

# ROAR

*How to improve Grade 10-12 interest and motivation in mathematics  
through a learning path based on Operations Research*

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# Overview

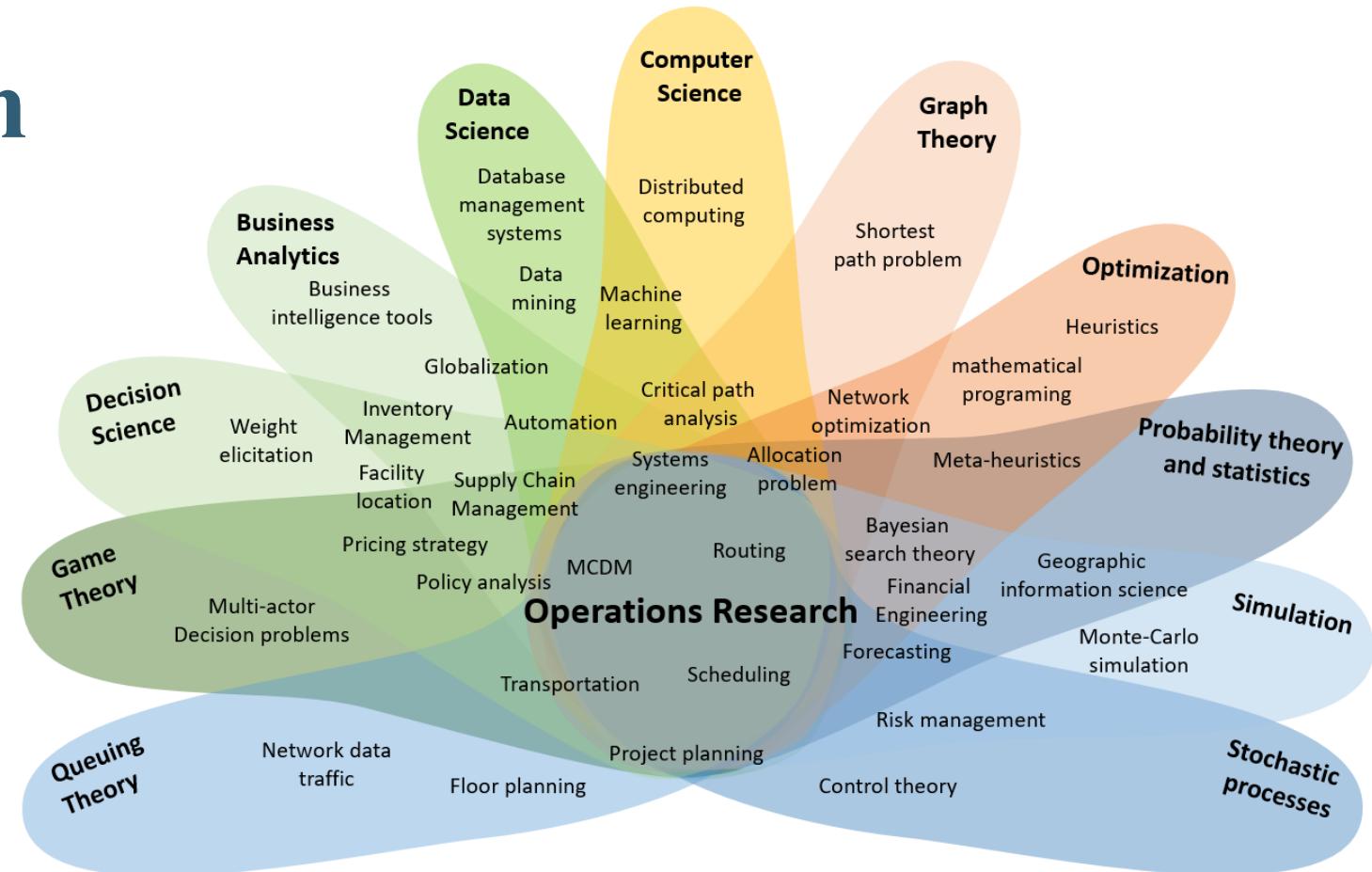
- Part 1 – Teaching Operations Research before university
- Part 2 – The ROAR project
- Part 3 – The “ROAR In Action!” seminars
- Part 4 – Conclusions and future work

