INTERNATIONAL CONFERENCE ON PHYSICS EDUCATION

1-5 OCTOBER 2018

Misty Hills Hotel and Conference Centre
Muldersdrift, Johannesburg, South Africa

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

ICPE

SOUTH AFRICAN INSTITUTE OF PHYSICS

INTERNATIONAL UNION OF PURE AND APPLIED PHYSICS

"To assist in the worldwide development of physics, to foster international cooperation in physics, and to help in the application of physics toward solving problems of concern to humanity"

60 MEMBER TERRITORIES

GENERAL ASSEMBLY

EXECUTIVE COUNCIL

INTERNATIONAL COMMISSIONS

- C1: Commission on Policy and Finance
- C2: Commission on Symbols, Units, Nomenclature, Atomic Masses and Fundamental Constants
- C3: Statistical Physics
- C4: Astroparticle Physics
- C5: Low Temperature Physics
- C6: Biological Physics
- C8: Semiconductors
- C9: Magnetism
- C10: Structure and Dynamics of Condensed Matter
- C11: Particles and Fields
- C12: Nuclear Physics
- C13: Physics for Development
- C14: Physics Education
- C15: Atomic, Molecular, and Optical Physics
- C16: Plasma Physics
- C17: Laser Physics and Photonics
- C18: Mathematical Physics
- C19: Astrophysics
- C20: Computational Physics

AFFILIATED COMMISSIONS

- AC1: International Commission for Optics
- AC2: International Commission on General Relativity and Gravitation
- AC3: International Commission for Acoustics
- AC4: International Commission on Medical Physics

WORKING GROUPS

- WG1: International Committee for Future Accelerators (ICFA)
- WG2: Communication in Physics
- WG5: Women in Physics
- WG7: International Committee on Ultrahigh Intensity Lasers (ICUIL)
- WG9: International Cooperation in Nuclear Physics (ICNP)
- WG10: Astroparticle Physics International Committee (ApPIC)
- WG11: Gravitational Wave International Committee (GWIC)
- WG12: Energy

Aims:

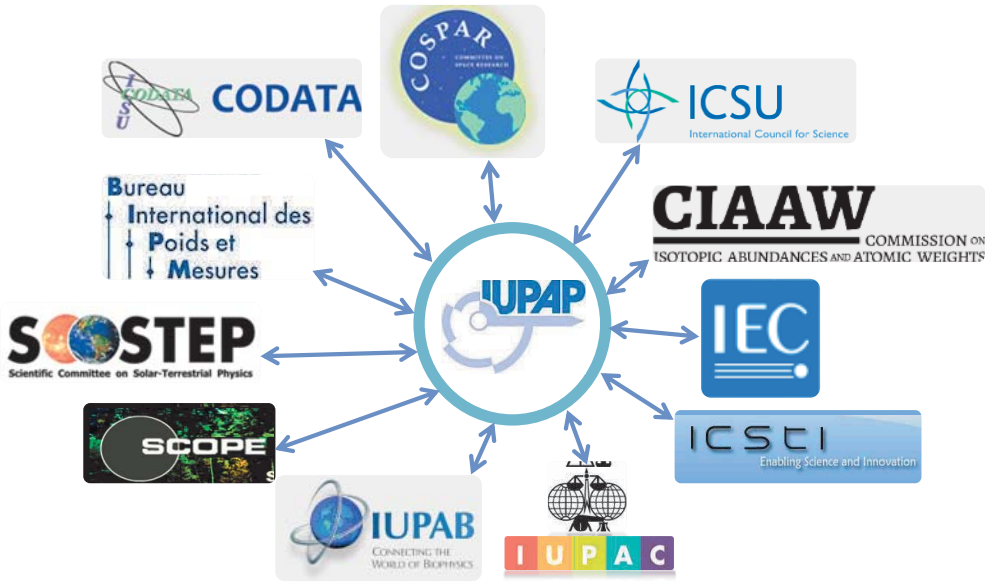
- to stimulate and promote international cooperation in physics;
- to sponsor suitable international meetings and to assist organizing committees;
- to promote international agreements on other use of symbols, units, nomenclature and standards;
- to foster free circulation of scientists; to encourage research and education.

