MPTL

Multimedia in Physics
Teaching and Learning

Training Teachers on New Topics and New Tools in Physics Education

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Outline

Context and motivations

The project

Tools and topics

Details on some activities

Conclusions and perspectives

Context and motivations

Old problems:

- bridging the gap between research and education
- avoiding the “one man show” and let any teacher be able to use innovation
- curriculum updates

New scenarios:

- The 2030 Agenda for Sustainable Development
- The European Digital Education Action Plan
  - Action 6: Ethical guidelines on the use of AI and data in teaching and learning for educators
  - Action 8: Updating the European Digital Competence Framework to include AI and data-related skills (DigComp 2.2)

Context and motivations

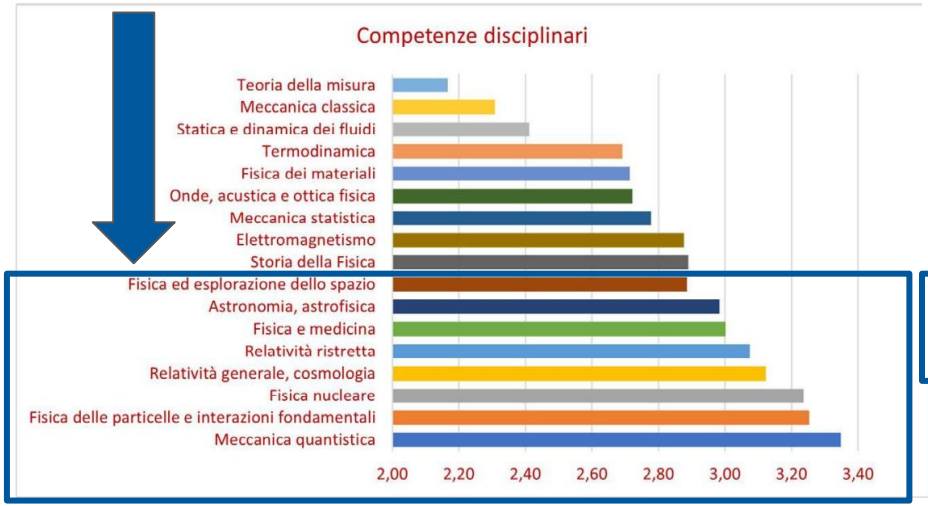
The **National Recovery and Resilience Plan/Next Generation** EU programme

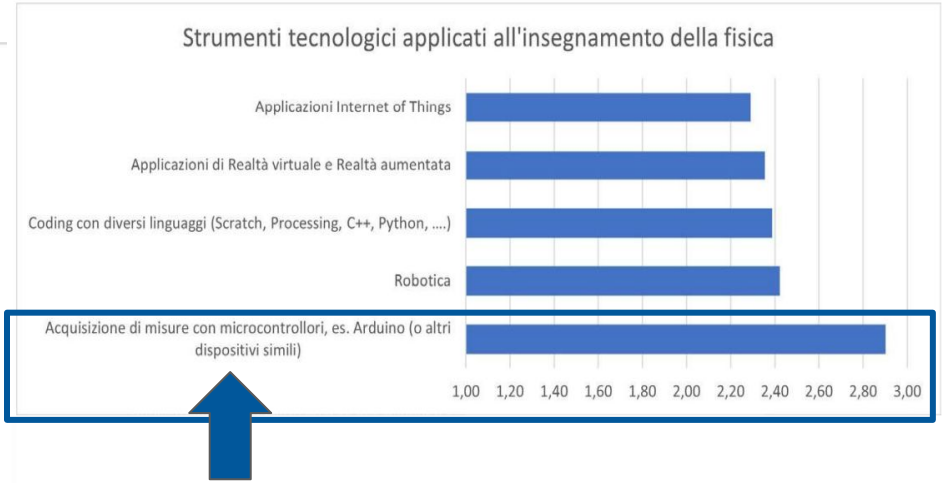
- Reform of the teacher recruitment system and in-service training
- STEM skills and multilingualism for teachers and students
  - The intervention consists of the integration into curricular disciplines of activities, methodologies and contents related to **developing and strengthening STEM skills and digitalisation and innovation, at all levels of education**, from childhood and primary to secondary school, with a view to **full interdisciplinarity, with particular attention to equal opportunities and gender equality in the methodological approach and orientation to STEM subjects**.
- School 4.0. Innovative schools, wiring, new classrooms and laboratories
  - The intervention aims to promote the strengthening of the digitalisation of schools, also in order to reduce the territorial gaps and to promote access to the technologies of all educational institutions, the **creation of innovative learning environments**, the digital transformation of the school organisation, including actions for the internal wiring of schools in order to improve connectivity, **the provision in classrooms of innovative and advanced tools for digital teaching**, the activation in high schools of workshops on the new professions connected to the **artificial intelligence, robotics and digitalisation**, also fostering collaborations between public and private sectors.

