

GRUPPO DI RICERCA IN DIDATTICA E STORIA DELLA FISICA E DELLA CHIMICA

Linee guida della ricerca, risultati e prospettive

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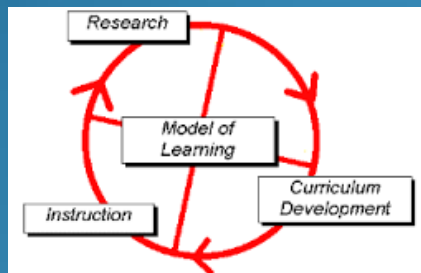
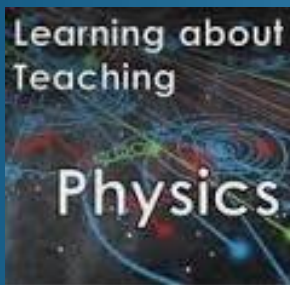
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Prof. Leonardo Bellomonte

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Nicola Pizzolato, Giovanni Tarantino.*

Le linee di ricerca attuali

Didattica della Fisica



Storia della Chimica



Ricerca in Didattica della Fisica

1. Who are Physics Education Researchers?

Physics Education Research has become recognized as a legitimate research subfield of physics only recently. Not too long ago, one could easily pick out physics faculty who did not conduct research. You would just open Barron's or Peterson's phonebook-like guide to graduate programs, turn to your favorite department's page, and see who was listed as "Physics Education." Those would be the faculty who focused exclusively on teaching. Today it is more difficult to make this distinction. Many departments have faculty who are conducting rigorous research on how students learn our subject. They are physicists who treat education as a topic worthy of scientific study.

Nonetheless, there is still confusion about this subfield of physics. Perhaps we should adapt the graduate program guide approach and explain what PER is not. Physics education research is not just curriculum development or instructional design. It is not merely a service enterprise for teachers, although its findings can certainly be put to good use by them. Instead, PER is focused inquiry into what happens as students struggle to grasp and use the concepts of physics. Obviously there are limitations to discerning a person's thoughts, but repeated patterns of responses (either in a single student or across many students at different times and places) can lead us to generate theories that explain other situations and, in some cases, have predictive power. This would be considered "basic" PER, in the sense that it is fundamental or foundational research. There is also "applied" PER where the researcher uses results from basic PER to modify instruction, examine the educational efficacy of the new approach, and use these results to iteratively improve instruction with more follow-up assessment.

Ricerca in Didattica della Fisica

Alcune riviste:

PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH

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NEW ARTICLE
Toward instructional design principles: Inducing Faraday's law with contrasting cases
Eric Kuo and Carl E. Wieman
Phys. Rev. Phys. Educ. Res. 12, 010126 (2016)

Early exposure to contrasting cases improves student learning of physics concepts

EDITORIAL
Renaming *Physical Review Special Topics - Physics Education Research*
January 26, 2016
Charles Henderson announces that as of January 1, 2016, the name of *Physical Review Special Topics - Physics Education Research* (PRST-PER) was changed to *Physical Review Physics Education Research* (PREPER).

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Vol. 12, Iss. 1 — January - June 2016
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February 22, 2016
A classroom simulator with virtual students can provide young teaching assistants a controlled setting for practicing teaching

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Science Education

Edited by John L. Rudolph
Impact Factor: 2.825
ISI Journal Citation Reports® Ranking: 2014, 7/224 (Education & Educational Research)
Online ISSN: 1098-237X

Describing "Science Practice" in Learning Settings

Overlapping components of "science practice."
Abstract (Full Article, HTML, PDF)

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AAPT AMERICAN JOURNAL OF PHYSICS

Welcome to the *American Journal of Physics* (AJP). AJP publishes papers that meet the needs and intellectual interests of college and university physics teachers and students. This Journal was established in 1933 under the title the *American Physics Teacher*, which covers Volumes 1 through 7. The name was changed to the *American Journal of Physics* in 1940.

EDITOR'S PICKS

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International Journal of Science Education

Volume 38, Issue 4, 2016

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Jonathan Osborne, et al., 2003

Conceptual change: A powerful framework for improving science teaching and learning
Renders Duk, et al., Volume 25, Issue 6, 2003

Does Practical Work Really Work? A study of the effectiveness of practical work as a teaching and learning method in school science
Ian Abrahams, et al., Volume 36, Issue 14, 2008

Collaborative Inquiry

Expert Interview
Interview with Professor John Gilbert, Editor of *International Journal of Science Education*.

