

An OR-based Teaching Unit for Grade 11: The ROAR Experience, Part II

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Alice Raffaele⁴, and Eugenia Taranto²

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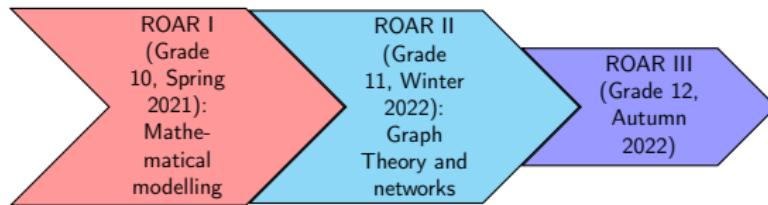
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INTERNATIONAL CONFERENCE ON
OPTIMIZATION AND DECISION SCIENCE
FIRENZE (ITALY) August 30th - September 2nd - 2022

Three-year project work that fits into a *Path for Transversal Skills and Orientation (PCTO)*:



ROAR II – Instructors' roles

To develop the teaching unit, there must be at least one *experimenter* and a couple of *observers*.

Classroom teacher	Experimenter	Observer
► A teacher of the Grade-11 class.	<ul style="list-style-type: none">► An OR expert who presents the teaching unit, in charge of leading the lectures.► Assumed either by the classroom teachers or by some experts external to the class.	<ul style="list-style-type: none">► Someone who attends the lectures and takes notes.► Recommended to know OR, but not mandatory.

In our experimentation: a classroom teacher (Marinella Picchi), two experimenters (Me and Alice Raffaele), and two observers (Gabriella Colajanni and Eugenia Taranto).

ROAR II – Objectives, Topics and teaching methods

1. Introduce Graph Theory to present some famous network problems
2. Introduce OR *optimization algorithms* to easily solve some network problems
3. Introduce the concept of *heuristic* to solve complex variants of some network problems
4. Reinforce *mathematical modelling* skills to create ILP models of network problems to be solved through Excel Solver
5. Teaching how to choose the right method to solve an authentic problem
6. Improve collaborative skills
7. Improve public-speaking skills

