UNIVERSITÀ di VERONA

Dipartimento di INFORMATICA

Investigating through worksheets the impact of short formative modules on prospective teachers' didactic projects about specific topics: **qualitative analysis and data visualization**.

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Case study: energy and IR cameras

A short didactic module aimed at introducing the concept of energy through the use of IR cameras.

65 Prospective Primary school Teachers (PPT)
Combined bachelor and master degree in Primary School Education- University of Verona - 2nd year Lab Module 1 CFU of the course in Physics Education

The proposed learning path

- We redesigned a previously developed approach focussed on the concepts of heat and temperature and on the use of on-line sensors (more accent on the process with respect to traditional thermometers)

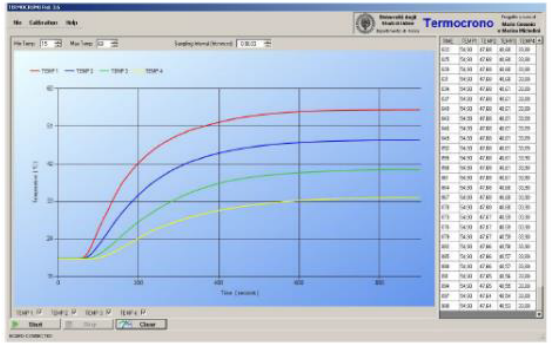
- Extended so as to highlight the concept of energy and use of infrared cameras.

Learning path: first phase
Interactive lecture

Interactive experiment-based lecture

to introduce the instrument termocrono, the concept of thermal equilibrium and the operational definition of temperature

TERMOCRONO (UniUD)
Four on-line sensors
(-10°-100°, 0.1°C sensitivity)

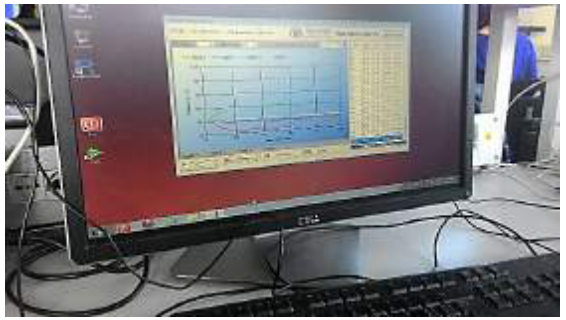


- *Simultaneous measurements*
- *Real-time*
- *Graphical interface*

Learning path: second phase
Two lab activities

Experiments were autonomously carried out by the students divided into groups

- Exp. 1 - Heating (= increase of temperature) of different masses of water with a boiler



- Exp. 2 - Heating (= increase of temperature) different masses of water by irradiation with a halogen lamp

Prediction – Experiment – Comparison modality using the termocrono

Learning path: third phase
Interactive lecture

Starting from Exp. 2 (irradiation)

- Introduction to the concept of energy, transfer of energy and thermal cameras

- Energy = "what is capable of heating"
- Thermal camera as a *bidimensional* remote sensor of the **energy** **emitted** in the form of non-visible (infrared) light

Learning path: fourth phase
Four *lab activities*

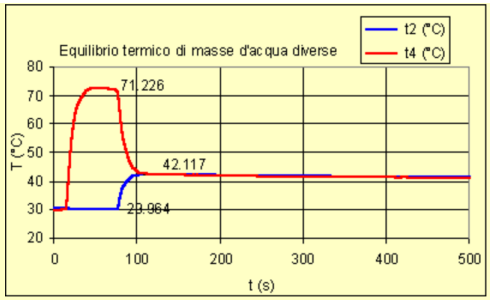
- Exp. 1 and Exp. 2 repeated with the thermal camera