# Part 1

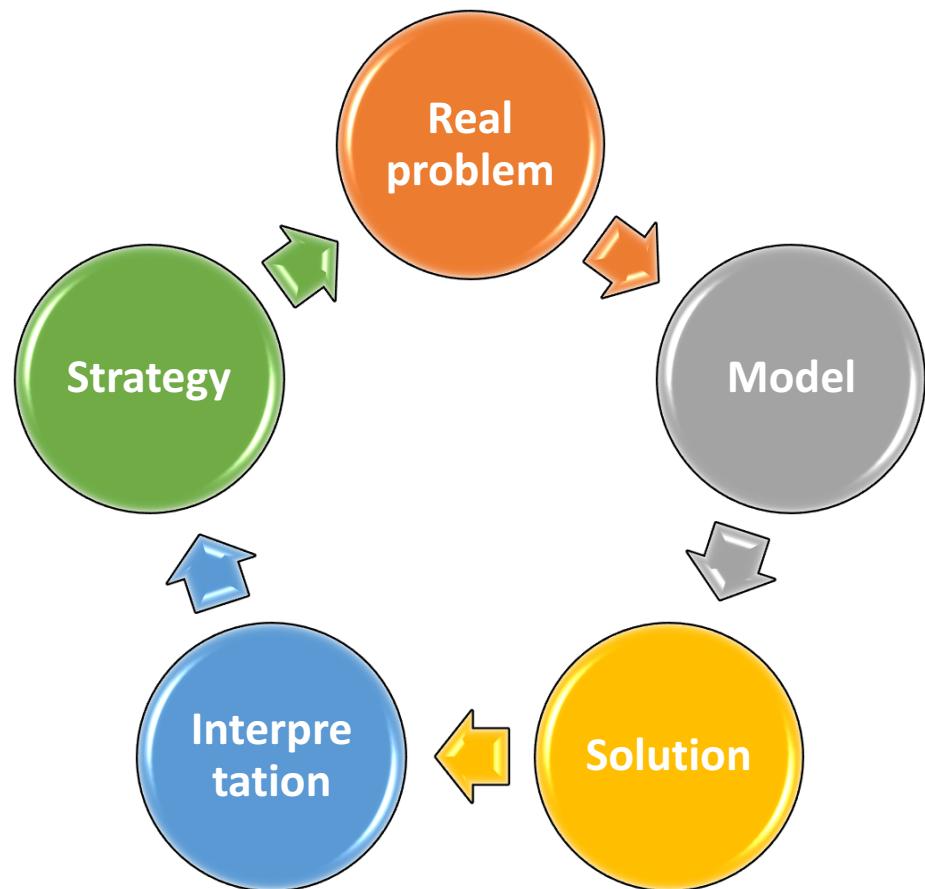
# Teaching Operations Research before university

# Operations Research

- Branch of applied mathematics born during World War II
- Interdisciplinary nature
- Focus on optimization
- Based on mathematical modelling and application of resolution methods (exact or heuristic approaches)