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Research in Science Education

ISSN 0157-244X (Print) 1575-1595 (Online)

Description
Research in Science Education is an international journal publishing and promoting scholarly science education research of interest to a wide group of people. The journal examines early childhood, primary, secondary, tertiary, workplace, and informal learning as they relate to science education. It publishes scholarly articles, RSE is looking for articulation of the principles and practices used by scholars to make sense of...

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Ricerca in Didattica della Fisica

Collaborazioni internazionali e nazionali:

- Centre for the Advancement of Mathematics and Science Teaching and Learning, Dublin City University, Ireland
- Division of Didactics of Physics, Pavol Jozef Šafárik University, Slovak Republic
- Physics Education Research Group, Univerzita Karlova V Praza, Czeck Republic
- Centre for Microcomputer Applications, Amsterdam, The Netherlands.
- Chemical Education Research Group, Jagiellonian University in Kracow, Poland
- Mathematics Education Research Group, Constantine the Philosopher, Nitra, Slovak Republik
- Unità di Ricerca in Didattica della Fisica, Università di Udine
- Unità di Ricerca in Didattica della Fisica, Università di Bologna
- Unità di Ricerca in Didattica della Fisica, Università di Napoli
- Unità di Ricerca in Didattica della Fisica, Università di Milano
- Unità di Ricerca in Didattica della Fisica, Università di Pavia
- Associazione per l'Insegnamento della Fisica AIF, c/o Liceo Classico "G. D. Romagnosi, Parma.

Ricerca in Didattica della Fisica

Alcuni punti fondamentali della ricerca svolta:

1) Analisi del contenuto fisico da insegnare e “ricostruzione educativa”

Il modello della “Educational Reconstruction” (la struttura del contenuto fisico, è riesaminata e ricostruita da un punto di vista pedagogico). Alcuni esempi: radiazione termica, fattore di Boltzmann, concetto di forza, fisica quantistica, etc.)

2) Ricerca sui processi di Apprendimento e Insegnamento

Apprendimento (le idee, le concezioni, le rappresentazioni comuni degli studenti sui concetti fisici, il problem solving, i modelli mentali, ...);

Insegnamento (tecniche e strategie di apprendimento, situazioni didattiche, effetti dell'interazione sociale, Pedagogical Content Knowledge, ...)

Metodi didattici (Inquiry Based Learning, uso del laboratorio, ambienti di modellizzazione, uso consapevole delle ICT, ...)

Valutazione (metodi per monitorare i risultati degli studenti, influenza delle variabili “affettive”, ...)

Il ruolo del docente (le idee degli insegnanti sull'insegnamento e sul loro ruolo in esso, la Natura della Scienza, ...)

Ricerca in Didattica della Fisica

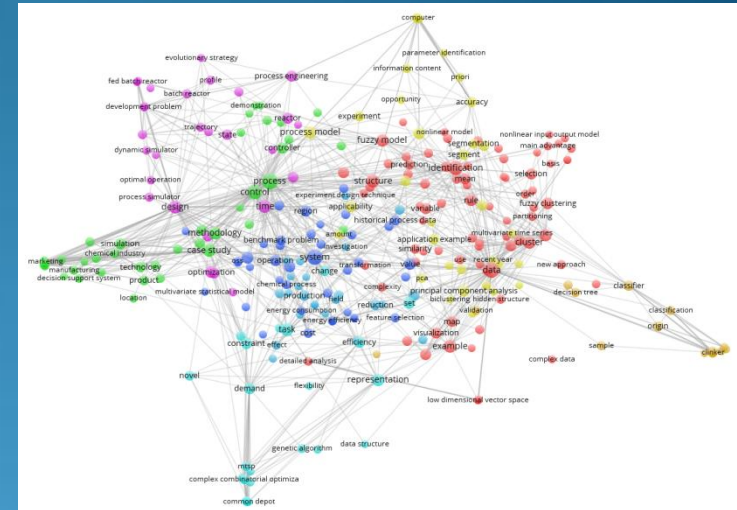
Studio delle comunità di apprendimento come sistemi complessi

Costruzione e uso di metodi di analisi dati (tecniche di Data Mining (Cluster Analysis, Factor Analysis), ...)