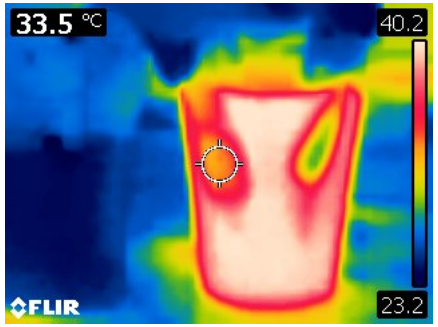
+

- Exp. 3 - Thermal interaction of different masses of water
- Exp. 4 - Locke experiment and thermal sensation

with termocrono

and with the thermal camera





Learning path: final considerations
Interactive lecture

- Temperature is a way of associating a number to the state of thermal equilibrium
- Thermal sensation is related to the rapidity of heating or cooling
- Heating means causing an increase of temperature
- Heat is transferred energy related to heating or cooling
- Temperature is a measure of the energy that is internal to bodies (internal energy)

Research methods (1)
Post-assessment questions

The investigation on the learning outcomes has been conducted on **65 PPT** through post-assessment questions, worksheets and final interviews.

The post-assessment questions were:

1) Which ways do you know for measuring temperature?
2) Which ways do you know for heating/cooling?
3) What difference/relation is there among heat, temperature and hot/cold sensation?

Research methods (2)
Worksheets and interviews

Worksheets: Personal development of a didactic project - addressed concepts and related activities on thermal phenomena

Interviews: focussed on the use or possible use of thermal cameras by PPT in the proposed activities

Research questions

Post-assessment questions

1) Do PPT cite thermal cameras among the possible instruments for measuring temperature?
2) Which concepts and corresponding activities do PPT choose in constructing their educational path on thermal phenomena?

Worksheets

3) Do (or would) PPT propose the use of thermal cameras in their activities and, if so, related to what concepts?

Worksheets and interviews

DATA ANALYSIS

Data analysis

Qualitative data analysis was performed by *reading and* identifying directly from students' answers a set of categories and refining them through successive re-readings of students' reports.

Problematica legata all'analisi di risposte aperte!

Attention was paid:

a) on the instruments (online sensors and thermal cameras) as cited in the post-assessment questions and as utilized in the activities proposed in their planned learning paths;

b) on the concepts addressed by PPTs and on their relation to the instruments utilized in the proposed activities.

Data analysis

- Citation of termocrono and thermal cameras as instruments for measuring temperature
- Use of termocrono and thermal cameras in the didactic project (+ interviews)
- Relation instruments <-> activities/concepts in the didactic project (+ interviews)

I) Identify and categorize the concepts and the related activities/instruments: thermal sensation/temperature; heating through irradiation; heat and energy

