Hello!

I am Natércia Lima

P. Porto-School of Engineering; CIETI (LABORIS)

Fostering Experimental Competences Using Complementary Resources

isep Instituto Superior de Engenharia do Porto

cieti centro de inovação em engenharia e tecnologia industrial

Problematic

There is a gap in the literature considering the **impact that a simultaneous experimental resources usage** -in experimental learning- has **on students' academic results**.

Experimental Practice

Resource	Hands-on	Remote lab	Simulation
Results	Real experimental results		Computational model results
Access	Physical contact with the experimental devices	Use the internet (interface mediated) (configuring, controlling and/or monitoring devices)	

"fluent in the language of nature and a successful designer, and for that engineering students must perform numerous experiments practice laboratory work." (Gustavsson, 2011) ***Blended or Hybrid Approach***

Goal

Identify **factors** which affect **students' learning and engagement** in the electric and electronic circuits topic using the remote lab **VISIR** along with other complementary resources.

Research Questions

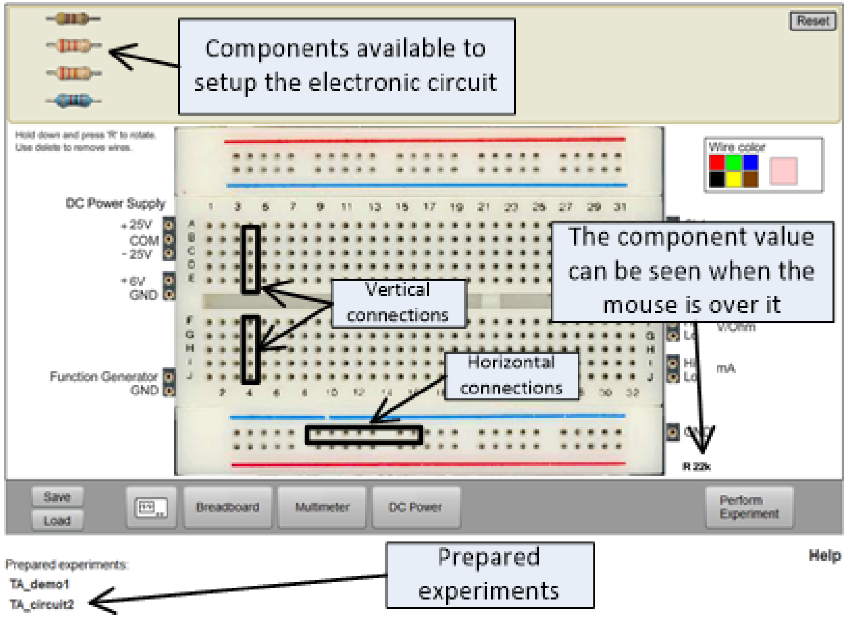
- In which way **the use of simultaneous resources** (hands-on, simulation and remote labs along with calculus), contributes to promote students’ learning and engagement?
- Are there **VISIR tasks characteristics** that affect students’ learning and engagement?
- Are there **teacher mediation traces** that can be linked to better students’ learning and engagement?
- Are there **students’ characteristics** that can be associated to students’ learning and engagement?

VISIR

Brief description of the **VISIR** (Virtual Instrument Systems in Reality) remote lab and the **VISIR+ Project**.

VISIR

- Started in **1999**, at the **BTH**, Sweden. Launched in **2004**.
- It is based on **virtual Instrumentation**, i.e., real physical instrumentation accessible through virtual interfaces.



VISIR+ Project

Educational Modules for **Electric and Electronic** Circuits Theory and Practice following an Enquiry-based Teaching and Learning Methodology supported by **VISIR**.

PARTNERS

- IPP - ISEP
- BTH
- CUAS
- IFSC
- PUC-Rio
- UDeusto
- UFSC
- UNED
- UNR
- UNSE
- IRICE-CONICET
- ABENGE

Methodology

Relies on a **multicase** study research methodology and combines quantitative and qualitative data, that is, uses a **mixed method** approach.