“ Following research fields that have recognized the drawback of linear modelling, i.e., assuming a direct link between cause and effect, there is a movement in Physics Education Research towards viewing education as a complex system. This is because the educational system gets recognized as being constituted by multiple interacting parts, where the adaptation and evolution of the system is partially unpredictable.

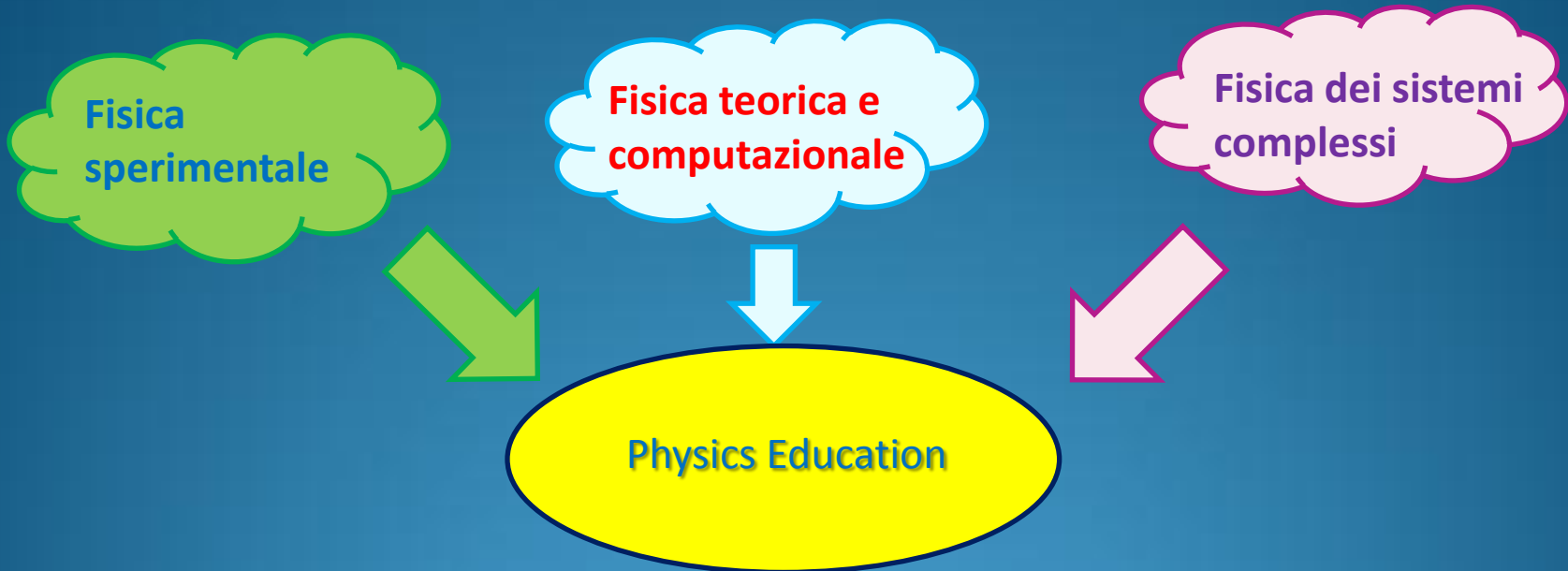
Applications of Complexity Thinking in Physics Education Research present new powerful ways of informing the improvement of physics education.”

University of Uppsala (Sweden) PER Group.



Ricerca in Didattica della Fisica

Temi di ricerca



- ✓ **INSEGNAMENTO DELLA FISICA CON APPROCCI INNOVATIVI , ANCHE A LIVELLO UNIVERSITARIO**
- ✓ **PROGETTAZIONE E VALIDAZIONE DI AMBIENTI DI APPRENDIMENTO PER UNA TRATTAZIONE EFFICACE DI ARGOMENTI AVANZATI DI FISICA**
- ✓ **SVILUPPO DI TECNICHE DI DATA MINING, CLUSTER ANALYSIS, FACTOR ANALYSIS PER LO STUDIO QUANTITATIVO DEI PROCESSI DI APPRENDIMENTO**