Conference Sponsorship

Each year, IUPAP sponsors from 20 to 30 international conferences and awards grants to some of them. The financial support given to these International Conferences is derived from funds collected as membership dues from the members of IUPAP.

Inter Union Relations

As one of the basic sciences, physics relates to all branches of natural science. Many of the most exciting developments take place in the border areas between different disciplines. To cover interdisciplinary activities IUPAP maintains close liaison with several other Unions, ICSU Global Programs and ISCU Interdisciplinary Bodies. These collaborations take many forms, other organisations may have associate members on IUPAP Commissions, IUPAP may have representatives in their governing structures, or IUPAP may appoint people as official liaisons with them.



Young Scientist Awards
Commission Awards

Publications

IUPAP General Report: published after each General Assembly.

Newsletter: published three times a year, contains Union news.

SUNAMCO Document: IUPAP's authoritative guide to correct usage of symbols, units, and nomenclature. Translated into several languages.

Contact Us

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ACKNOWLEDGEMENTS

The Organising Committee of the ICPE-SAIP-WITS 2018 wishes to thank the exhibitors and sponsors.

EXHIBITORS

PASCO scientific and PERT INDUSTRIALS FOR A BETTER WAY TO TEACH

CAEN Tools for Discovery

SPONSORS

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SOUTH AFRICAN INSTITUTE OF PHYSICS

IUPAP

NRF National Research Foundation

South Africa Inspiring new ways www.southafrica.net

SOUTH AFRICAN INSTITUTE OF PHYSICS

INTERNATIONAL UNION ON PURE AND APPLIED PHYSICS

COMMISSION 14: PHYSICS EDUCATION - MANDATE

Article 1
To promote the exchange of information and views among the members of the international scientific community in the general field of Physics Education including:

1. the collection, evaluation, coordination and distribution of information concerning education in the physical sciences at all levels;
2. information relation to the assessment of standards of physics teaching and learning;
3. suggesting ways in which the facilities for the study of physics at all levels might be improved, stimulating experiments at all levels, and giving help to physics teachers in all countries in incorporating current knowledge of physics, physics pedagogy, and the results of research in physics education into their courses and curricula.

Article 2
To recommend for Union sponsorship international conferences which qualify for support under Union regulations.
To initiate such conferences as their need arises from the evolution of the Commission field.
To assist in the organization of such conferences when practical. To ensure the compatibility of international conferences in its field and to discourage clashes and incompatibility of dates.

Article 3
To promote the free circulation of scientists; to assist conference organizers in ensuring such free circulation and in resolving potential infringements.

Article 4
To organize where feasible the award of medals or other testimonials of excellence in its field.

Article 5
To publish where feasible newsletters, circulars, occasional books, journals or handbooks in its area.

Article 6
To maintain liaison with other IUPAP Commissions, with the Commissions or Committees of other Unions or of the International Council of Scientific Unions (ICSU) or other scientific organizations, with a view to collaborating and cooperating in sponsoring joint conferences and to participating in joint projects when need arises. In particular to maintain close liaison with the General Commissions of IUPAP (SUNAMCO, Physics Education and Development), so as to ensure suitable input from its field into these physics-wide activities.

Article 7
To make available to each General Assembly of the Union a summary of activities and progress in its field since the previous Assembly.

C14: OFFICERS

Chair: Roberto Nardi (2014) (2017)	Email: nardi@fc.unesp.br
Vice-Chair: Deena Naidoo (2014) (2017)	Email: Deena.Naidoo@wits.ac.za
Secretary: David Sands (2017)	Email: d.sands@hull.ac.uk

Members

Mayank Vahia (2017)	Email: vahia@tifr.res.in
Eilish McLoughlin (2014) (2017)	Email: eilish.mcloughlin@dcu.ie
Jenaro Guisasola (2017)	Email: Jenaro.guisasola@ehu.es
Julio BENEGAS (2017)	Email: jbenegas@unsl.edu.ar
Naoshi Takahashi (2017)	Email: naoshi@ed.kagawa-u.ac.jp
LEBRUN Nathalie (2017)	Email: nathalie.lebrun@univ-lille1.fr
David R Sokoloff (2017)	Email: sokoloff@uoregon.edu
Manjula Sharma (2017)	Email: manjula.sharma@sydney.edu.au
Zuzana Jeskova (2017)	Email: zuzana.jeskova@upjs.sk
Tetyana Antimirova (2017)	Email: antimiro@ryerson.ca
Ian G. Bearden (2014) (2017)	Email: bearden@nbi.ku.dk