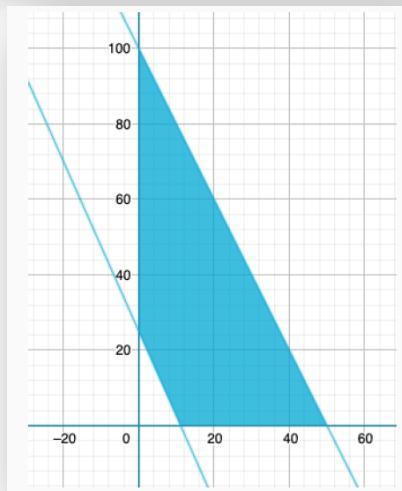


Picture by Alex Elkjær Vasegaard



#### Problem description

A farm must determine how many hectares of land they owe be dedicated to lettuce and tomato production. By cultivating one hectare of land, the company estimated that 20 quintals of lettuce and 30 quintals of tomatoes can be produced annually. To complete the crops, one laborer has to be assigned to each hectare planted with lettuce and two laborers have to be assigned to each hectare planted with tomatoes. In order to have enough manpower for other crops, the company does not want to use more than 100 workers. Also, the company sells every kilogram of lettuce and every kilogram of tomatoes for 1 euro and 1.5 euro, respectively. Moreover, it wants to ensure an annual profit of at least 50,000 euro from the sale of these two products.



```

from pulp import *

# Inizializzazione del problema assegnando un nome e la direzione dell'ottimizzazione
model = LpProblem("InsalataPomodori", LpMinimize)

# Variabili
x_INS = LpVariable("Num_ettari_lattuga", lowBound=0, cat=LpContinuous)
x_POM = LpVariable("Num_ettari_pomodori", lowBound=0, cat=LpContinuous)

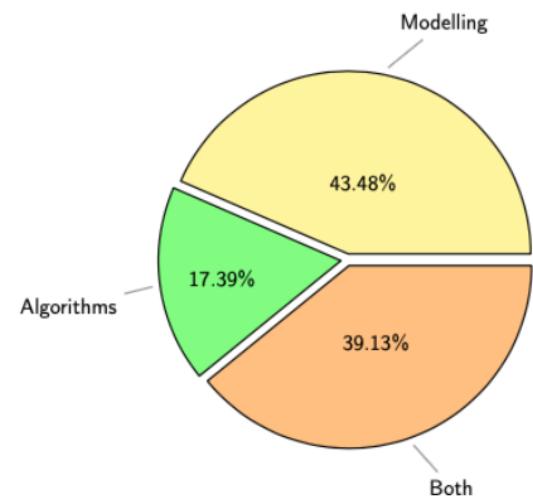
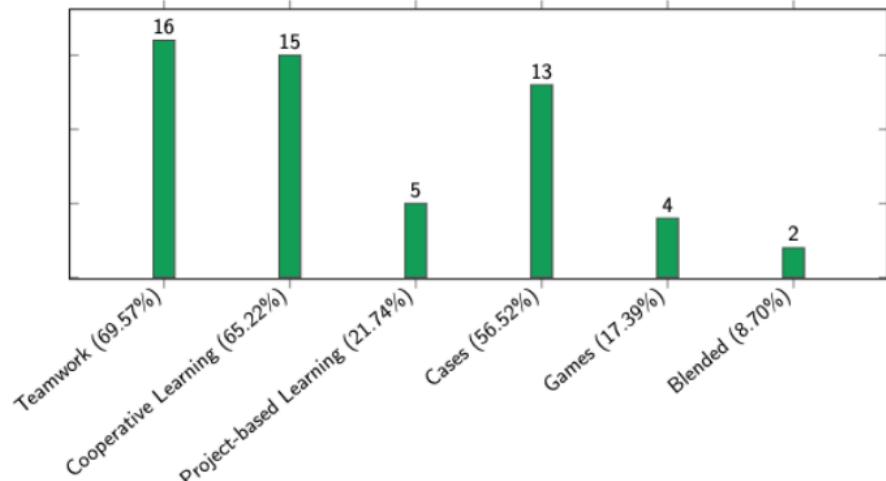
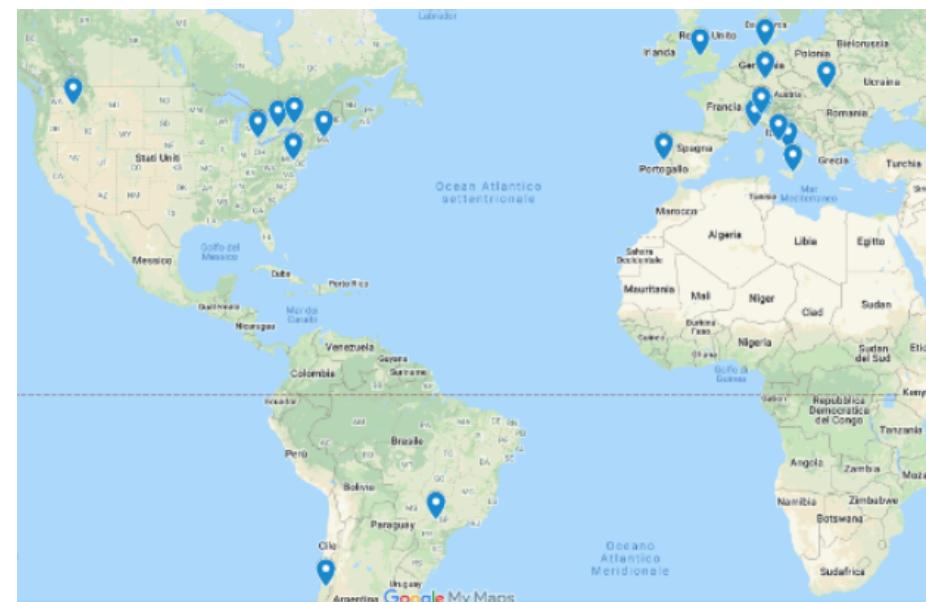
# Vincoli
model += 1*x_INS + 2*x_POM <= 100
model += 2000*x_INS + 4500*x_POM >= 50000

# Funzione obiettivo
model += x_INS + x_POM

# Chiamata al solver
model.solve()

# Stampa soluzione ottima trovata
for v in model.variables():
    print(v.name, " = ", round(v.varValue,2))

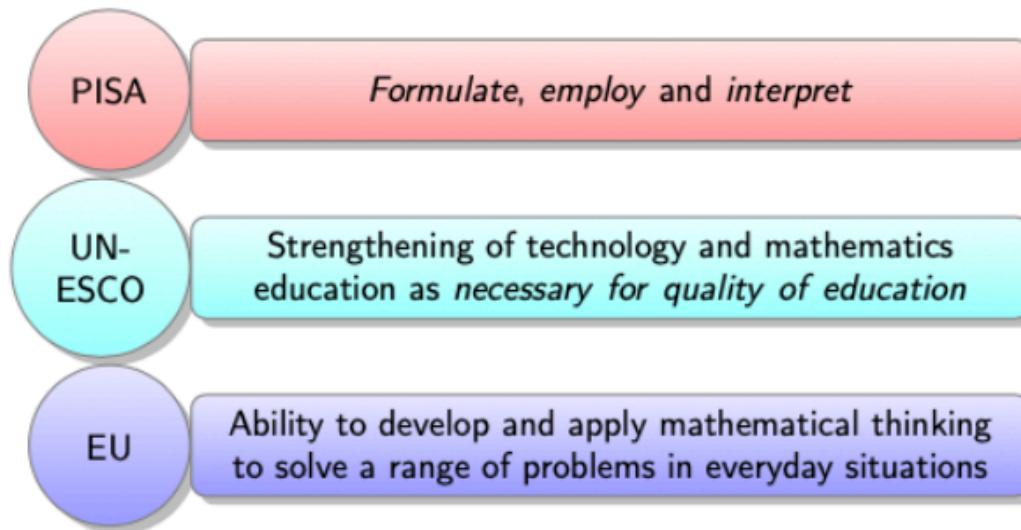
# Valore della funzione obiettivo
print("Numero minimo di ettari richiesti = {}".format(round(value(model.objective),2)))
    
```