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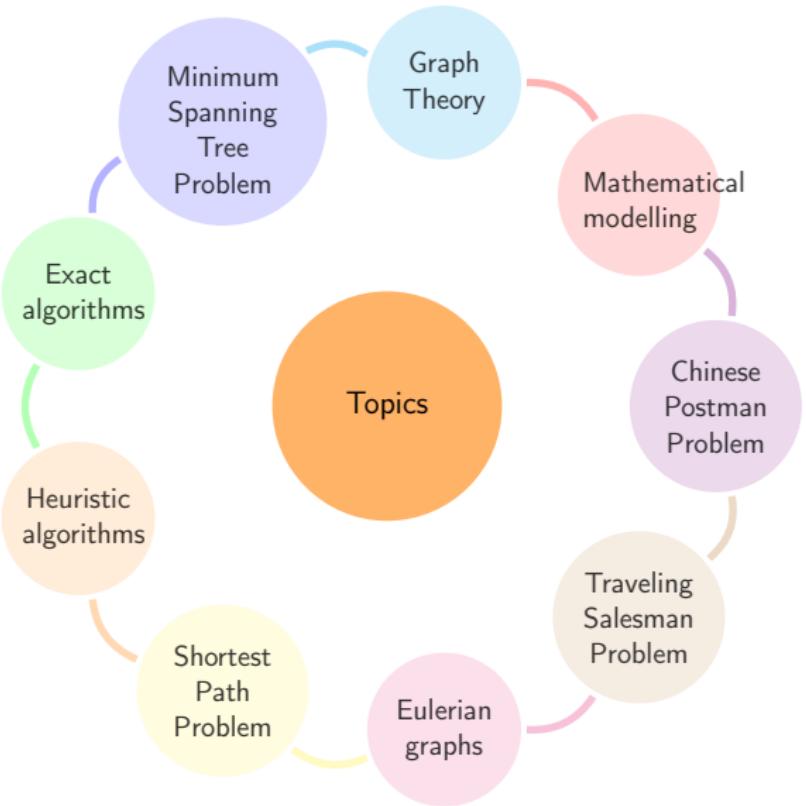
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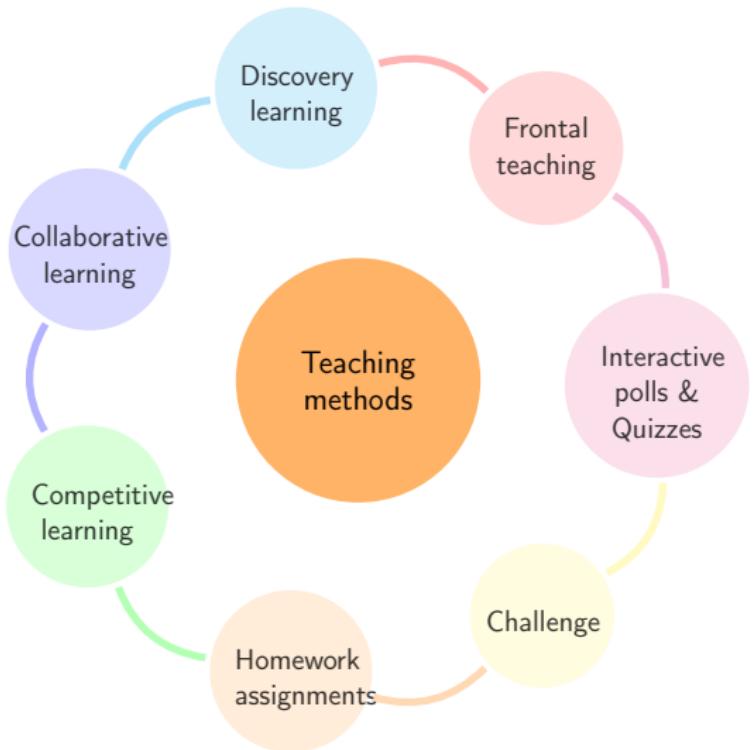
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ROAR II – Objectives, Topics and teaching methods



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ROAR II: January – April 2022

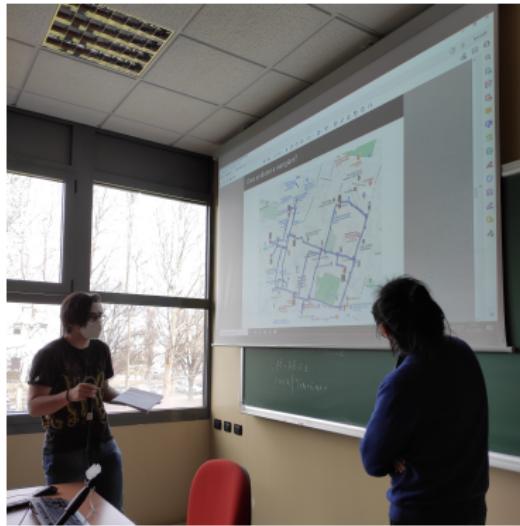
Calendar:

1. January 17 (3 hours)
2. January 29 (4 hours)
3. February 5 (4 hours)
4. February 11 (all day)
5. March 12 (4 hours)
6. March 21 (3 hours)
7. April 22 (3 hours)

According to the pandemic emergency and the rules established by the Italian government, some students had to follow some lectures remotely.



A day at University of Brescia (morning)

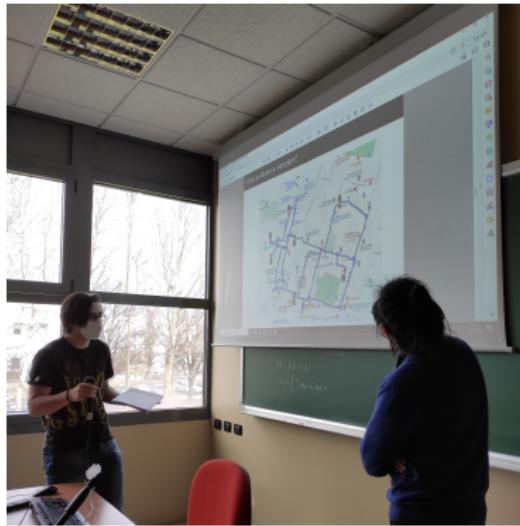


- ▶ Live quizzes on **Kahoot!**
- ▶ ILP Model of Shortest Path Problem
- ▶ Exercise on Dijkstra algorithm: “Where are we going to eat?”