Associate Members 2015-2018:

Sarojiny Saddul-Hauzaree	Email: s.saddul@mieonline.org
Mehmet Fatih Taşar	Email: mftasar@gazi.edu.tr
Alex Mazzolini	Email: amazzolini@swin.edu.au

For detailed C14 information on events, reports, newsletters and awards goto:

http://iupap.org/commissions/physics-education/

GENERAL INFORMATION

REGISTRATION DESK

The registration desk will be situated on the Foyer of Pelindaba 1 and 2. Registration will open from 15:00 to 18:00 on Sunday 30 September 2018 and every morning thereafter at 07:30.

NAME TAGS

Delegates are requested to wear their name tags at all times to have access to sessions and refreshments, including lunches, functions and dinners.

BANKING AND CURRENCY

- NOTE that Misty Hills only accepts payment by VISA or MasterCard and is a cashless facility.
- Local currency is South African Rand (ZAR). Everything in South Africa must be paid in local currency. It is recommended that exchange be arranged at the airport foreign exchange centres.

VENUE AND CONNECTIVITY

Note that all conference sessions and evening functions will be conducted at Misty Hills Hotel and Conference Centre. Venue facilities include:

- Business Centre: Audio Visual equipment, photocopies, faxing, general conference administration.
- Sport & leisure facilities includes a swimming pool and Spa in the Country onsite.
- Complimentary parking is available to conferencing delegates and In-house guests.
- FREE WIFI for in-house guests (daily limit of 4MB) and the password will be provided at the registration desk.

SOCIAL FUNCTIONS AND DRESS CODE

- The dress code for the conference is smart casual/casual.
- Note that each person will receive a ticket for one drink (soft drink/wine/beer) at the welcome reception and conference banquet. A cash bar will be available at all functions.
- The dress code for the conference dinner will be smart casual and you are welcome to dress up, but black tie is not required.

EMERGENCY NUMBERS

Internal emergencies:	dial 9
National emergency call centre	10111
Fire:	011 951 3000 / 083 433 5822
Ambulance:	Johan Schwartz (Muldersdrift Fire Protection Association) 084 124 (ER 24) or 082 911 (Netcare)
Police:	011 952 4600 or 011 952 4642
Pinehaven Hospital:	011 950 5400
Wilgeheuwel Hospital: Poison	011 796 6500/19
Information Centre: Life Line:	0800 333 444
	086 132 2322

CONTACT DETAILS

Emergency logistic contact: Carla de Jager	+27 83 376 2368 or carla@carlamani.co.za
On-site conference contact:	+27 82 8122 078
Misty Hills Hotel and Conference Centre:	+27 11 950 6000

SOCIAL AND OTHER EVENTS

OPENING CEREMONY
Date: Monday, 01 October 2018
Venue: Pelindaba 1, Misty Hills Hotel and Conference Centre
Time: 09:30-10:00

WELCOME RECEPTION
Date: Monday, 01 October 2018
Venue: Pelindaba 1, Misty Hills Hotel and Conference Centre
Time: 19:15-21:00

CARNIVORES DINNER
Date: Tuesday, 02 October 2018
Venue: Carnivores Restaurant, Misty Hills Hotel and Conference Centre
Time: 19:15-21:00

CONFERENCE SITE AND OFF-SITE VISITS
Date: Wednesday, 03 October 2018
Venue/Time: Buses depart at 08:30 from Misty Hills Hotel and Conference Centre (front of Hotel Reception) to the University of the Witwatersrand.
Venue/Time: 09:30-13:00 Refreshments, Invited Plenary Talk by Professor Diane Grayson (University of the Witwatersrand), viewing of exhibitions and lunch at the Origins Centre, University of the Witwatersrand.

Venue/Time: Buses depart at 13:00 from the University of the Witwatersrand to the Lion and Safari Park.
Venue/Time: Buses depart at 17:30 from the Lion and Safari Park to Lesedi Cultural Village for viewing of exhibitions, dinner and show.
Venue/Time: Buses depart at 20:00 from Lesedi Cultural Village to Misty Hills and Conference Centre.