II) Construction of an Excel data sheet based on that categorization

Matrice binaria

II) Construction of the Excel data sheet

Cita termocamera fra gli strumenti di misura della temperatura	Cita termocrono	Propone temperatura/ sensazione termica	Propone irraggiamento	Propone calore/energia come concetti da spiegare	Propone calore/energia attraverso attività	Usa terrmocrono	Usa termocamera per irraggiamento	Usa termocamera per calore/energia	Non la usa ma la userebbe per irraggiamento	Non la usa ma la userebbe per calore/energia	I+H	E H	D-E-H	IK	JL	BOTH
1	1	1	1	1	0	1	0	0	0	0	2	2	3	0	0	0
1	1	1	1	1	1	1	0	0	0	0	2	2	3	0	0	0
0	1	1	1	1	0	0	0	0	0	1	1	1	2	0	1	1
0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0
1	1	1	1	1	0	1	0	0	0	1	2	2	3	0	1	1
1	1	1	1	1	0	1	0	0	0	0	2	2	3	0	0	0
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0	1	1	1	1	1	0	0	0	0	1	1	1	2	0	1	1
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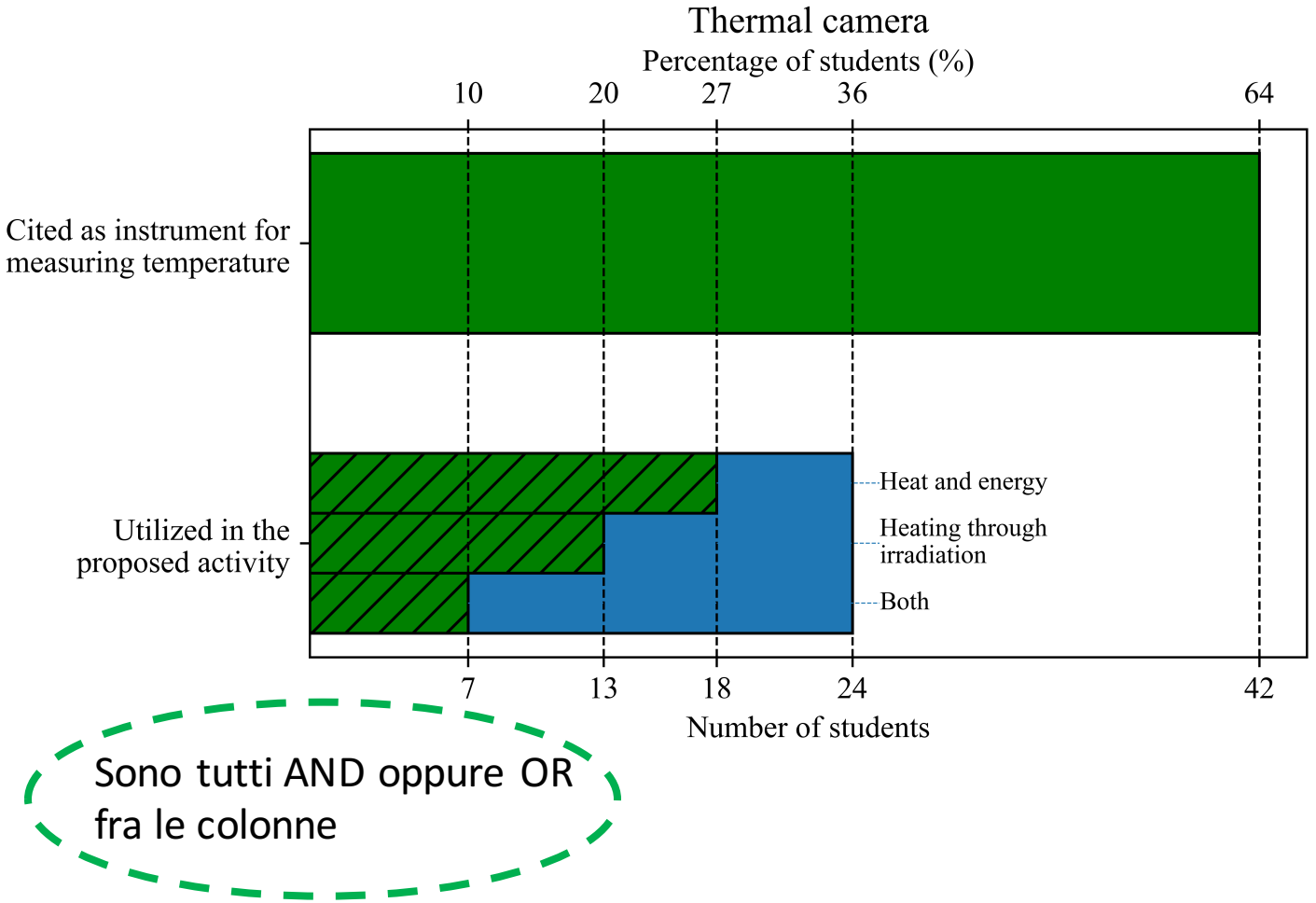
1	1	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0
1	1	1	1	0	0	1	0	0	1	1	2	2	3	1	1	2
0	1	1	1	1	1	1	0	1	0	0	2	2	3	0	1	1