- ▶ Gamification
- ▶ Inquiry learning
- ▶ Group working

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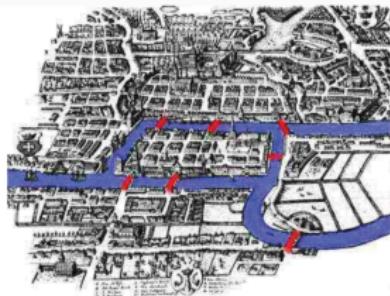
- ▶ Gamification
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A day at University of Brescia (afternoon)

- ▶ Discovery learning
- ▶ Orientation activity



Una passeggiata per sette ponti



Gli abitanti della città rappresentata nella mappa si chiedevano spesso se fosse possibile fare una passeggiata iniziando da un punto qualsiasi della città, per poi attraversare ogni ponte una e una sola volta e ritornare al punto di partenza. Riuscite ad aiutarli?

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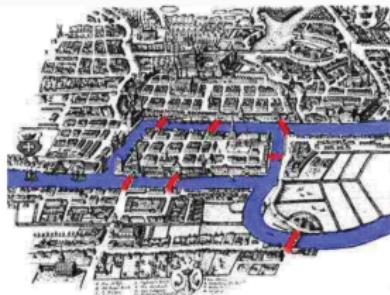
- ▶ Properties and theorems on Eulerian Graphs
- ▶ Visit of the university premises

A day at University of Brescia (afternoon)

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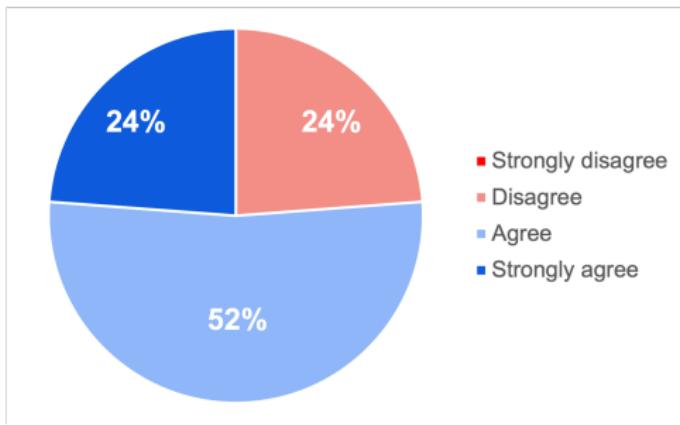


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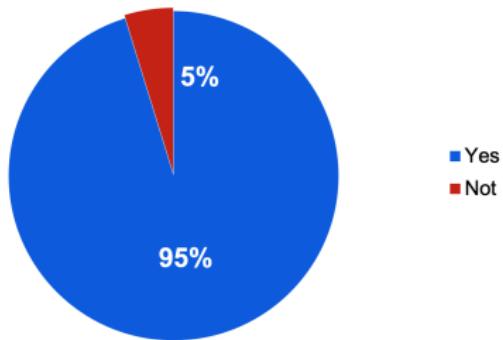
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- ▶ Properties and theorems on Eulerian Graphs
- ▶ Visit of the university premises

The day at university helped me to orient myself on possible university career



Would you repeat such an experience? Why?



- ▶ “Beautiful, engaging, formative”
- ▶ “I understand, albeit to a small extent, how a university environment is lived”
- ▶ “I liked it a lot, especially for having worked in different environments with my teammates”

ROAR in action!



