Sherson, Aarhus U.
Jorge Yago Malo, University of Pisa
HTW STUDENTS OVER almost 20 YE

Present and future perspective implementations
Lou Bloomeld, *University of Virginia*
Laura Gentini: *University of Pisa*
Treccani Futura: *Cristina Pozzi & Thomas Ducato*
Zanichelli Editor: *Giuseppe Ferrari, Giulia Laffi, Elena Bacchilega, Valentina Gabusi*

BACKUP SLIDES

SYLLABUS +
MICRO, MACRO, HYPERMACRO STORIES

Scientific agenda	SPT concepts	Macrostories	Hyper-Macrostories
Dynamics			
Force laws of motion	*Point-like bodies*:	Skateboards	Sports physics (4):
	Vectors		• soccer
	Position		• volleyball
	Velocity		• tennis
	Acceleration		• basket
	Inertial mass		
	Force		
	3 Dynamics laws (3 pills)		
	Initial conditions	Falling balls	
	Constraints	Ramps	
	Gravitational force		
	Elastic force	Spring scales	
	Static friction	Wheels	
	Dynamic friction	&bykes	
	Rigid bodies:	Seesaws	
	Angular position	Carousels	
	Angular velocity		
	Angular acceleration		
	Rotational mass		
	Center of mass		
	Torque		
	3 Dynamics laws		
	Fluids:		
	Pressure	Balloons	
	Archimede's&Bouyant force	Diving	
Momentum& Energy conservation	*Point-like bodies*:	Bouncing balls	
	Momentum		
	Momentum conservation		
	Impulse		
	Impulse theorem		
	Anelastic collisions		
	Elastic collisions		
	Work&Energy	Ramps	
	Kinetic energy		
	Potential energies		
	Thermal energy		
	Energy conservation		
	Power		
	Rigid bodies:	Bumper cars	
	Angular momentum		
	Angular impulse and collisions		
	Rotational kinetic energy		
	Fluids:		
	Matter conservation in flow	Water distribution	
	Energy conservation (Bernoulli)	Water gardening	
	Lift forces	Airplanes&airfoils	
	Viscous and pressure-drag forces	Vacuum cleaners	

Scientific agenda	SPT concepts	Macrostories	Hyper-Macrostories
Resonance&waves			Musical
Natural resonance	Forced damped h.o.	Clocks	instruments (2)
Generalities on waves	Freq., wavelength, speed	Sea&surf	
	Stationary waves		
Thermodynamics			
Dictionary	Temperature&Eq. of state	Heaters	Atmospheric weather (2)
	T-forces: thermal expansion		
	Internal energy		
	Thermo work		
	Heat		
Heat transport	Conduction	Thermos	
	Convection	Clothes	
	Radiation	Lamps	
Thermo laws	0, 1, 2 (3 pills)	Air conditioners&engines	

Electromagnetism			
Sources	*Electricity*		Medical imaging (2)
	Charges	Xerocopiers	
	Polarization		
	Induction		
	Magnetism	Household magnets	
	Charges in motion and spins		
Fields& forces	*Electricity*		
	Coulomb& Gauss	Static electricity	
	Magnetism	Household magnets	
	Biot-Savart& Ampère	Magnetic tapes	
	Lorentz force		
Energy	Electrostatic energy	Static electricity	
EM waves	Faraday and Maxwell laws	Microwave oven	
		Radio and TV	
		Cellphones	
		Levitating trains	
		Gen.&dist. electric power	
Light&optics		Sunlight. Paints	
		Analogic&digital cameras	
		Micro-&tele-scopes	
Quantum Physics (*)	Quantum state	Resources	Teleportation (2)
	Quantum measurement	from Quest	
	Superposition	&Discover	
	Entanglement	section at	
	Wavelike behavior	qplaylearn.com	
	Spin		
	Heisenberg principle		
	Tunnelling		