Student of the example worksheet: all '1' in the first nine columns

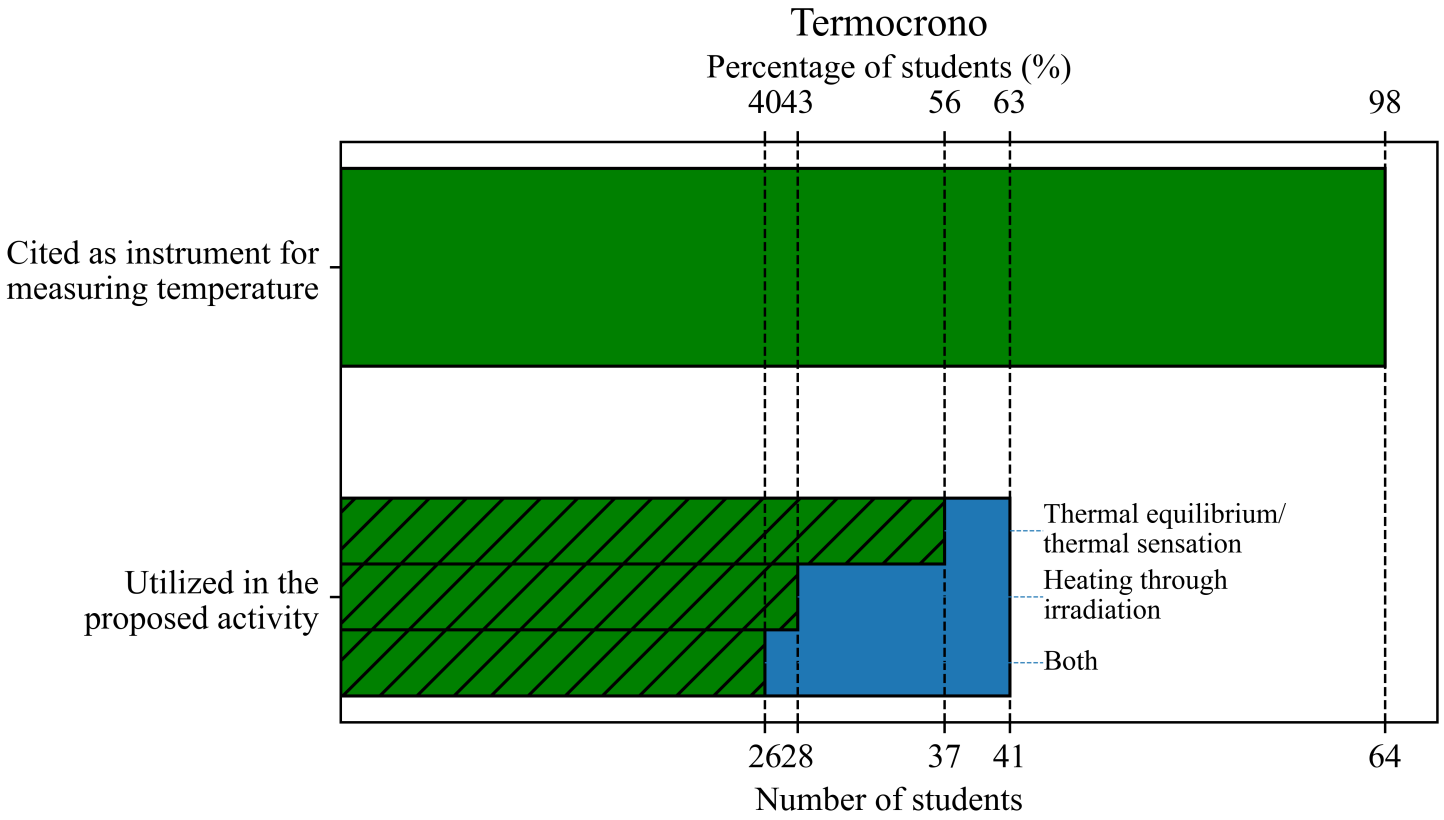
Results: use of the IR-camera



Sono tutti AND oppure OR fra le colonne