Context and motivations

Results from a recent survey on teacher's needs
made by an association of teachers (AIF) (915 answers):

Modern Physics TOPICS





Data acquisition TOOLS

The project: a synergy among different players

- **Physics Department of Turin University**
  - public engagement
  - planning a course for the master's degree and
  - planning a short course to Ph.D. students in Physics.
- **Regional Education Office (USR)**
  - supporting organizational flexibility, teaching, educational research and collecting the local needs so as to create training opportunities
  - diffusion/organization of courses and resources
- **Territorial Training Équipe (EFT) of Piedmont**
  - promoting the experimentation of innovative teaching methodologies
  - supporting of new learning spaces/organizational models
  - planning and implementation of training courses
- **Association of Physics Teachers (AIF)**
  - organization of schools, conferences, seminars
  - announcing competitions, both for teachers and students

The project: training activities for teachers

The project structure:

- focus on secondary school teachers
- five meetings on site/online (2 hours each):

    1. updates from scientific and educational researchers
    2. tools and suggestions from expert teachers
    3. teaching-learning activities with students in the classrooms (optional)

- teachers were asked to carry their own laptop
- seminars had been carried out in presence in Turin, and broadcasted in streaming
- 2 meetings @ Physics Department, 3 meeting @ Plana Secondary School

Tools and topics

The seminars from University teachers and researchers:

1. Physical Computing, STEM and educational robotics (D. Grosso, Genoa U.)
2. Meteo-Climate Data acquisition and analysis (E. Palazzi, Turin U.)
3. Data from space missions: Rosetta @ 67P and NASA DART (C. Tubiana, INAF-IAPS)
4. Data from space missions: Fermi LAT and AI (R. Bonino, Turin U.)
5. RelActivity: an interactive path to teach Relativity (M. L. Ruggiero, Turin U.)

Tools and topics

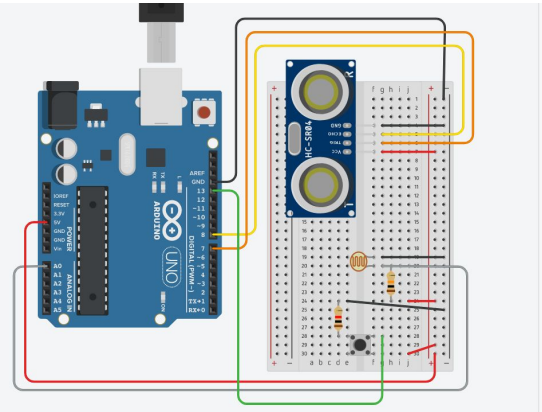
The laboratories from expert teachers and graduate students:

1. **microcontroller development board** (T. Marino, S. Falabino, S. Coscia, G. Saglietto)
2. spreadsheet and notebooks for data analysis (A. Piccione, A. A. Massa)
3. virtual assistant simulators (T. Marino)
4. **AI tools to classify images** (A. Piccione)
5. **GPS and General Relativity** (G. Lombardo)

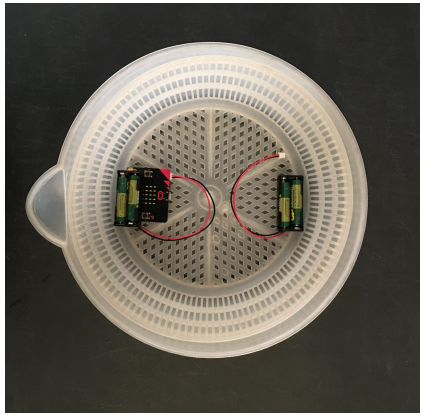
Microcontroller development boards

Educational applications for Physical Computing:

- online resources to start with virtual implementations
- hands on real boards

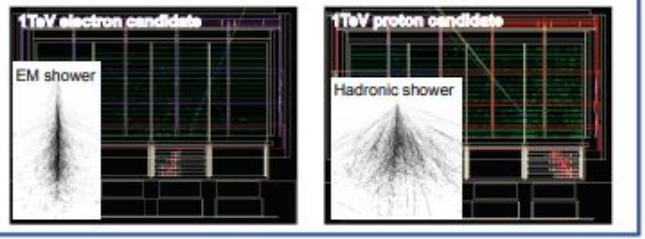


```
const int InPin=13;
const int triggerPort = 7;
const int echoPort = 8;
const float conv=5./1.023;
int i=1;

void TriggerSignal (int period){
  //porta bassa l'uscita del trigger
  digitalWrite( triggerPort, LOW );
  //invia un impulso di 10microsec su trigger
  digitalWrite( triggerPort, HIGH );
  delayMicroseconds( period );
  digitalWrite( triggerPort, LOW );
}
void setup() {
  Serial.begin(9600);
  pinMode(InPin,OUTPUT);
  pinMode( triggerPort, OUTPUT );
  pinMode( echoPort, INPUT );
  Serial.println( "Misuriamo l'intensità luminosa in funzione de
  Serial.println( "Distanza misurata in centimetri voltaggio in
}
void loop() {
  if(digitalRead(InPin)==HIGH){

    TriggerSignal(10);
    float v =(5000-(analogRead(A0)*conv)); //leggiamo il voltagg
    double duration = pulseIn( echoPort, HIGH );
    double r = (0.034 * duration / 2); //convertiamo il segnale

    if( duration > 38000 ) {  //se la durata dall'invio del segn
      Serial.println( "fuori portata");
      }
    //stampa della distanza e il voltaggio
    else {
      Serial.print(i);
      Serial.println(") ");
      Serial.print( "r= " );
      Serial.print(r);
      Serial.print(" , ");
      Serial.print( "V= " );
      Serial.println(v);
      i++;
      }
  delay(500); //evita di stampare numerose misure di seguito una
  }
}
```



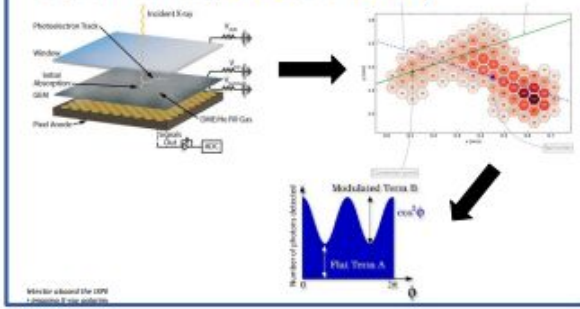
Data from space missions: research applications of AI

Event selection (e.g. CR electrons Vs protons)

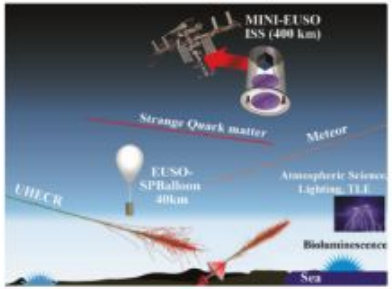


Detection and tracking of **space debris**

Track reconstruction in X-ray polarimetry experiments (**IXPE** and **eXTP**)



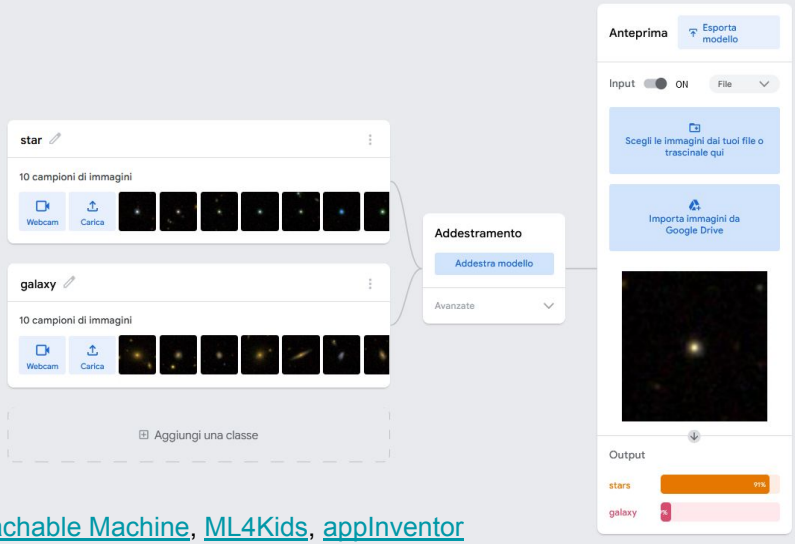
Imaging of atmospheric phenomena, meteors, bio-luminescence, strange quark matter