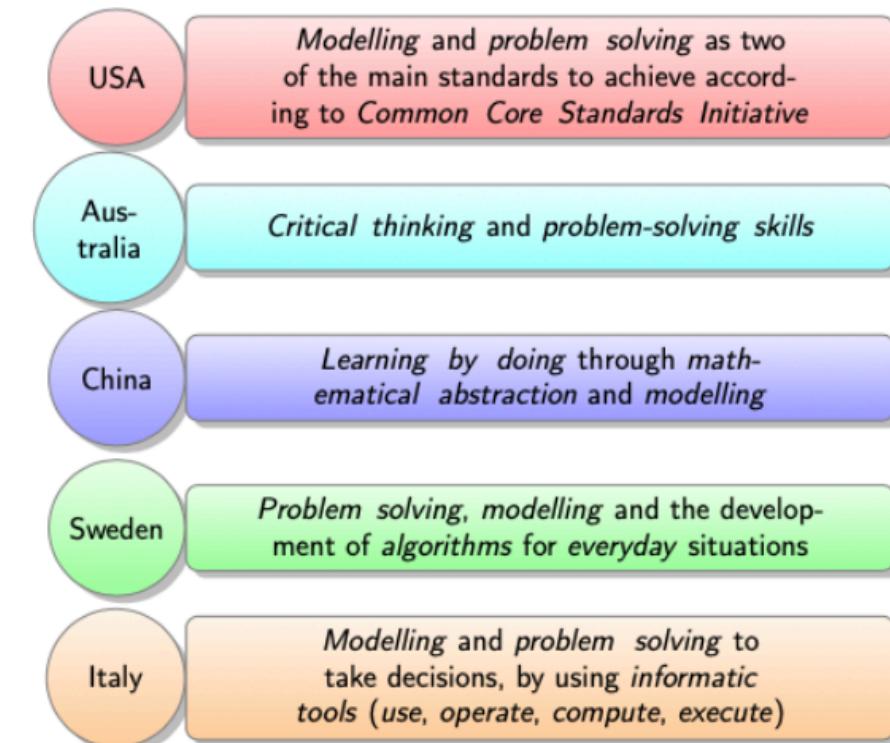
# A literature review about OR initiatives addressed to Grades 9–12

# Looking for explicit and implicit references to OR

## International guidelines



## National guidelines



# Part 2

# The ROAR project

# Research team



**Gabriella Colajanni,**  
University of Catania



**Alessandro Gobbi,**  
University of Brescia



**Alice Raffaele,**  
University of Verona



**Eugenia Taranto,**  
University of Catania

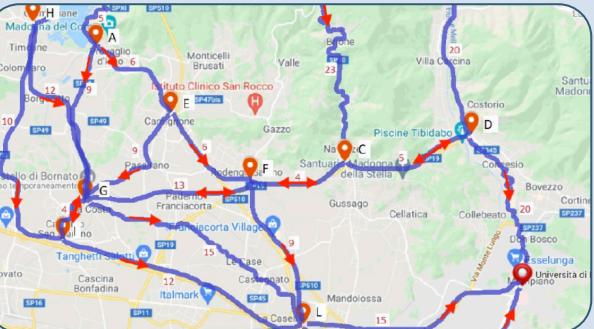
# Ricerca Operativa Applicazioni Reali (ROAR)



The scientific high school **IIS Antonietti** in Iseo (Brescia, Italy) and **Dr. Marinella Picchi**, the mathematics and physics teacher of the class involved in the project