Ricerca in Didattica della Fisica

Inquiry Based Science Education a livello universitario

*I laureati dovrebbero possedere conoscenze specialistiche, legate ai contenuti propri della disciplina, capacità di risolvere problemi pratici, competenze sull'uso di strumenti matematici, scientifici e tecnologici per analizzare e interpretare i dati, capacità di comunicazione e buona attitudine per intraprendere un apprendimento permanente. Lo sviluppo di tutte queste competenze ha bisogno di un **insegnamento efficace delle scienze**, in grado di fare acquisire agli studenti una più profonda comprensione dei concetti fondamentali disciplinari e, allo stesso tempo, di **rafforzare le loro capacità di ragionamento e le loro abilità trasversali**.*

I metodi tradizionali di insegnamento della Fisica, principalmente basati sulla trasmissione delle informazioni e delle leggi, producono un apprendimento non duraturo e non efficace. Il metodo scientifico, nella forma in cui viene comunemente utilizzato non riesce a coinvolgere gli studenti in una profonda comprensione dei contenuti.

Un approccio inquiry (active learning) potrebbe rappresentare una integrazione molto valida alla didattica tradizionale della Fisica anche in ambito universitario.

Ricerca in Didattica della Fisica

Inquiry Based Science Education a livello universitario

Livelli molto alti di abilità di pensiero possono essere raggiunti "forzando" gli studenti a sperimentare personalmente e a sforzarsi per trovare soluzioni ai problemi di vita comune. Questo può essere fatto insegnando agli studenti a porre domande scientificamente rilevanti, a effettuare indagini scientifiche, ottenendo misurazioni significative e analizzando i dati, a creare modelli esplicativi, a verificare i risultati con ulteriori prove, a condividere e discutere i risultati con i coetanei.

Questa "forzatura" può essere ottenuta coinvolgendo gli studenti in progetti di apprendimento molto interessanti e che li stimolino fortemente a partecipare attivamente alla ricerca scientifica.

PHYSICAL REVIEW SPECIAL TOPICS - PHYSICS EDUCATION RESEARCH 10, 010107 (2014)

Open-inquiry driven overcoming of epistemological difficulties in engineering undergraduates: A case study in the context of thermal science

Nicola Pizzolato,^{1,*} Claudio Fazio,¹ Rosa Maria Sperandeo Mineo,¹
and Dominique Persano Adorno²

¹*UOP-PERG (University of Palermo–Physics Education Research Group),
Università di Palermo, Palermo 90128, Italy*

²*GIP (Group of Interdisciplinary Physics), Dipartimento di Fisica e Chimica,
Università di Palermo, Palermo 90128, Italy*

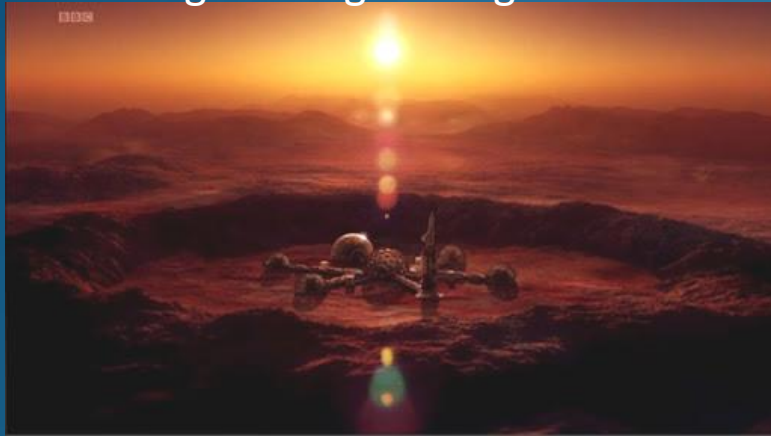
(Received 15 August 2013; published 18 February 2014)

Ricerca in Didattica della Fisica

Inquiry Based Science Education a livello universitario

MISSION TO MARS:

A research-based learning environment for engineering undergraduates



PHYSICAL REVIEW SPECIAL TOPICS - PHYSICS EDUCATION RESEARCH 10, 010107 (2014)

Open-inquiry driven overcoming of epistemological difficulties in engineering undergraduates: A case study in the context of thermal science

Nicola Pizzolato,^{1,*} Claudio Fazio,¹ Rosa Maria Sperandeo Mineo,¹ and Dominique Persano Adorno²

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Università di Palermo, Palermo 90128, Italy

(Received 15 August 2013; published 18 February 2014)