Case Studies Characterization

24% of the students

Secondary Education

Case #	Country	Institution	Implementation Topic	Degree	Course Name	Level	Number		
							h/w	T	St
C1	Br	IFC C. Sombrio	Physics	Informatics	Physics	Non-EE	2	1	65
C2	Br	IFC Aranangu á	Electricity	Electromechanics	Basic Electronics	EE	2	1	25
C3	Ar	IPS	Physics	Constructor/ Industrial Facilities/ Mechanics	Physics IV	Non-EE	2	4	121

Technological Education

Case #	Country	Institution	Implementation Topic	Degree	Course Name	Level	Number		
							h/w	T	St
C4	Br	SATC	Electricity	Industrial Automation Technologies	Circuits Theory	EE	4	1	15
C5	Br	IFSC	Electricity	Technical Electronics	Electricity I	EE	6	3	164
C6	Br	IFSC	Electricity	Technical Electronics	Electricity II	EE	5	1	8
C7	Br	ITAJAI	Electricity	Technical Electronics	Instrumentation	EE	2	1	35

Higher Education

DECEL

Case #	Country	Institution	Implementation Topic	Degree	Course Name	Level	Number		
							h/w	T	St
C8	Br	UFSC	Mathematics	Computer/ Energy	Calculus IV	Non-EE	4	1	124
C9	Br	UFSC	Mathematics	Computer/ Energy	Probabilities and Statistics	Non-EE	4	1	84
C10	Br	SATC	Electronics	Mechatronic	Instrumentation I	Non-EE	2	1	45
C11	Br	IFSC	Electricity	Electronic	Circuits III	EE	3	1	19
C12	Br	IFSC	Electricity	Electronic	Electronics II	EE	4	1	18
C13	Br	IFSC	Electronics	Industrial Electronics	Amplifying Structures	EE	4	1	10
C14	Br	PUC-Rio	Electricity	Control & Automation / Electrical/ Computer	Electric Circuits Laboratory	EE	8	2	59
C15	Br	PUC-Rio	Projects	Control & Automation / Electrical/ Computer	Engineering Introduction	EE	4	4	20
C16	Br	PUC-Rio	Electricity	Chemical/ Civil/ Environmental/ Materials /Mechanical/ Production/ Petrol/ Industrial	General Electricity Laboratory	Non-EE	3	4	442
C17	Br	UERJ	Electricity	Electrical	Electric and Magnetic Measurements	EE	4	2	50
C18	Br	UCP	Electricity	Electrical	Applied Electricity	EE	4	1	15
C19	Ar	UNR	Electronics	Electronic	Physics of Electronic Devices	EE	6	4	55
C20	Ar	UNR	Electricity	Electronic	Circuits Theory	EE	6	5	91
C21	Ar	UNR	Electronics	Electronic	Devices & Electronic Circuits I	EE	6	7	60
C22	Ar	UTN FRRo	Physics	Electrical	Physics II	EE	5	3	41
C23	Ar	UNSE	Electronics	Electronic/ Electrical/ Electromechanical	Electronics 2	EE	7	2	13
C24	Ar	UNSE	Electronics	Electronic/ Electrical/ Electromechanical	Electronics 3	EE	7	2	8
C25	Ar	UNSE	Physics	Electronic	Electronics 1	EE	6	2	8
C26	Pt	ISEP	Physics	Systems	Applied Physics	Non-EE	6	1	199

76% of the students

3 course editions

2 course editions

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Data Collection Tools and Analysis

TOOLS

- Questionnaire (SSQ)
  - F1 – Students' perceived learnings
  - F2 - Students' satisfaction with VISIR
  - F3 - Students' satisfaction with support
- Teachers' interview
  - F2_T – Teachers' satisfaction with VISIR
- Documents:
  - Educational module. Target course fact file
  - Students academic results. VISIR Usage
- Informal Contacts
- Observation

ANALYSIS

Quantitative: Correlation, Difference tests, Chi-square test

Qualitative: Content Analysis, Grounded Theory

Results

Explores the results of **26 cases** (43 didactical implementations), involving **52 teachers** and **1794 students**.