- Learning path for higher secondary schools based on **active learning** and **constructionism**
- Problems closely connected with **students' everyday life or reality**
- **Balance** of mathematical modelling and algorithms
- **Main goal:** improving students' interest, motivation, and skills related to STEM disciplines
- Three-year ***Path for Transversals Skills and Orientation*** at IIS Antonietti in agreement with **University of Brescia**

A	B	C	D	E	F	G	H	I
<b>DEL PROBLEMA</b>								
gradimento	9,5	8	9	7	6,5	9	10	
<b>dimensione</b>								
	25	20	30	20	18	22	27	
<b>RIABILI</b>								
x	1	0	0	3	4	1	1	7
<b>MODELLO</b>								
funzione obiettivo	50							
vincoli:	al massimo 140MB	136	<=	140				
	almeno 6 brani	6	>=	6				
	al massimo 2 titoli inglese	2	<=	2				



```

version: 2.10.3
Build Date: Dec 15 2019

command line - /Users/aliceraffaele/opt/anaconda3/lib/python3.8/site-packages/pulp/
    ./solverdir/cbc/osx/64/cbc /var/folders/g4/2nykfn_n47d6s4xb9qf74wr000gn/T/
    j9548efab3bd415f82816447e1951638-pulp.mps timeMode elapsed branch printingOptions al
solution /var/folders/g4/2nykfn_n47d6s4xb9qf74wr000gn/T/
    j9548efab3bd415f82816447e1951638-pulp.sol (default strategy 1)
At line 2 NAME MODEL
At line 3 ROWS
At line 7 COLUMNS
At line 14 RHS
At line 17 BOUNDS
At line 18 ENDATA
Problem MODEL has 2 rows, 2 columns and 4 elements
Coin0008I MODEL read with 0 errors
Option for timemode changed from cpu to elapsed
Presolve 2 (0) rows, 2 (0) columns and 4 (0) elements
0 Obj 0 Primal.inf 11.11111 (1)
1 Obj 11.11111
Optimal - objective value 11.11111
Optimal objective 11.11111 - 1 iterations time 0.002
Option for printingOptions changed from normal to all
    
```

## ROAR I – Grade 10 (March – May 2021)

Mathematical modelling  
Linear, integer, and mixed-integer linear programming  
Digital technologies:  
GeoGebra, Microsoft Excel add-in Solver, Mentimeter

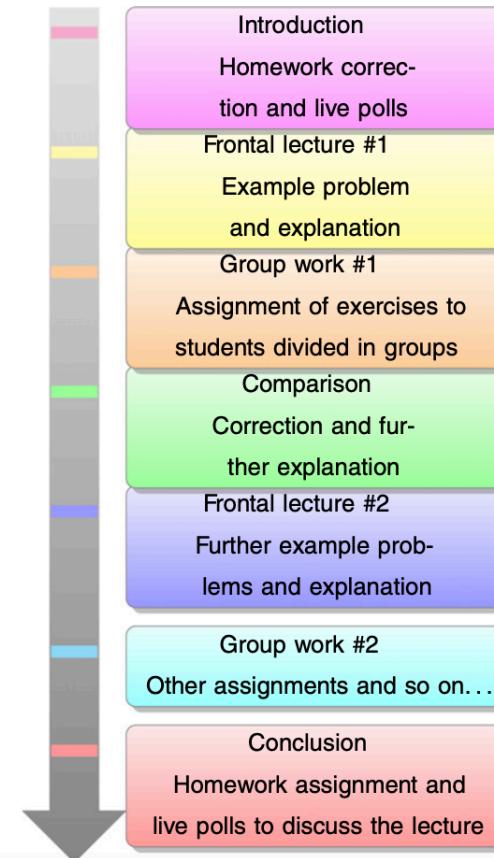
## ROAR II – Grade 11 (January – April 2022)

Graph theory and network applications (Minimum spanning tree, Shortest path, Travelling Salesman problems)  
Heuristics and pseudocodes  
Digital technologies: + Kahoot

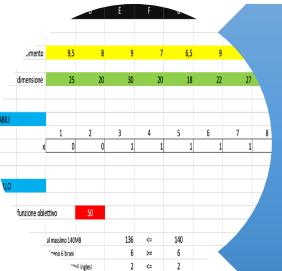
## ROAR III – Grade 12 (October 2022 – January 2023)

Implementation of mathematical models in Python  
Resolution by means of PuLP  
Digital technologies: + Spyder

# Macro-structure of (almost) every lecture



# Final projects of the three units



ROAR I (March – May 2021) – COLLABORATIVE LEARNING

Students were divided into five groups, each one tackling a different *authentic problem*



**ROAR II (January – April 2022) – COMPETITIVE LEARNING**

Again, students were divided into five groups, but this time they competed with each other in solving the same challenging problem