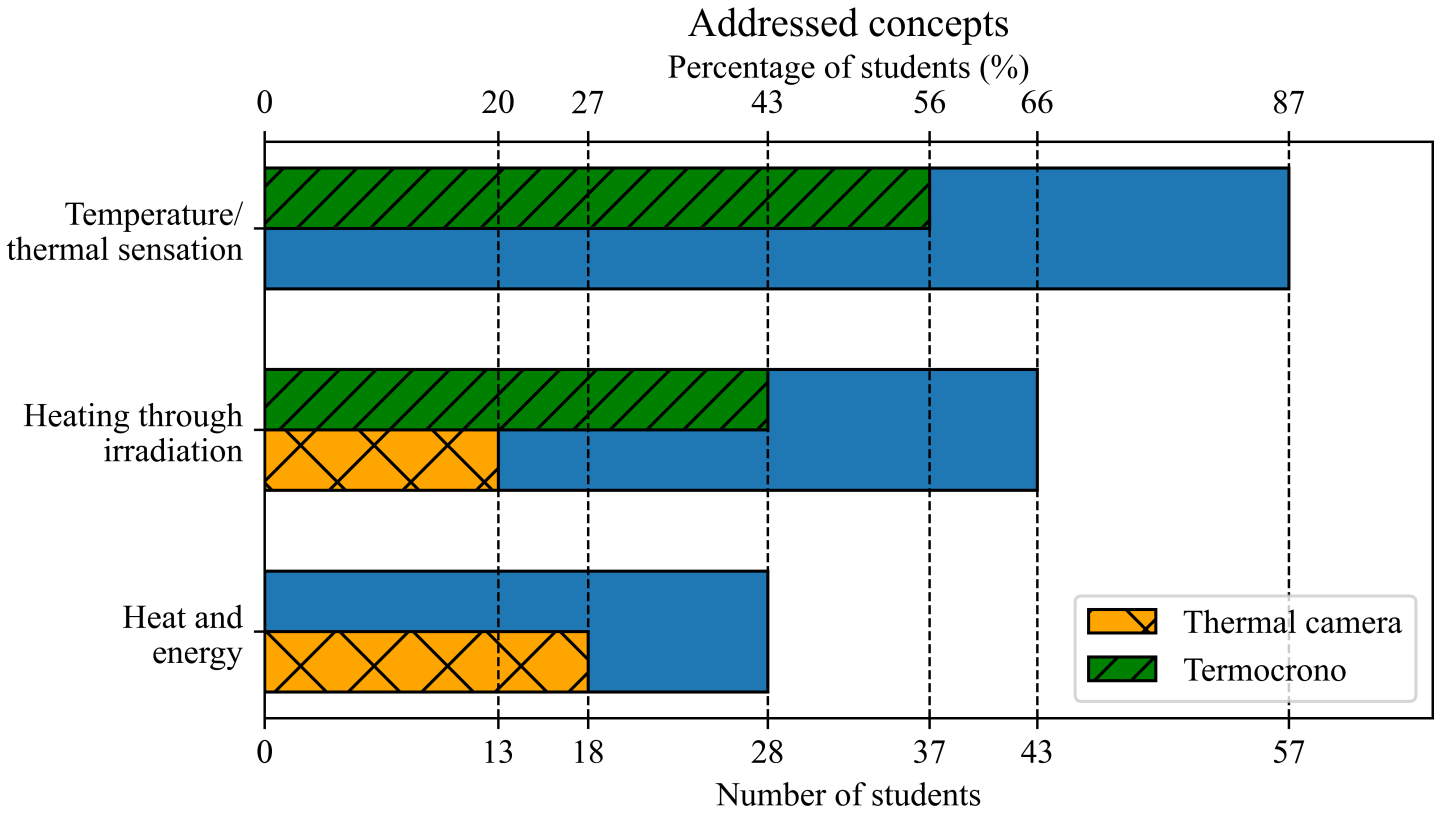
- Thermal camera is less cited (42/65), used (or possibly used if available) by 24/65 for **visualisation** (13 related to irradiation, 18 related to heat and energy, 7 for both)