Open Inquiry



Ricerca in Didattica della Fisica

Inquiry Based Science Education a livello universitario

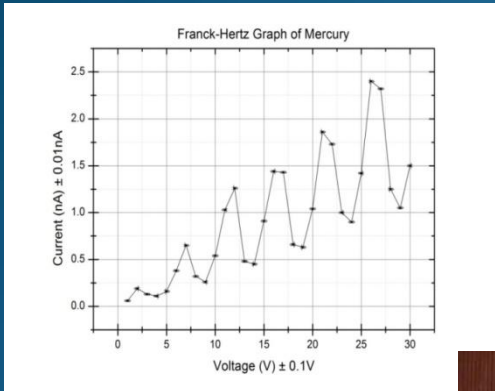
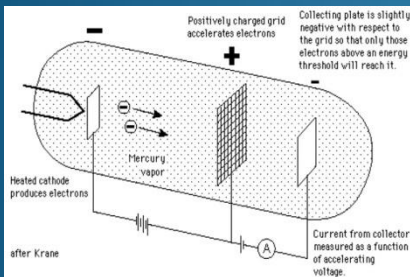


TABLE I. – Percentage of students showing Speech Events (SE) during the performance of the Franck-Hertz experiment.

Speech events (SE)	Percentage of students showing SE during the performance of the Franck-Hertz experiment	
	Traditional Inquiry	Structured Inquiry with activation
Critique	27%	75%
Elicitation of critique	13%	54%
Awareness of knowledge gained	34%	82%
Contextualization of research	17%	63%
Explanation of research	27%	67%
Negotiation	12%	54%
Consensus Building	18%	68%



IL NUOVO CIMENTO 38 C (2015) 109
DOI 10.1393/ncc/i2015-15109-y

COLLOQUIA: GIREP/MPTL 2014

Structured Inquiry

An inquiry-based approach to the Franck-Hertz experiment

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Viale delle Scienze, Ed. 18, 90128 Palermo, Italy

Ricerca in Didattica della Fisica

Progettazione e validazione di ambienti di apprendimento per una trattazione efficace di argomenti avanzati di fisica

Argomenti di fisica avanzata e laboratori sperimentali su tali argomenti sono raramente affrontati dai docenti, maggiormente concentrati sui laboratori introduttivi di fisica. Questa tematica di ricerca cerca di colmare questo divario, progettando ambienti di apprendimento e fornendo esempi di laboratori avanzati, da utilizzare durante la laurea specialistica o il master.

IOP Publishing

European Journal of Physics

Eur. J. Phys. 36 (2015) 055017 (19pp)

doi:10.1088/0143-0807/36/5/055017

Elucidating the electron transport in semiconductors via Monte Carlo simulations: an inquiry-driven learning path for engineering undergraduates

Dominique Persano Adorno, Nicola Pizzolato and Claudio Fazio

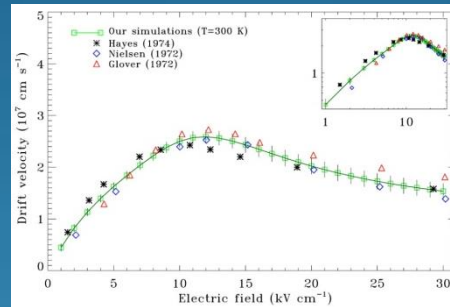
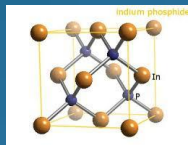
Physics Education Research Group, Dipartimento di Fisica e Chimica, Università di Palermo, Italy

Proprietà di trasporto nei semiconduttori

Simulazione Monte Carlo

Ricerca in Didattica della Fisica

Progettazione e validazione di ambienti di apprendimento per una trattazione efficace di argomenti avanzati di fisica



Inquiry sequence	Reasoned student questions	Planned simulations	Concepts acquired
Phase I	<ol style="list-style-type: none"> 1) Which physical quantities affect the electron velocity-field characteristic? 2) How the electron energy changes at different values of the driving electric field? 3) What really happens to the electron ensemble at electric fields higher than the Gunn field? 	Study of drift velocity, energy and occupation number of electrons in InP bulk for lattice temperature $T=77$ and 300 K and a driving electric field ranging between 1 and 30 kV cm^{-1} .	Gunn Effect; Role of intervalley transition; Dependence of phonon scattering probability on the temperature.
Phase II	How can we be definitely sure that the observed maximum in the velocity - field characteristic can be ascribed to intervalley transitions?	Study of electron dynamics, forcing all electrons to remain in the Γ -valley, independently of their energy and changing the value of the effective mass.	Effective mass as a measure of the inertial response of the system.
Phase III	What are the effects due to a change on the impurity density?	Study of electron dynamics at different values of the doping density.	Dependence of intravalley transition probabilities on the energy; Screened Coulomb interaction.