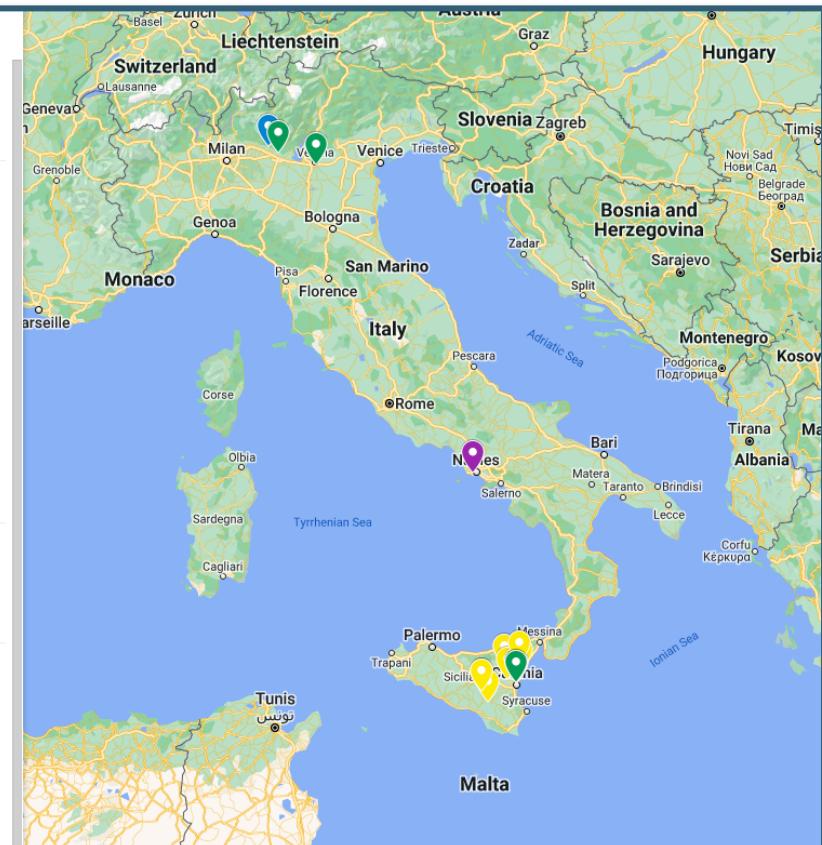
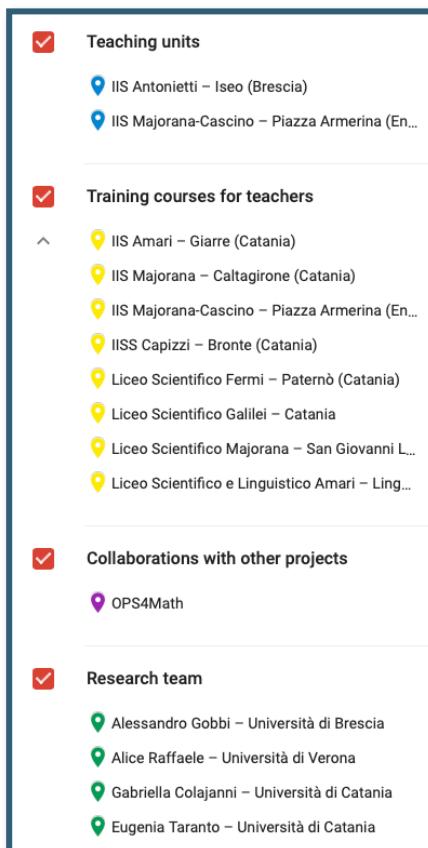


**ROAR III (October 2022 – January 2023) – COOPERATIVE LEARNING**

Students are divided into five groups, joining forces also with the experimenters to tackle a real industrial problem

# Other ROAR-based initiatives

- **Autumn 2021:**
  - Training course to in-service teachers in Sicily
  - ROAR I in a scientific high school in Piazza Armerina (Enna)
- **Autumn 2022:**
  - Seminars in the OPS4Math project in Naples
  - Training course to in-service teachers in Sicily
- **Winter 2022 (upcoming):**
  - Training course to in-service teachers in Cernusco sul Naviglio (Milan)