VISIR's Implementation

Combination of experimental resources

Experimental Resources Combination	Cases	Average # of Tasks	
		Hands-on	VISIR
VISIR	C3(1st), C20		2
VISIR + simulation	C6, C8, C17(2nd)		1.2
VISIR + hands-on	C1, C2, C9, C16, C19(2nd), C21, C26	6.1	1.6
VISIR + simulation + hands-on	C3(2nd), C4, C5, C7, C10, C11, C12, C13, C14, C15, C17(1st), C18, C19(1st, 3rd), C22, C23, C24, C25	6.8	2.1

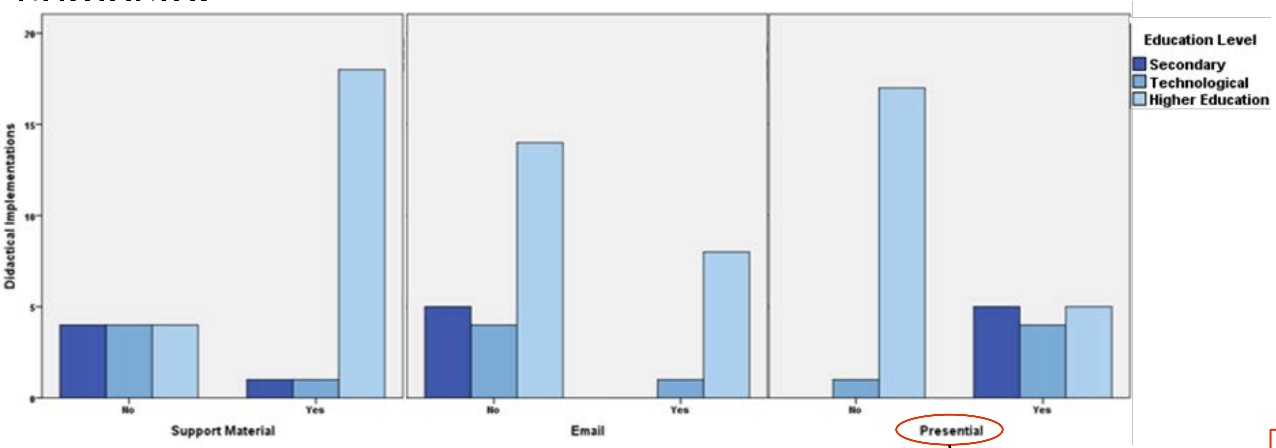
VISIR and hands-on combination

VISIR Usage		Cases
Prior the hands-on	Similar experiments	C7, C18, C21, C26(1st, 2nd)
	Different experiments	C3(2nd), C5, C10, C16, C25
After the hands-on		C19
Prior and after the hands-on		C14, C24, C26(3rd)
Not clear		C1, C2, C4, C11, C12, C13, C15, C17, C22, C23
Contextualization		C8, C9

DECEL

VISIR’s Implementation

Support during the semester



47%

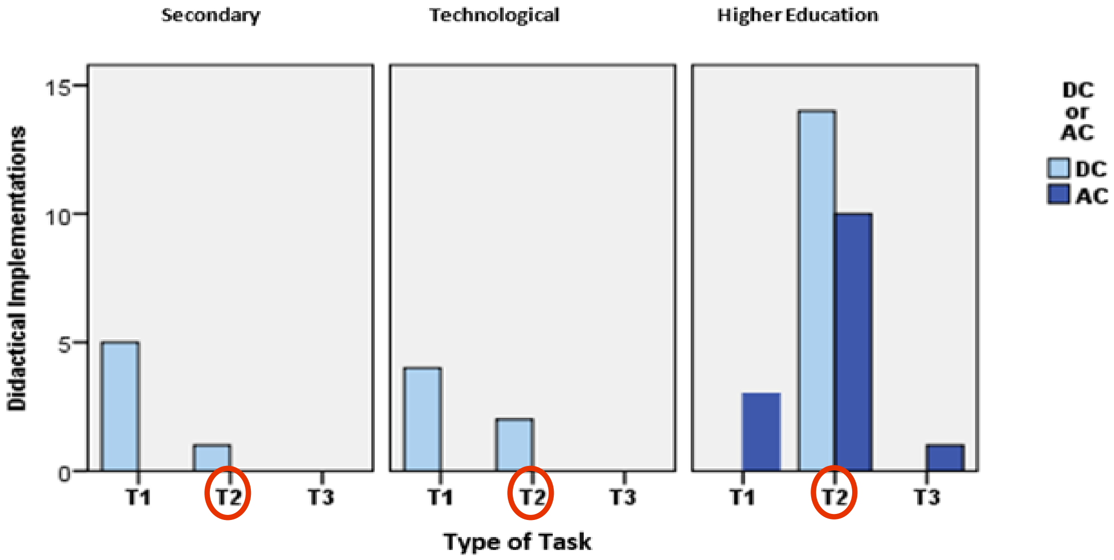
21%

33%

Class Monitoring Office Hours

VISIR's Implementation

Tasks attributes



1 to **4** Tasks
37% **Group**/40% **Individual** Tasks
26% **Mandatory** Tasks

VISIR's Implementation

- Courses with 2 or 3 course editions – **modifications** in subsequent didactical implementations:

Characteristics	Cases
Increase VISIR usage (%) in course contents	C5, C8, C9, C10, C19
Implemented other experimental resources	C3, C9
Increase task weight in final grade	C3, C26
Change tasks regime (to mandatory and/or group)	C3, C9, C19
Increase number of tasks and/or its complexity	C3, C9, C14, C26
Adjust implementation competence goal level	C10, C19

Teachers **reinforced VISIR usage** making a special effort when **planning and implementing** VISIR tasks.

Teachers' Perception

No Negative Factors (25 %)

Teachers were very satisfied with VISIR (**1** to **5 implementations**; **3** to **85 accesses/task**).
The satisfaction is intrinsically connected to the added value they consider VISIR has in their practices.

There is a correlation with the education level: $r_P = 0.404$ ($p = 0.011$; $N = 39$).

Positive Factors

- Increase students' practise.
- Increase students' motivation.
- Diversify teacher autonomy.

Negative Factors

- Configuration issues.
- Teachers' experience required.
- Interface old fashionable.

External Factors

- Problems with internet.
- Computer and/or computer room not adequate.

Students' Results

- Good grades in VISIR (exception: **C11**), other tasks and lab.
- Worse results in the exam and final grade.
- Success in the course varies with education level.
- N. VISIR accesses/task shows a wide variability
- F1 (perceived learnings) is 3 for the majority.
- F2 (satisfaction with VISIR) is 3 for the majority.
- F3 (satisfaction with support) is lower.
- The majority of students **prefer remote labs**.

42.5 %

Electronics students access more

C7 (F1=F2=4)
C14 (F1=2; F2=1)

72% in the secondary

Students’ Results

- Their **satisfaction** with VISIR is correlated with the perceived **utility** in their **learning process**.
- VISIR usage depends more on "**external factors**" than their direct perception of the tool.
- VISIR has a positive **impact in their academic performance**:
  - Students with better **academic results** are **more critical and demanding** in their evaluation.
  - VISIR can be **more appropriate** for **students** with **some difficulties**.

Students’ Results

VISIR has **no disadvantages** (15% students)

Positive Factors

- The potential of the equipment.
- Access from anywhere/anytime.
- Better more complete understanding.
- No fear of damaging.

Negative Factors

- Operating issues.
- Problems in understanding.
- Poor interface/old fashionable/too simple.