CONFERENCE BANQUET (DINNER AND DANCE)
Date: Thursday, 04 October 2018
Venue: Pelindaba 1 and 2, Misty Hills Hotel and Conference Centre
Time: 19:15-late

CLOSING CEREMONY
Date: Friday, 05 October 2018
Venue: Pelindaba 1, Misty Hills Hotel and Conference Centre *Time:*
13:00-13:30 followed by lunch

MAP OF MISTY HILLS HOTEL AND CONFERENCE CENTRE

MISTY HILLS COUNTRY HOTEL, CONFERENCE CENTRE & SPA

ACCOMMODATION

Village 1 - Rooms 19 - 38
Village 2 - Rooms 201 - 215
Executive Suites - 650 - 653
Village 3 - Rooms 301 - 320
Village 4 - Rooms 401 - 421
Village 5 - Rooms 501 - 523
Executive Suites 654 - 656
Village 6 - Rooms 601 - 621
Village 7 - Rooms 701 - 722
Village 8 - Rooms 801 - 832
Executive Suites - 833 - 838
Junior Suites - Rooms 723 - 724
Royal Suites - Rooms 900 - 903
Presidential Suites 750 - 751

RECREATION

1. Curio Shop
2. Summerhouse Lawn
3. Garden Chess Board
4. Business Centre
5. Reception Guest Lounge
6. Peregrine Castle
7. Residents Pool Complex
8. Residents Gym
9. Residents Game Room
10. Volleyball Court
11. Team Building Field
12. Village 8 Observatory
13. Village 5 Observatory

CONFERENCE VENUES

1. Impala Room
2. Tusker Pavilion
3. Zebra Room
4. Reedbuck Room
5. Hartebeest Room
6. Gemsbok Rooms 1 & 2
7. Springbok Room
8. Pelindaba
9. Exhibition Centre
10. Lilly Room
11. Lapa
12. Sable Hall
13. Lion Room
14. Leopard Room
15. Caracal Room
16. Cheetah Room
17. Civet Room
18. Elephant Room
19. Carnivore Teambuilding

PARKING

P1 Parking 1
P2 Parking 2
P3 Parking 3
P4 Parking 4
P5 Parking 5
P6 Parking 6

PLACES OF INTEREST

1. Kgosi Mogali
2. Eland
3. Elephants in the Mist
4. Hall of Kings
5. Impala
6. Kudu
7. Village Gong
8. The Beer Drinker
9. Ox Wagon
10. Waterbuck
11. Aloe Garden
12. Protea Garden
13. Sable Antelope
14. Wildebeest
15. Cycad Garden
16. Eagle
17. Water Bearing Woman
18. Hippo & Calf
19. Buffalo
20. Giraffe
21. Bad Hair Day
22. Maiden in the Garden
23. Water Nymph
24. Eve at the Waterfall
25. Helen's Orchid Pavilion
26. Mr. Robert Forsyth
27. David Livingstone
28. Bird Walk
29. Historic Information Board
30. Acacia Walk

SPA IN THE COUNTRY

1. Spa Complex
2. Signature Room
3. Signature Room
4. Indoor Pool

RESTAURANTS & PUBS

1. Carnivore Restaurant
2. The Gin Box Pub
3. The Gin Box Coffee Shop
4. Summerhouse Restaurant, Wine Cellar & Cigar Lounge
5. Boma Restaurant

WiFi HOTSPOT

Wifi available on this property and all conference venues, for best coverage please see marked Wifi hotspots

WARWICK

RECREATION AFRICA

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Life responds to seed not need