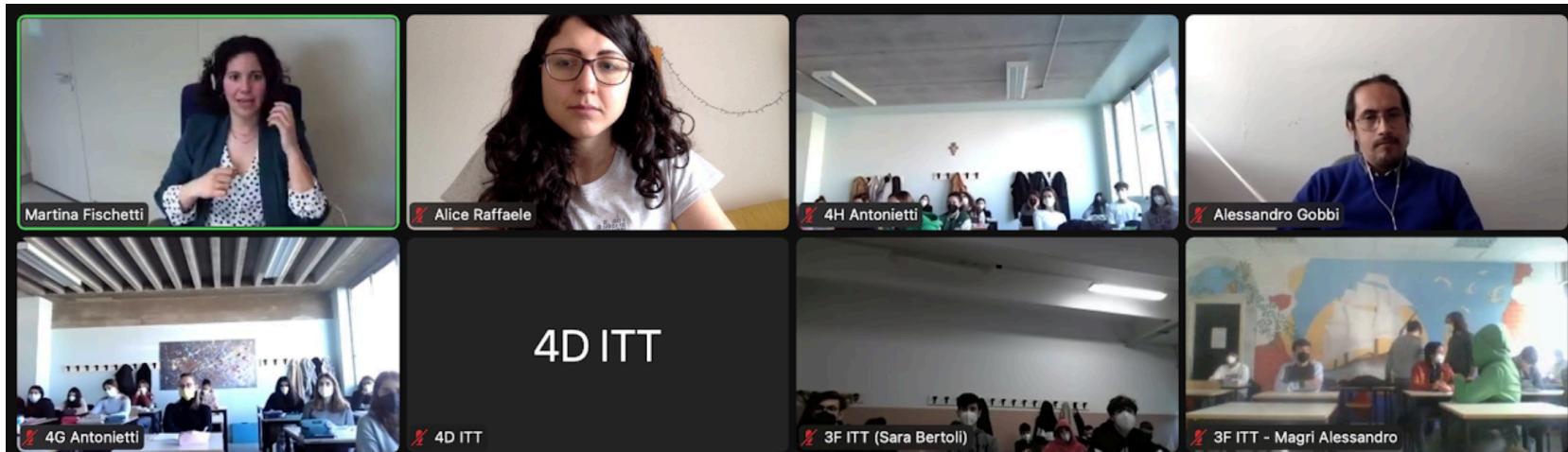


# Part 3

# The “ROAR In Action!”

# seminars

# Seminars for orientation and civic education purposes



- Six Zoom meetings with speakers (both from industry and academia) who presented several applications of OR
  - Focus also on their background and career paths
- OR topics covered: routing, facility locations, railway and freight transportation, public transportation, sustainability, and supply chain management

# Part 4 Conclusions and future work

# Conclusions

- The implementation of a modelling pathway such as ROAR can be successfully tackled by ordinary higher secondary students
- ROAR broadened students' experiences with OR and their views of the mathematical world
- In our opinion, it is appropriate to include OR and its type of problems in regular mathematics lectures, clearly not every day, but on a regular basis