ROAR IN AZIONE! PAROLA AGLI ESPERTI

UN CICLO DI SEMINARI SU APPLICAZIONI REALI DELLA RICERCA OPERATIVA

FEBBRAIO – APRILE 2022



MARTEDÌ 01 FEBBRAIO 2022, ORE 11:00



IL SERVIZIO DI PRESTI INTERBIBLIOTECARIO DA UN PUNTO DI VISTA MATEMATICO

Speaker: **Marco Gussago** (Ufficio Biblioteche, Provincia di Brescia) e **Fabio Bazzoli** (Sistema Bibliotecario del Sudovest Bresciano).

Analisi dell'organizzazione del servizio in termini del calcolo dei percorsi dei carriera.

LUNEDÌ 14 FEBBRAIO 2022, ORE 11:00



AMAZON LOGISTICS: OTTIMIZZAZIONE GEOSPAZIALE DELLE CONSEGNE

Speaker: **Leonardo Drahosad** (Amazon).

Presentazione di alcuni problemi dell'ultimo miglio, l'ultima fase della gestione dell'ordine del cliente.

MERCOLEDÌ 02 MARZO 2022, ORE 11:00



COME LA MATEMATICA AIUTA A FAR FUNZIONARE MEGLIO I TRENI

Speaker: **Veronica Dal Sasso** (Optirail s.r.l.).

Planificazione, gestione e supervisione del traffico ferroviario, in termini anche di dispacciamento.

GIOVEDÌ 10 MARZO 2022, ORE 11:00



LA MATEMATICA PER UN FUTURO PIÙ SOSTENIBILE TRA ENERGIE RINNOVABILI E TRASPORTI

Speaker: **Martina Fischetti** (European Commission, Joint Research Centre).

Design e posizionamento ottimale di turbine eoliche per minimizzare costi di produzione e dell'energia.

VENERDÌ 18 MARZO 2022, ORE 11:00



OTTIMIZZAZIONE DELLE OPERAZIONI DI MANOVRA FERROVIARIA IN AMBITO PORTUALE

Speaker: **Veronica Asta** (OPTIMOsys Srls).

Planificazione e gestione di attività e processi all'interno dell'area portuale e dei terminal ferroviari.

VENERDÌ 08 APRILE 2022, ORE 11:00



OPTIMUS: COMBATTERE LA FAME NEL MONDO CON L'OTTIMIZZAZIONE

Speaker: **Anna Melchiori** (World Food Programme).

Utilizzo dei dati per organizzare all'ottimo la catena di approvvigionamento di cibo di una regione.



ORGANIZZATORI



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Eugenio Taranto
(Università degli Studi di Catania)
eugenio.taranto@unicat.it

Tutti gli incontri saranno in video-conferenza su Zoom. Per avere il link, contattateci!

6 seminars on real applications of Operations Research held by industry experts.

What opportunities do you think the seminars have given you?

- ▶ “See the work we do in the classroom applied in the world of work”
- ▶ “See other examples of applications in which Mathematics and Operations Research makes a difference (even in the most unpredictable areas)”
- ▶ “Understand, for a moment, what it means to enter the world of work”

Context: home delivery of groceries from a supermarket chain, minimizing the total travel cost

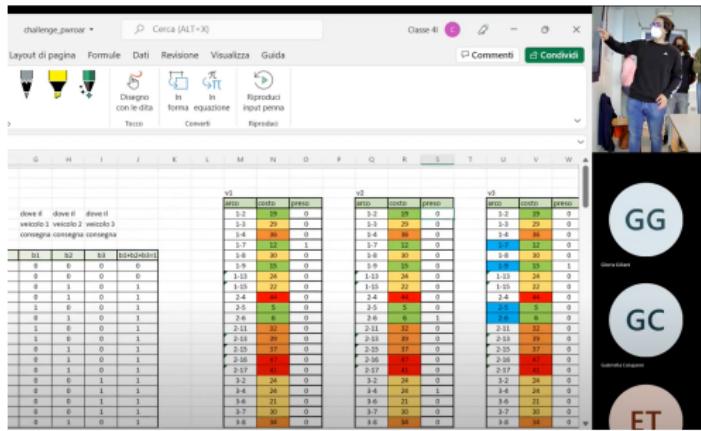
Goal: find at least a feasible solution for 3 instances of a Vehicle Routing Problem