Data from space missions: teaching tools with AI

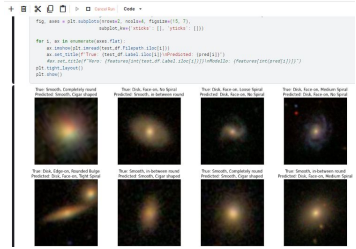
Different kinds of tools for any level

SDSS17 dataset

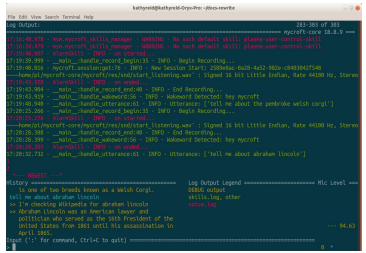


Teachable Machine, ML4Kids, appInventor

Galaxy10 SDSS dataset



Python notebooks



Mycroft AI with Picroft

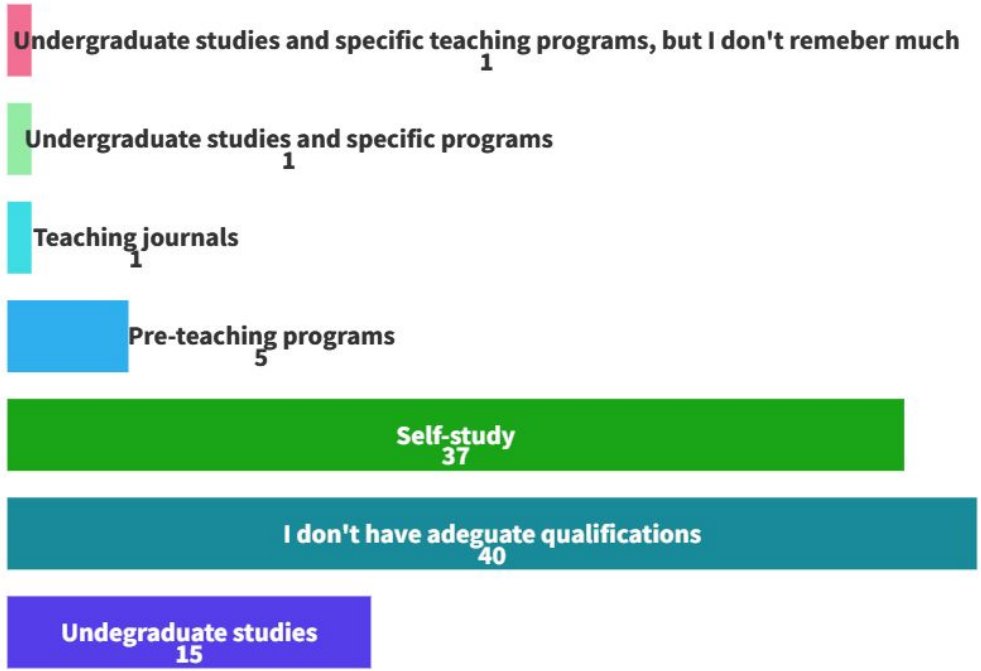
Context and motivations

Question:

I think I have achieved adequate qualifications to introduce the General Theory of Relativity during ...

Results from a survey in a thesis (about 100 answers, % data).

Answers:



[G. Scalzo Graduation Thesis, 2023]

Relativity: a teaching tool

A web based platform:

- inspired by the classical textbook by Einstein-Infeld
- a step by step interactive path which starts from Galileo and Newton and ends with the basic ideas of General Relativity

https://sites.google.com/view/evoluzionedellafisica23/

General Relativity: GPS as a laboratory

Teachers are asked to evaluate the impact of the relativistic corrections on the GPS accuracy, by using online maps

Relativistic effects on time measurements

Effetti relativistici sugli orologi

Dilatazione dei tempi

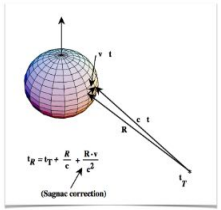
Per un orologio in moto il tempo scorre più lentamente che per un orologio identico in quiete. GPS: Se la velocità del satellite è di 3,874 km/s, l'orologio in orbita va più lento di 7.100 ns al giorno (nota: 1 ns=30cm)

Redshift

Effetto del campo gravitazionale: se l'altezza dell'orbita è di 20183 km, l'orologio in orbita va più veloce di 45.700 ns al giorno circa 15 centimetri al secondo!!