# Official website and online repository

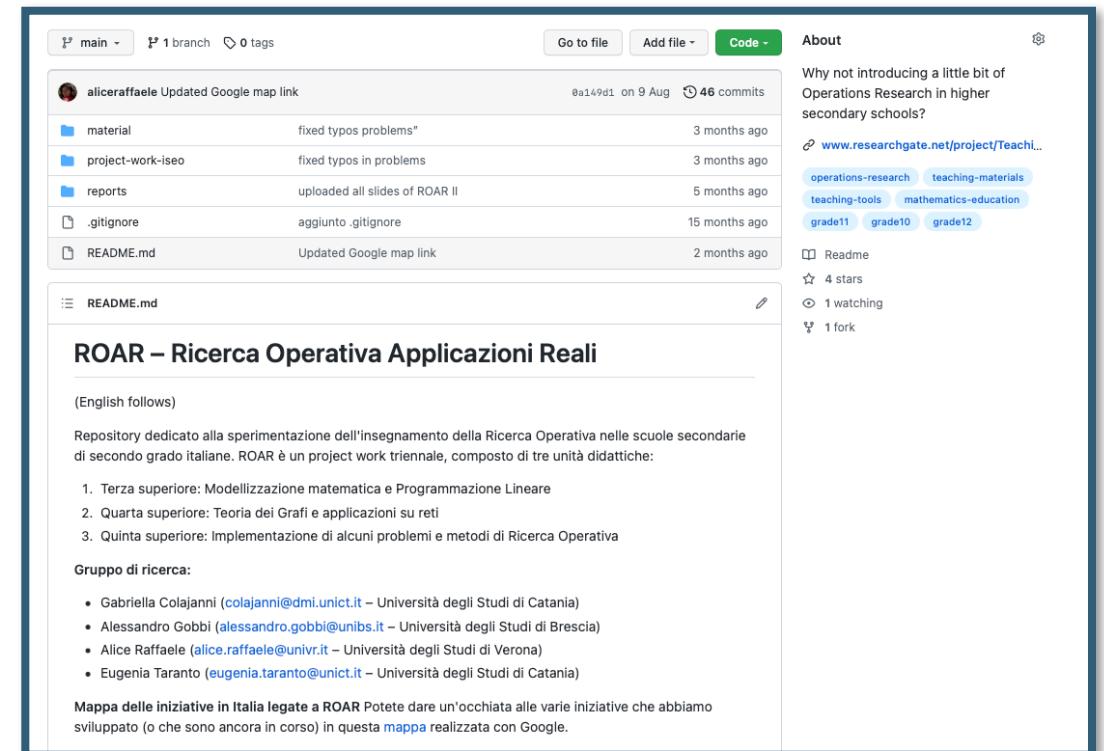


**ROAR**  
*Ricerca Operativa Applicazioni Reali*

**ROAR è un progetto didattico triennale rivolto a studentesse e studenti del triennio della scuola secondaria di II grado che mira ad accrescere il loro interesse e migliorare le loro abilità nelle discipline scientifiche attraverso la *ricerca operativa*.**

ROAR si compone di tre unità didattiche:

- la prima unità introduce la **modellizzazione matematica** e la **programmazione lineare**;
- la seconda unità tratta della **teoria dei grafi** e di alcuni dei più famosi **problemis su rete**;
- la terza unità riguarda l'**implementazione con un linguaggio di programmazione** di alcuni problemi e metodi della ricerca operativa.



main · 1 branch · 0 tags

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aliceraffaele Updated Google map link 8a149d1 on 9 Aug 46 commits

material	fixed typos problems"	3 months ago
project-work-iseo	fixed typos in problems	3 months ago
reports	uploaded all slides of ROAR II	5 months ago
.gitignore	aggiunto .gitignore	15 months ago
README.md	Updated Google map link	2 months ago

README.md

**ROAR – Ricerca Operativa Applicazioni Reali**

(English follows)

Repository dedicato alla sperimentazione dell'insegnamento della Ricerca Operativa nelle scuole secondarie di secondo grado italiane. ROAR è un project work triennale, composto di tre unità didattiche:

1. Terza superiore: Modellizzazione matematica e Programmazione Lineare
2. Quarta superiore: Teoria dei Grafi e applicazioni su reti
3. Quinta superiore: Implementazione di alcuni problemi e metodi di Ricerca Operativa

Gruppo di ricerca:

- Gabriella Colajanni ([colajanni@dmi.unict.it](mailto:colajanni@dmi.unict.it) – Università degli Studi di Catania)
- Alessandro Gobbi ([alessandro.gobbi@unibs.it](mailto:alessandro.gobbi@unibs.it) – Università degli Studi di Brescia)
- Alice Raffaele ([alice.raffaele@univr.it](mailto:alice.raffaele@univr.it) – Università degli Studi di Verona)
- Eugenia Taranto ([eugenia.taranto@unict.it](mailto:eugenia.taranto@unict.it) – Università degli Studi di Catania)

Mappa delle iniziative in Italia legate a ROAR Potete dare un'occhiata alle varie iniziative che abbiamo sviluppato (o che sono ancora in corso) in questa [mappa](#) realizzata con Google.

# Future work

- **Until January 2023:** finish carrying out the experimentation with the Grade 12 class in Iseo
- **October 2022 – April 2023:** training course addressed to in-service teachers in Catania
- **January – March 2023:** training course addressed to in-service teachers in Cernusco sul Naviglio, Milan
- **Scientific papers:**
  - about to submit the paper related to the design and implementation of ROAR II
  - writing of a paper about the challenge of ROAR II from a teaching perspective
  - similar papers about ROAR III
  - longitudinal study to compare all three teaching units to evaluate the impact of ROAR on students' motivation and interest in STEM

# References

- Alice Raffaele and Alessandro Gobbi (2021). *Teaching Operations Research Before University: A Focus on Grades 9–12*, Operations Research Forum.
- Gabriella Colajanni, Alessandro Gobbi, Marinella Picchi, Alice Raffaele, and Eugenia Taranto (2022). *An Operations Research-Based Teaching Unit for Grade 10: The ROAR Experience, Part I*, INFORMS Transactions on Education.
- Eugenia Taranto, Gabriella Colajanni, Alessandro Gobbi, Marinella Picchi, and Alice Raffaele (2022) *Fostering students' modelling and problem-solving skills through Operations Research, digital technologies, and collaborative learning*, International Journal of Mathematical Education in Science and Technology
- Official website (in Italian only): <https://sites.google.com/view/progettoroar/home>
- Online repository (in Italian and English): <https://github.com/aliceraffaele/ROAR>
- ROAR YouTube channel: <https://www.youtube.com/channel/UCQAD88ykMHWHTa-O-FBCA>
- MaddMaths!, “*ROAR IN AZIONE!*”, *un ciclo di seminari sulle applicazioni della Ricerca Operativa*: <https://maddmaths.simai.eu/divulgazione/roar-in-azione-ciclo-seminari-applicazioni-ricerca-operativa/>