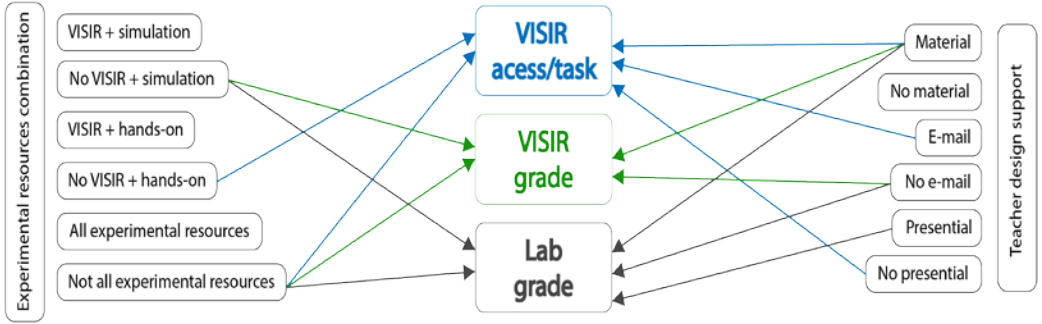
External Factor

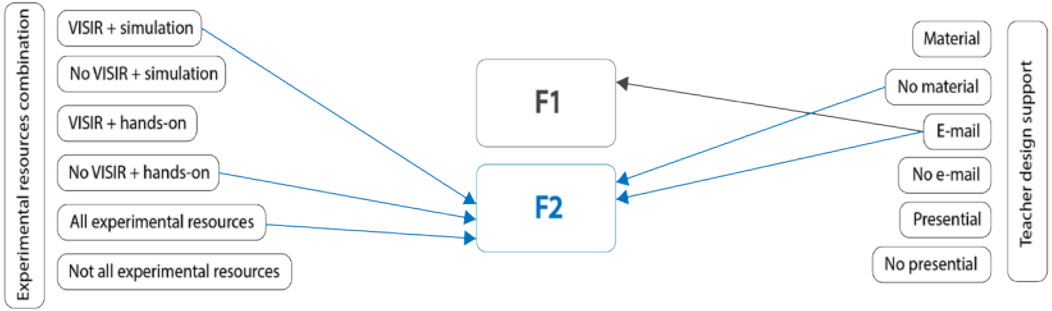
- Problems with internet.

907 **positive** remarks and 555 negative

959 answered SSQ (Q21 – 76%; Q22 – 73%)

Use of Resources & Students' Results

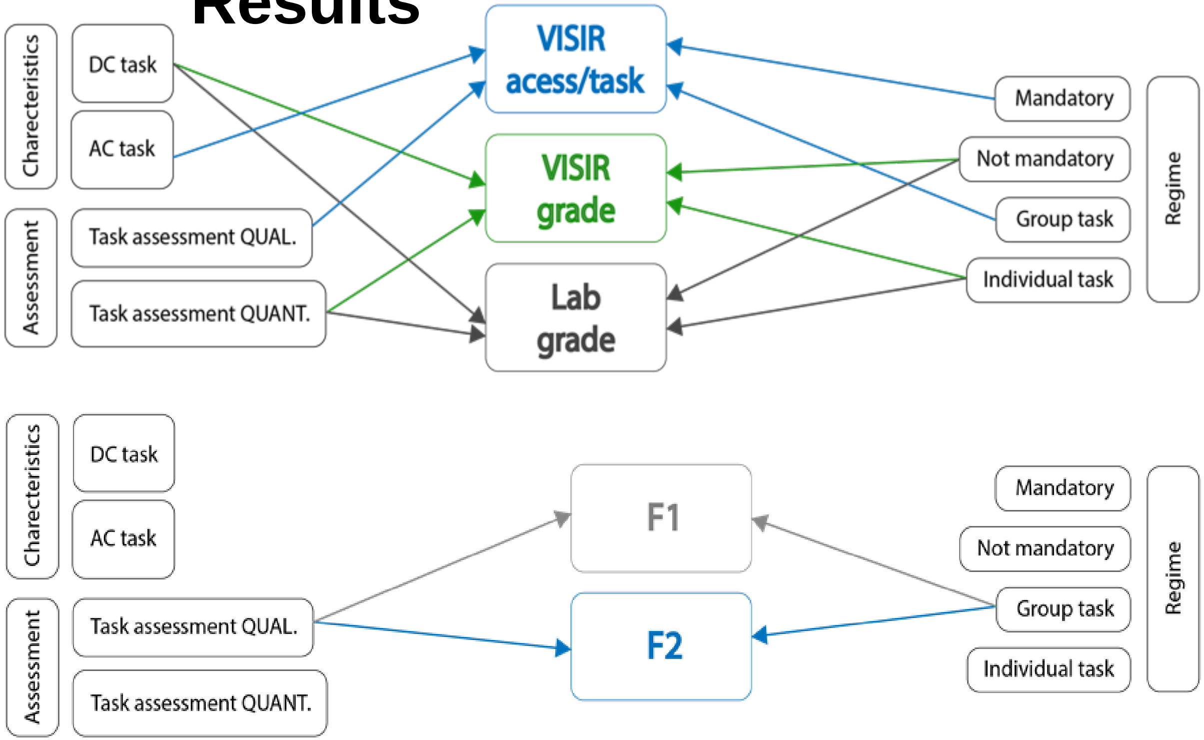




Students need **support** – in the right proportion (**tips**, **clues**) – to keep the **tasks authentic** and challenging – to compel them to **autonomous work**.

The use of **simultaneous resources** promotes the development of **HOS**

Tasks Characteristics & Students' Results



When the tasks are **mandatory,** they **use more VISIR**. The **qualitative assessment** impacted their VISIR usage and their **satisfaction**. Students also achieve a higher perception in **group tasks**.

RQ1 Answer

- In which way the **use of simultaneous resources** (hands-on, simulation and remote labs along with calculus), contributes to promote students' learning and engagement?