Sagnac

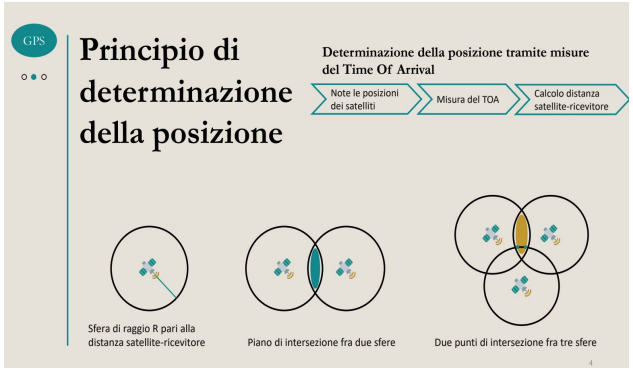
Effetto della rotazione terrestre (effetto Sagnac): 200 ns



Effetto netto relativistico: l'orologio in orbita è più veloce di quello a Terra di 38600 ns al giorno che corrispondono a 11,58 Km.

Trascurando gli effetti relativistici il GPS "non funzionerebbe" !!!

The principle to determine the position



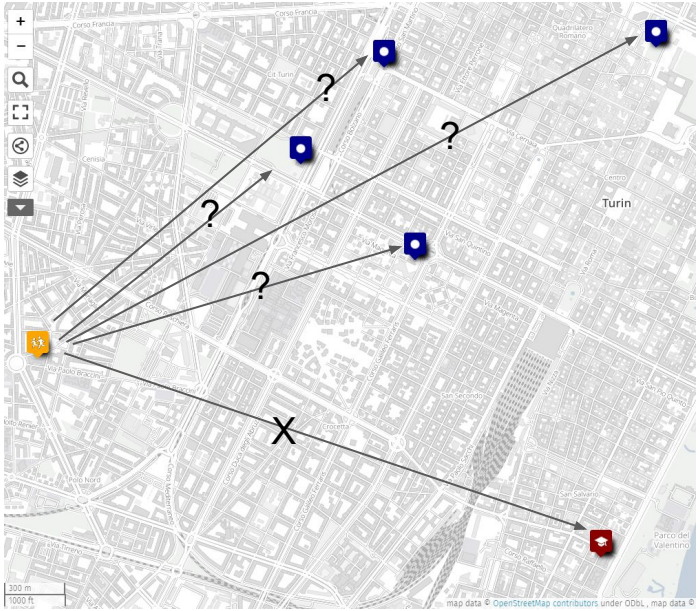
General Relativity: GPS as a laboratory

Let us imagine that, suddenly, the fundamental constants of Nature change. Since we have power and imagination, let's make c infinite.

In this way all the relativistic effects that we have come to know would cancel out. But are we sure that everything would go smoothly? How would GPS work?

Suppose that it no longer takes into account the time dilation effect. We start from **this school**, and we want to go to the **Physics Department**. But your GPS, gone crazy, takes you elsewhere... In which of **the places** is it possible that you are?

What if it no longer takes into account only the gravitational redshift effect? By how many metres, or kilometers, do you risk missing the point of arrival?



Conclusions and perspectives

About 100 registered teachers, on average 30 teachers per meeting

Contacts and relationships among teachers from different schools

Sharing knowledge about specific technologies and software, and experiences on different projects.

The activities can be applied in different contexts:

- civic education courses
- dual training (learning and working)

Conclusions and perspectives

The collaboration worked!

First steps towards new courses for novice teachers training

Suggested topics and tools

Extra - Data from space missions: classroom activity

The context:

- Humanities high school, limited curriculum in Physics
- 12th grade class, 16 students with no coding experience
- 2 hours deepening activity

The structure of the lesson

- Brief introduction on AI [30']
- Classification of Stars vs. Galaxies [30']
- Classification of different kinds of Galaxies [30']
- Discussion and applications [30']