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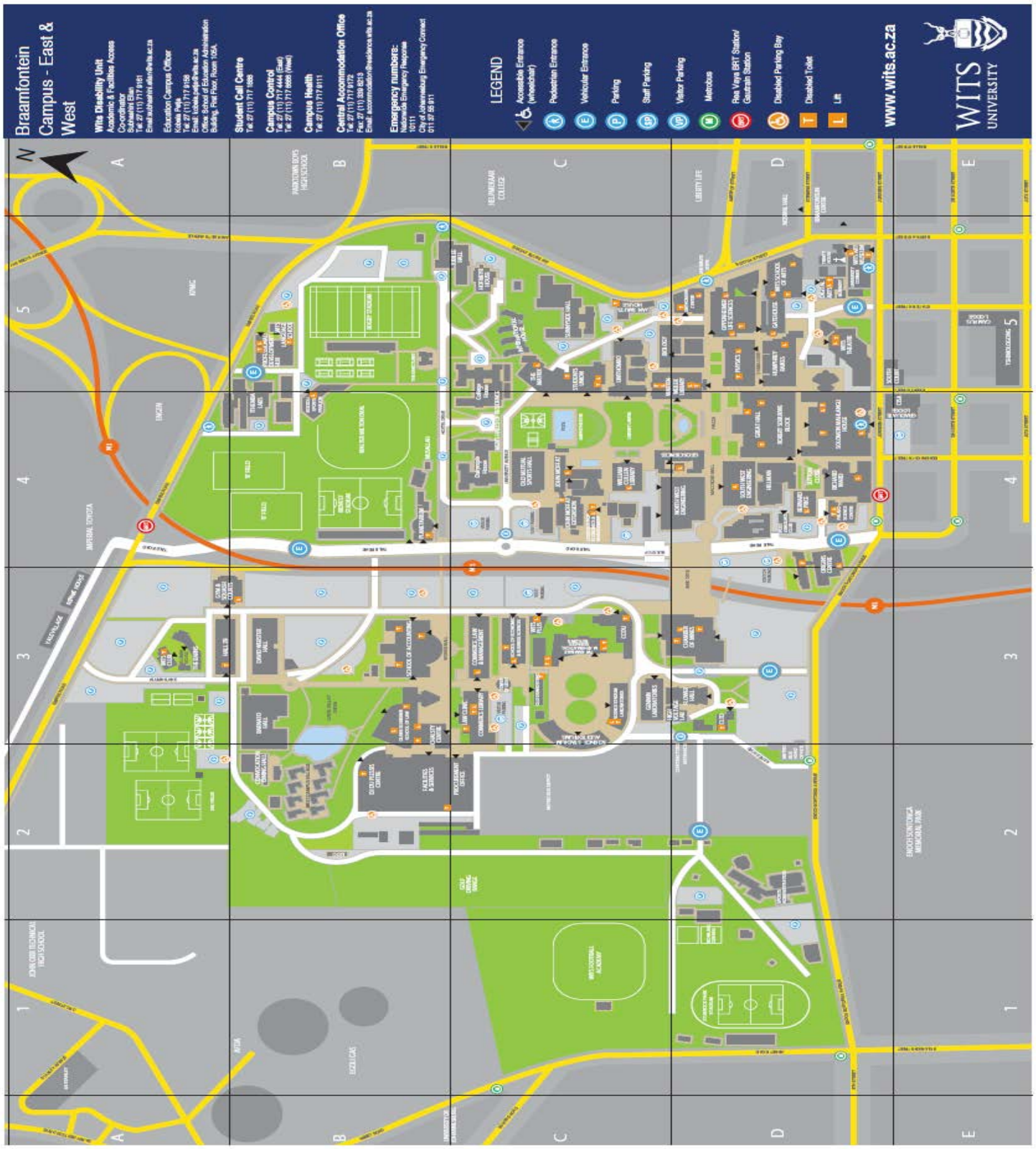
MAP OF WITS UNIVERSITY



FAST FORWARD INTO THE FUTURE

Careers in SCIENCE

Infinite options through Physics...

Transport

aeronautical engineer
air traffic controller
armed services
astronaut
automobile engineer
ceramicist
ergonomics expert
flight engineer
material scientist
merchant navy officer
motor mechanic
naval architect
navigator
nautical scientist
pilot
structural engineer
transport manager
transport researcher
vehicle designer

Industry / Wealth

aeronautical engineer
agricultural engineer
biotechnologist
brewing technologist
building technologist
chemical engineer
colour technologist
computer-aided designer
cybernetics
design engineer
factory inspector
financial analyst
food scientist
industrial designer
investment banker
mechanical engineer
operational research scientist
patent engineer
printing technologist
production engineer

Medicine

audiology technician
biochemist
biomedical engineer
biophysicist
dentist
dietician
dispensing optician
medical doctor
environmental health officer
forensic scientist
medical physicist
optometrist
orthoptist
osteopath
pharmacist
physiotherapist
radiographer
speech therapist
veterinary surgeon