  - Teachers support plays a crucial role.
  - The order of TL and NTL has little effect.
  - Evenly distributed balance of experimental resources.
  - Adequate for course that do not have an experimental component.

Its use, *per se*, does not seem to have a direct impact in students' grades. But there is an association between its usage and **development of HOS** and **students' satisfaction.**

RQ2 Answer

- Are there **VISIR tasks characteristics** that affect students' learning and engagement?

  - VISIR tasks aligned with ILO and the level of competence.
  - VISIR tasks vary in content and be diversified.
  - Assessment has a major influence.
  - Tasks that promote collaborative work are valued by students.

As useful for introductory courses as for more advanced ones, as long as the **didactical implementations** are **planned accordingly** to the **type of course** and **students' background**.

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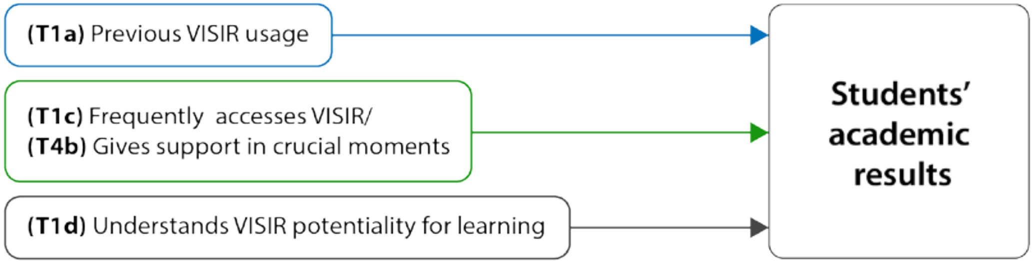
RQ3 Answer

- Are there **teacher mediation traces** that can be linked to better students' learning and engagement?
  - When teachers were not so enthusiastic with VISIR, students learning, and engagement is affected.
  - Some mediation traces seem more dominant.



RQ4 Answer

- Are there **students' characteristics** that can be associated to students' learning and engagement?

  - The course level (EE/non EE) has a significant influence on students' VISIR usage. These more interested and proficient students in these topics tend to use more VISIR.
  - The more enthusiastic and reflective students are, the more they use VISIR and the better perception they have.

"**Students level**", per se, does not determine students' learning outcomes and engagement. Teachers should plan **didactical implementations accordingly**.

Conclusion

Presents the main **conclusions** of the work.

DECEL

Suggestions/Advices	Experimental Resources Combination	VISIR Tasks Characteristics	Teacher Mediation
	- Prepare an introductory activity (and some support material) and give students time - Give support to students – with minimum supervision – but providing clues and tips - Choose the sequence of VISIR and hands-on lab (order) according to what suits you best - Using VISIR before hands-on is a good tactic for introductory courses and/or students first contact with EE topics: increase their confidence in labs - Propose an evenly distributed balance of experimental resources - Find strategies to stimulate students to use VISIR	**Propose tasks:** - Perfectly aligned with the ILO(s) and type/level of competence - Diversified in content - Involving the comparison and the analysis of the data obtained with other experimental resources and/or theoretical calculations - Contributing with an adequate weight to (students') final grade or mandatory - Promoting collaborative work among students If you use qualitative assessment include pertinent comments on students' performance	- Be particular alert to the mediation traces that seem to be more dominant (in affecting students' results): **teachers' experience with VISIR, teachers give support** (only) **in crucial moments** - With time, experience and support by colleagues, you will be able to be more alert to this component - Try to address most relevant mediation characteristics/ traces in (and out) your classes

Students' Characteristics: Education level, course level, students background (partially), some psychological characteristics (enthusiasm, reflection)

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Advancement of Knowledge

Teachers from higher levels of education more satisfied with VISIR

Methodology:

Use of several experimental resources (hands-on, simulation, VISIR) along with calculus

Perfectly adequate for courses that do not have an experimental component, nor its contents are directly related to EE topics (e.g. mathematics for contextualizing theoretical concepts)

As useful for introductory courses as for more advanced ones (where the addressed topics are more complex)

VISIR seems to be more useful to students that require some support in their learning (still struggling with some difficulties)

Students from lower levels of education more satisfied with VISIR

Thanks!

You can find me at

- nmm@isep.ipp.pt