IOP Publishing

European Journal of Physics

Eur. J. Phys. **36** (2015) 055017 (19pp)

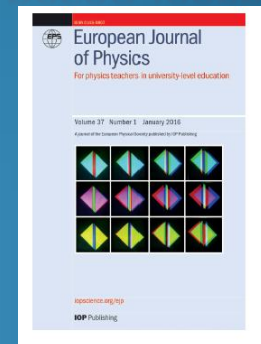
doi: 10.1088/0143-0807/36/5/055017

Elucidating the electron transport in semiconductors via Monte Carlo simulations: an inquiry-driven learning path for engineering undergraduates

Dominique Persano Adorno, Nicola Pizzolato and Claudio Fazio

Physics Education Research Group, Dipartimento di Fisica e Chimica, Università di Palermo, Italy

The inquiry-based learning cycle



Questo articolo è stato incluso negli **Highlights 2015** di EJP.

Ricerca in Didattica della Fisica


Progettazione e validazione di ambienti di apprendimento per una trattazione efficace di argomenti avanzati di fisica

Grafene

Teoria dei gruppi


Proprietà di simmetria

Equazione di Dirac



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University of Palermo – Physics Education
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GIREP 2015 International Conference on Physics Education
Key competences in physics teaching and learning
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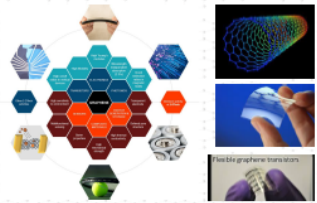
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Electronic properties of graphene: A learning path for undergraduate students

Dominique Persano Adorno, Leonardo Bellomonte and Nicola Pizzolato
UOP_PERG (University of Palermo, Physics Education Research Group)
Department of Physics and Chemistry, University of Palermo, Italy

The purpose of this work is to present a learning path where students may be guided to deepen their understanding of the fundamental concepts underlying the electronic properties of new materials, graphene in particular. To achieve this task, we propose a learning path based on the introduction and utilization of the basic concepts of Solid State Physics, rarely used in learning paths, such as the symmetry properties of the crystal lattice and the group theory, the features of the electron energy bands and the degenerations of the wave function, the Dirac equation. Particular emphasis is given to the way of introducing these concepts, where a basic knowledge of relativistic behaviour and quantum physics is first required. Here we present and discuss these concepts as possible steps of a learning sequence that physics/engineering undergraduates may be guided to follow in order to reach a deeper understanding of the physics underlying the complex world of graphene and its properties. The conceptual framework here presented might support both instructors and students on performing reasoned sequences of further scientific investigations.

Graphene: the miracle material that could revolutionize our world



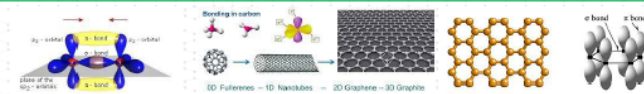
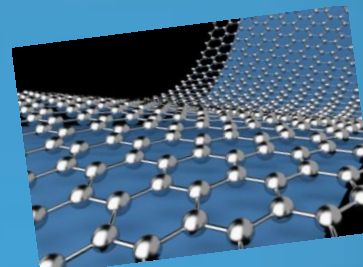
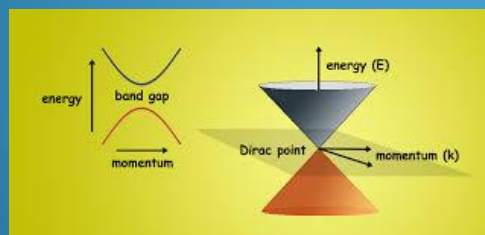
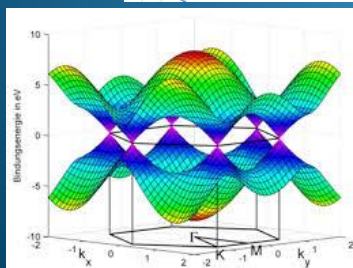
Since its discovery, there has been a massive explosion of interest in the study of graphene, a single layer of graphite. Indeed, thanks to its remarkable unusual electrical and optical properties, the scientific and technological applications of this material seem to be unlimited. **The understanding of its properties can open doors towards new frontiers in electronics, as well as in manufacturing applications.** The circumstance that in graphene the electron mobility is much greater than in semiconductors promotes its use in bipolar transistors and integrated circuits.