Leisure

acoustic engineer
computer game designer
graphic artist
lighting engineer
material scientist
model maker
museum and science centre manager
photographer
picture restorer
safety engineer
sport equipment designer
sports injury specialist
water manager
yacht designer

Space

astronaut
astronomer
cartographer
climatologist
instrumentation technologist
meteorologist
satellite engineer
space scientist
test engineer

Energy

chemical engineer
civil engineer
computer scientist
control systems engineer
electrical / electronic engineer
environmental control scientist
exploration and production engineer
geologist
geophysicist
health and safety physicist
instrumentation technician
mining engineer
oilfield services engineer
pollution control scientist / engineer
R&D scientist / technologist

Environment

agricultural scientist
archaeologist
architect
building supervisor
cartographer
civil engineer
climatologist
conservation officer
draughts person
environmental scientist
geologist
geophysicist
health and safety officer
marine scientist
meteorologist
noise engineer
oceanographer
soil scientist
surveyor
water manager

Education

company training officer
information scientist
laboratory technician
mathematician
physics lecturer
primary / secondary teacher
science administrator
science advisor
science broadcaster
science inspector
science journalist
science teacher
statistician
technical illustrator
technical writer

Physics is the fast-track to the biggest choice of jobs and the widest range of opportunities.

This poster samples the infinite options open to people who have studied physics.

Are you interested in the big question in life:
How will the **universe end?** Does a black hole lead to a **parallel universe** or is it the secret of **time travel?** Then physics is definitely for you.

Do you want to improve our quality of life?
Engineers are working to **improve technology**, looking for solutions to the **energy crisis** and ways of controlling pollution. **Engineers all start out studying physics**.

Perhaps you want to work in medicine, in the leisure industry, in education or the media. **Physics** offers a surprising range of options.

Are you excited by the buzz of life in the city:
Working in **high powered jobs** in law, finance or computing? People with **physics** qualifications are being snapped up to work in these areas because **they are logical and quick thinking.**
Whatever you dream of doing, physics offers the best way forward...

SOUTH AFRICAN INSTITUTE OF PHYSICS

082 823 0890

LOCAL ORGANISING COMMITTEE

Professor Deena Naidoo – Chair, University of the Witwatersrand, South Africa
Mr. Brian Masara, South African Institute of Physics Office, South Africa
Professor Jonathan Keartland, University of the Witwatersrand, South Africa
Dr Sam Ramaila, University of Johannesburg, South Africa
Professor Saalih Allie, University of Cape Town, South Africa
Professor Cedric Linder, Uppsala University, Sweden
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Dr Krish Reddy, University of Johannesburg, South Africa
Professor Alan Cornell, University of the Witwatersrand, South Africa
Mr. Itumeleng Phage, Central University of Technology, South Africa
Mr. Tebogo Mokhine, South African Institute of Physics
Ms. Ndanganeni Mahani, South African Institute of Physics

Conference Logistics Management
CARLAMANI CONFERENCES AND EVENTS

PROGRAMME COMMITTEE

Professor Deena Naidoo – Chair, University of the Witwatersrand, South Africa
Mr. Brian Masara, South African Institute of Physics Office, South Africa
Professor Jonathan Keartland, University of the Witwatersrand, South Africa
Dr Sam Ramaila, University of Johannesburg, South Africa
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Dr Douglas Clerk, University of the Witwatersrand, South Africa
Professor Jeanne Kriek, UNISA, South Africa
Dr Krish Reddy, University of Johannesburg, South Africa
Dr Femi Otulaja, University of the Witwatersrand, South Africa
Mr. Tebogo Mokhine, South African Institute of Physics

SCIENTIFIC ADVISORY COMMITTEE

Professor Roberto Nardi (UNESP/FC - Campus de Bauru, Brazil)
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Professor Jenaro Guisasalo (Spain)
Professor Julio Benegas (Argentina)
Professor Naoshi Takahashi (Japan)
Professor Natalie Lebrun (France)
Professor Manjula Sharma (Australia)
Professor Zuzana Jeskova (Slovakia)
Professor Tetyana Antimirova (Canada)

WELCOME NOTE: CHAIR OF THE ORGANISING AND PROGRAMME COMMITTEES OF THE INTERNATIONAL CONFERENCE ON PHYSICS EDUCATION

On behalf of the Local Organizing and Programme Committees, I take great pride in welcoming all the delegates to the International Conference on Physics Education (ICPE-SAIP-WITS 2018). We are honoured to have eight prominent invited plenary speakers grace the conference and a host of single oral, workshop and poster presentations by speakers from all parts of the world. It is particular pleasing to note the composition of delegates: postgraduate students, teachers, university lectures, government officials and experienced researchers. The scientific programme and schedule has been designed to allow for much interaction in the form of discussion, collaboration and networking on current issues surrounding Physics Education Research, Research and Development and Teaching and Learning practices.