Constraints:

- ▶ each client must be visited
- ▶ maximum number of available vehicles
- ▶ each vehicle must leave from and return to a specific depot

Final project: rules

- ▶ Each group had to work on the same problem and same instances (**challenge**)
- ▶ To find their solutions, students could exploit mathematical modelling, Excel Solver, or heuristic algorithms
- ▶ Students could ask tutors for clarification about the problem up to 10 days before the delivery date



Final project: rules

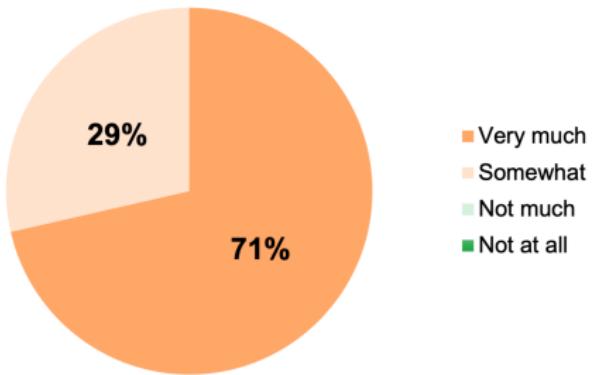
- When a group had found a new solution, it had to send it and explain their method to the tutors for validation. Then, tutors updated a public Google spreadsheet with the best solutions found so far by each group

INSTANCE 0					
Opt: 120.51	120.51	120.51	120.51	120.51	120.51
GAP (%)	0.00	0.00	0.00	0.00	0.00
INSTANCE 1					
Opt: 118.13	176.6	175.62	169.25	169.67	168.69
GAP (%)	49.50	48.67	43.27	43.63	42.80
INSTANCE 2					
Opt: 170.93	176.95	176.88	174.08	175.97	172.75
GAP (%)	3.52	3.48	1.84	2.95	1.06
	Group 1	Group 2	Group 3	Group 4	Group 5

- Winning group of challenge based on level of collaboration + final presentation + average gap from the optimum.

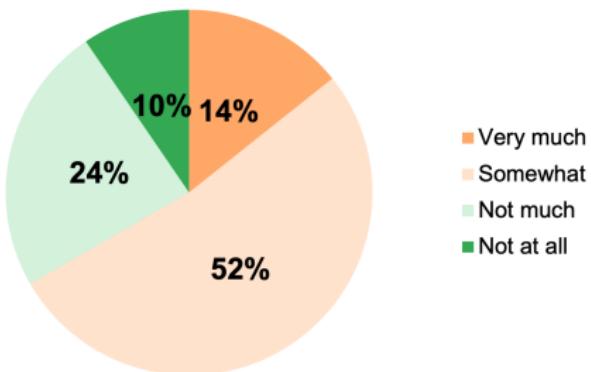
Feedback from students about the challenge

How demanding do you think the challenge was?



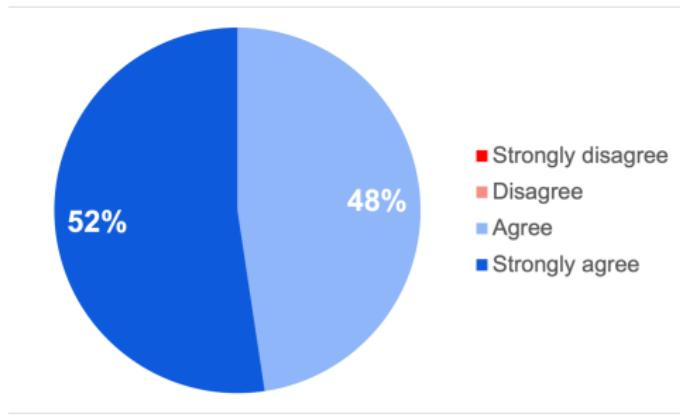
Feedback from students about the challenge

How much did you perceive the challenging atmosphere between yours and the other groups?