Difficulties on achieving an effective learning of Graphene properties

A deeper understanding of the peculiarities of the electron behavior in a single layer of graphene is essential in undergraduate education of electronic engineering and physics students, as well as in semiconductor science. Since the current scientific literature on the quantum mechanics of graphene is beyond the scope of the usual undergraduate courses and outside the experience of most non-specialist physicists, an effort is devoted to fill up this shortcoming. Traditional courses introducing quantum mechanics in solid state physics and materials science provide the students with a theoretical background on the band structure, the origin of energy gaps, the concept of effective mass and the basic mechanism of phonon-induced scattering. However the students are not trained to an appropriate use of them. Moreover, student difficulties may be related to the way such concepts are presented to them, sometimes because of introducing these concepts as separate chunks of knowledge or using fruitless mathematical formalisms. In this regard, often students have difficulties to visualize the physics meaning beyond equations. Finally, student difficulties may also arise from epistemological stances that limit an effective understanding of the presented concepts.

Students achieve an effective instruction and hold a stable theoretical knowledge when they become able to view knowledge as an instrument of practice for further discoveries. An effective and efficient science instruction, should have a general character engaging the students toward a full comprehension of the fundamental concepts and training them to connect transversal facts that at a first look may appear to be not related. Graphene is adapt to achieve this task.

The crystal structure of graphene consists of a xy planar honeycomb lattice of carbon atoms. The in-plane σ bonds are formed from the $2s$, $2p_x$ and $2p_y$ orbitals hybridized in a sp^2 configuration. They give rigidity to the structure and do not contribute to the conductivity. The $2p_z$ orbital binds covalently with neighboring atoms leading to the formation of the half filled π band, contributing to the conductivity.

Ricerca in Didattica della Fisica

Sviluppo e utilizzo di tecniche di data mining (cluster analysis, factor analysis) per lo studio quantitativo dei processi di apprendimento

In questa tematica di ricerca vengono sviluppate, validate e utilizzate, **tecniche di clustering gerarchico e non gerarchico**, che sono abbastanza conosciute in altri ambiti di ricerca, ma che rappresentano una novità pressoché assoluta per la Ricerca in Didattica della Fisica. Accanto a tali tecniche, il Gruppo sviluppa e utilizza metodi di **analisi implicativa e di analisi qualitativa**.

Ad esempio, gli approcci alla costruzione di modelli fisici da parte di studenti universitari possono essere studiati tramite le risposte da loro fornite ad un questionario appositamente progettato e validato. Lo studio è svolto tramite una analisi di cluster costruita a partire da uno schema di riferimento generale sull'epistemologia della matematica e della fisica.

PHYSICAL REVIEW SPECIAL TOPICS - PHYSICS EDUCATION RESEARCH 8, 010110 (2012)

Prospective elementary teachers' perceptions of the processes of modeling: A case study

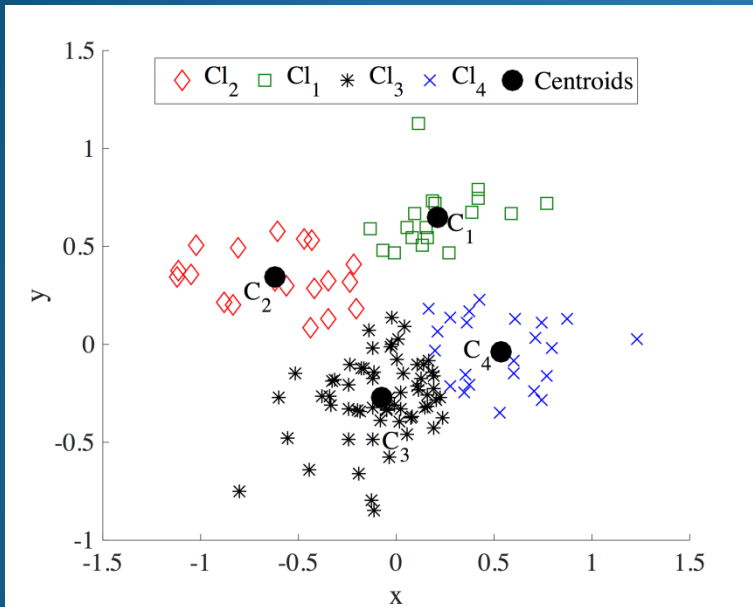
Claudio Fazio,^{1,*} Benedetto Di Paola,² and Ivan Guastella¹