We hope that you will have a productive and rewarding conference and that you will enjoy our South African hospitality and all the social functions.

Professor Deena Naidoo

Chair of the Organising and Programme Committees (ICPE-SAIP-WITS 2018)

WELCOME NOTE: CHAIR OF THE INTERNATIONAL COMMISSION ON PHYSICS EDUCATION

Welcome! It is with great satisfaction that we receive all of you for this International Conference on Physics Education (ICPE-SAIP-WITS - 2018) here in Johannesburg, South Africa. We are honoured to share this discussion space with you during this week. We hope that in these days we can establish environments of dialogue and reflection on the reason and emotion that we dedicate to Physics and to the Teaching of Physics!

On behalf of IUPAP – The International Union of Pure and Applied Physics, and the International Commission on Physics Education (ICPE), I would like to thank the Organizing Committee and everyone present at this event.

Professor Dr. Roberto Nardi

ICPE Chair, UNESP - São Paulo - Brazil

WELCOME NOTE: PRESIDENT OF THE SOUTH AFRICAN INSTITUTE OF PHYSICS

It is my pleasure to welcome you all to the 2018 International Conference on Physics Education (ICPE2018), co-hosted by the School of Physics at the University of the Witwatersrand and the South African Institute of Physics (SAIP), together with the International Commission on Physics Education (commission 14) of the International Union of Pure and Applied Physics. The conferences takes place from 1-5 October 2018 in the close proximity of the Pilanesberg National Park and the Cradle of Humankind.

I would like to extend a special welcome to first time visitors to South Africa, to all the distinguished invited plenary speakers, and to students and researchers who attend the ICPE conference for the first time. South Africa and the SAIP is proud to host this international conference on Physics Education. This is an important international platform for colleagues working in physics education and physics educational research to exchange the latest ideas and experiences in Physics Education. The main theme of ICPE2018 is "Physics Education for Development: A Focus on Context". T

The focus on Physics Education for Development is particularly relevant for the SAIP. Established in 1955, the mission of the SAIP is to be the Voice of Physics in South Africa. Amongst its divisions and fora, the SAIP division for Physics Education is one of the main pillars of the institute, carrying forward its mission to all corners of the country. One of the essential activities of the SAIP in the last 5 years is the coordination and running of Physics Teacher development workshops in places in South Africa where this is most needed. I am particularly delighted to see that ICPE2018 is also hosting a teacher workshop at its meeting. Diversity, gender equality and inclusivity are key elements of our institutional culture. I am also very happy to see the excellent representation of Women in Physics amongst the invited plenary speakers and the inclusion of special sessions for Women in Physics in the scientific program.

In concluding, I want to express my sincere gratitude to the organisers of ICPE2018 - the colleagues of the School of Physics at the University of the Witwatersrand, led by Prof Deena Naidoo - for putting together a very exciting program, showcasing the very best in the global research in physics education.

I wish you all a most successful conference!

Professor Patrick Woudt

President: South African Institute of Physics

WELCOME NOTE: DVC: RESEARCH AND POST GRADUATE AFFAIRS, UNIVERSITY OF THE WITWATERSRAND

It is an honour and a privilege to welcome physics scholars, educators, students, teachers, researchers, policy makers and delegates from around the world to the 2018 International Conference on Physics Education. I am particularly pleased that the theme of the conference Physics Education for Development: A focus on context explores best practices in teaching physics by global standards whilst remaining cognisant of the local environments in which teaching, learning and research takes place. The advent of the Fourth Industrial Revolution is set to change dramatically how humans interact with technology, how we express ourselves, communicate and engage in a new world order. In this context it is imperative for each and every one of us to actively participate in knowledge creation and to empower others through sharing knowledge and making knowledge accessible. This is to ensure that we are not confined to being passive receptors of the new revolution. It is this challenge – to be globally competitive but locally relevant – that should resonate across the themes to be explored at this conference.