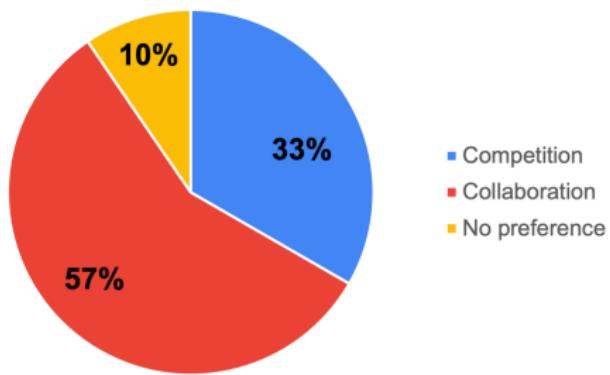
Feedback from students about the challenge

I know how to collaborate in a group in order to face and solve a challenging problem



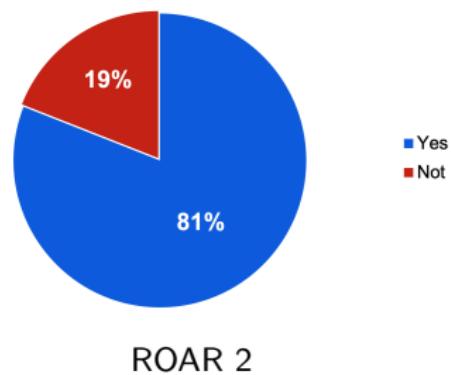
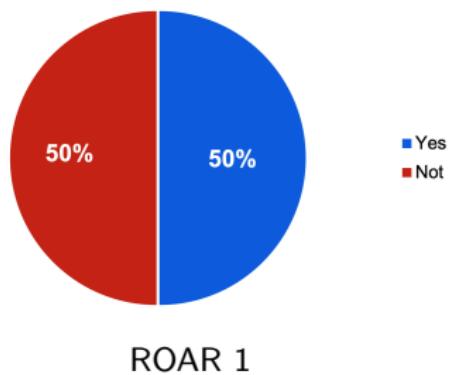
Feedback from students about the challenge

Compared to the experiences you have gained in this path so far, what do you prefer between competition and collaboration?



Final feedback

Do you think what you have learned during ROAR has changed or influenced the idea you had about mathematics and its applications in the real world?



Past and current works

- ▶ Raffaele, A., Gobbi, A. (2021). **Teaching Operations Research Before University: A Focus on Grades 9–12.** *SN Operations Research Forum* 2, 13
- ▶ Colajanni G., Gobbi A., Picchi M., Raffaele A., Taranto E. (2022). **An Operations Research based Teaching Unit for Grade 10: The ROAR Experience, Part I.** *Informs Transaction On Education.*
- ▶ Taranto E., Colajanni G., Gobbi A., Picchi M., Raffaele A. (2002). **Fostering students' modelling and problem-solving skills through Operations Research, digital technologies, and collaborative learning.** *International Journal of Mathematical Education in Science and Technology* (in press).
- ▶ G. Colajanni, A. Gobbi, M. Picchi, A. Raffaele, and E. Taranto, “*An OR-based Teaching Unit for Grade 10: The ROAR Experience, Part II*”, INFORMS Transaction on Education (working paper).

Timeline



Website of ROAR project

<https://sites.google.com/view/progettoroar>



Per scoprire di più sui ricercatori e le ricercatrici che lavorano a ROAR



Materiali

Per mettere a disposizione risorse da cui prendere spunto o da riutilizzare in altri progetti



Iniziative

Seminari per studentesse e studenti e corsi di formazione per docenti



Pubblicazioni

**Presentazioni e articoli scientifici
per approfondire i risultati
raccolti dal team e dalle classi**

Future work

- ▶ Autumn 2022: **ROAR III**, addressed to the now Grade-12 class at IIS Antonietti:
 - ▶ Python language (**interdisciplinary skills**)
 - ▶ Use of LP modeler PuLP to solve complex MILP problems (**strengthening of OR skills**)
- ▶ **Other experimentations** in other classes.



Thank you for your attention