Results: use of the online sensors



- Termocrono is cited by 64/65 PPT, used by 41/65 of which: 37 for thermal equilibrium/sensation, 28 for irradiation, 26 for both

Results: addressed concepts



- Temperature/ thermal sensation (57/65) is associated to the use of the termocrono (37) or of more traditional thermometers (20)
- Irradiation (43/65) is associated to the use of both termocrono (28/43) and thermal camera (13/43), including 6 who propose and 7 who would propose its use if available.
- Heat/energy are addressed by 28/65 of which 18/28 propose (only 7) or would propose (11) related activities with use of IR-camera and 10/27 visualisation with sawdust or ink or nothing.

Data analysis

III) Calculation of the related frequencies (Excel or Jupiter Notebook)

IV) Visualization of the obtained results (Bar charts – Jupiter Notebook)

=> Functions and calculations can be defined and done in Excel + bar charts are drawn writing a code in Python in the Jupiter Notebook environment

OR

=> The Excel file is converted into «.csv» + functions and calculations are defined and done directly in Python in the Jupiter Notebook environment

Data analysis: Jupiter Notebook

https://jupyter-notebook-beginner-guide.readthedocs.io/en/latest/what_is_jupyter.html

> Un'applicazione web open source, gestita localmente, che permette di sviluppare un progetto. E' un ambiente di sviluppo e di supporto utile anche per lavorare nella data science tramite i linguaggi di programmazione R e Python, i più usati nella data science e nel machine learning.

> Incluso nel software Anaconda. E' quindi sufficiente installare Anaconda sul PC. Al termine dell'installazione Jupiter è già disponibile.

> Supporta diversi linguaggi di programmazione

> Le attività di sviluppo e test sono organizzate in un'unica interfaccia utente user friendly che semplifica il lavoro con le librerie.

> Il codice è organizzato insieme a visualizzazioni e testo. In questo modo il progetto viene sviluppato e in tempo reale si può scrivere la documentazione tramite un unico software.

localhost

Desktop/ESERA 2017 2019 2021/NAPOLI 2023/FILE DA GIACOMO/Re ... R file excel corretto/

Tabelle giuste cambio i commenti - Jupyter Notebook

File Edit View Insert Cell Kernel Widgets Help

Trusted

Python 3 (ipykernel)

In [1]:
```
from IPython.display import IFrame
IFrame('https://www.esera.org/esera-2021/', width=800, height=250)
```

Out[1]:

EUROPEAN SCIENCE EDUCATION RESEARCH ASSOCIATION ESERA

Analisi dei dati e visualizzazione usando i notebook interattivi Jupyter

Di seguito viene riportata l'analisi dei dati dell'esperimento usando i notebook interattivi Jupyter. Jupyter permette di eseguire delle celle di codice all'interno di un notebook dove è possibile scrivere porzioni di testo formattandolo usando il linguaggio di mark-up markdown. L'obiettivo del progetto Jupyter è quello di fornire degli strumenti open-source per un analisi riproducibile e documentata dei dati.

Useremo la libreria `pandas` per l'analisi statistica e `numpy` per manipolare i vettori contenenti i dati, infine usiamo `matplotlib` per disegnare i grafici. Ci assicuriamo che le libreria siano installate usando i seguenti comandi:

In [2]:
```
!pip install pandas
!pip install numpy
!pip install matplotlib
```

...

Importiamo i moduli:

Results: general aspects

- The thermal camera is considered an expensive specialistic instrument not easy to be found in the school, so PPT tend not to propose its use in their planned activities.

- The present study suggests a kind of exclusive correspondence between addressed concepts and chosen instruments, which seems based on the fact that, differently from the on- line sensors, thermal cameras have been considered as instruments for visualisation purposes rather than for measuring temperature.

THANK YOU FOR YOUR ATTENTION!