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(Received 29 July 2011; published 15 March 2012)

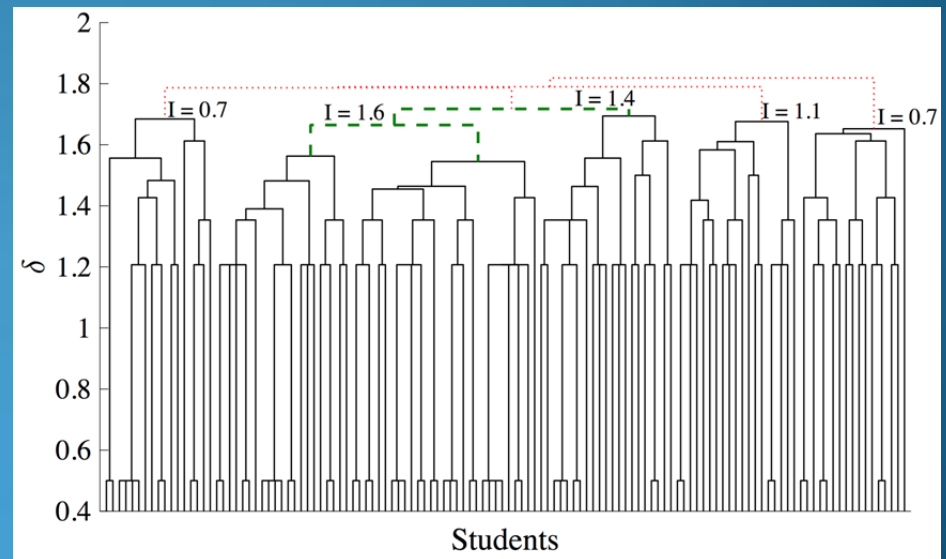
Ricerca in Didattica della Fisica

Sviluppo e utilizzo di tecniche di data mining (cluster analysis, factor analysis) per lo studio quantitativo dei processi di apprendimento



Cluster	Cl ₁	Cl ₂	Cl ₃	Cl ₄
More frequent answers	1B, 2C, 3B, 4A	1B, 2B, 3E, 4A	1C, 2B, 3A, 4A	1C, 2C, 3B, 4B
Number of subjects	18	19	63	24
$\langle S_k \rangle$	0.75	0.62	0.60	0.56
r_k^{norm}	1.3	0.5	-1.4	-0.3

Esempi di Cluster Analysis sulle risposte ad un test



Ricerca in Didattica della Fisica

Sviluppo e utilizzo di tecniche di data mining (cluster analysis, factor analysis) per lo studio quantitativo dei processi di apprendimento

PHYSICAL REVIEW SPECIAL TOPICS - PHYSICS EDUCATION RESEARCH 9, 020101 (2013)

Investigating the quality of mental models deployed by undergraduate engineering students in creating explanations: The case of thermally activated phenomena

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Cluster Analysis of Educational Data: an Example of Quantitative Study on the answers to an Open-Ended Questionnaire







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Ricerca in Didattica della Fisica

Progetti EU finanziati e svolti/in corso

	<u>Introduction to Modelling in PHYSics</u>
 <p>Establishing a pathway for a common science teachers training framework</p>	<u>The Project</u> <u>UoP-PERG Materials</u>
	<u>European Teacher: Initial Training of Secondary School Teachers</u>
	Move'in Science: Modelling the European Science Teacher Education
	<u>ESTABLISH European Science and Technology in Action: Building Links with Industry, Schools and Home</u>
	OPEN DISCOVERY OF STEM LABORATORIES

Ricerca in Storia della Chimica

Gli avvenimenti e i personaggi che hanno caratterizzato lo sviluppo della ricerca e della didattica chimica a Palermo, dalla fondazione dell'Accademia ai primi anni del '900.

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