I can think of two relevant examples where we use technology to participate globally but to act locally. There is a strong South African contingent working at CERN, including theoreticians and experimentalists. From Wits, there are over 35 students involved in the search for new bosons. Whilst these students spend a significant amount of time at CERN and play an active role in upgrading the ATLAS particle detectors in the Large Hadron Collider (LHC), there are also teams based at the University who can actively monitor activities at CERN from Johannesburg in real time thanks to technology. Another great example is the work undertaken in the Structured Light laboratory, where teams are harnessing light for a myriad of applications in what we can call the age of photonics. A good example is how the digital divide can be bridged through photonics.

It is imperative for us to collectively educate learners, students and scholars in physics, to train them to master their disciplinary knowledge, but at the same time teach them to deal with the challenges of the 21st Century, some which we may not yet have encountered. We need to develop students and educators who are problem-posers and problem-solvers, who have the ability to change this world for the better today and in the future.

The new world order, including the use of mechanisation and artificial intelligence, has the potential to vanquish jobs as we know it today and to deepen inequality in an already divided society. However, if we work collaboratively, we have the ability to develop the next generation of scholars who will change the futures of Africa, of society, through developing the tech required for us to leapfrog across eons of poverty, unemployment and inequality, and in so doing to create a new world order that prioritises humanity before profits and power.

Educators are called upon to do more than ever before - to teach at the highest level, to develop critical thinkers and professionals, to prepare scholars to be good citizens and to prepare people capable of solving socio-economic problems.

These are some of the values that we try to live at the University of the Witwatersrand, one of the leading universities on the continent. We are a research-intensive, increasingly postgraduate university committed to academic excellence and the promotion of social justice. You can learn more about us at www.wits.ac.za/research.

We are honoured to co-host this conference through the Wits School of Physics and the South African Institute of Physics, in collaboration with the International Commission on Physics Education established by the International Union of Pure and Applied Physics.

Enjoy our traditional South African hospitality and I hope that the 2018 International Conference on Physics Education will be a memorable one. We look forward to engaging and collaborating with you.

With great appreciation,

Professor Zeblon Vilakazi

Deputy Vice-Chancellor: Research and Postgraduate Affairs University of the Witwatersrand

WELCOME NOTE: DEAN - FACULTY OF SCIENCE, UNIVERSITY OF THE WITWATERSRAND

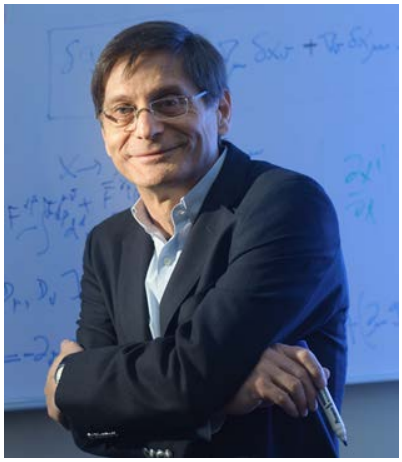
On behalf of the Faculty of Science at the University of the Witwatersrand, Johannesburg, I extend my warmest welcome to delegates of the International Conference on Physics Education (ICPE-SAIP-WITS2018). The conference is made up of plenary, poster, workshop and parallel sessions in this important field in Physics spanning a number of subthemes. The School of Physics at Wits University has an active research programme in this field. Whilst visiting Johannesburg you will have the opportunity to visit the Cradle of Humankind, an internationally recognised heritage site, the Pilansberg National Park and other proudly South African tourist attractions. We hope that you will enjoy the site visit to the university, the viewing of exhibitions and tours to facilities.

I encourage you to network at the conference and share experiences and expertise. The Faculty wishes you all a fruitful and engaging conference and a pleasant stay in the City of Johannesburg.

Professor Ebrahim Momoniat

Dean: Faculty of Science, University of the Witwatersrand

WELCOME NOTE: HEAD OF THE SCHOOL OF PHYSICS, UNIVERSITY OF THE WITWATERSRAND



On behalf of the School of Physics, University of the Witwatersrand, I wish to extend a warm welcome to delegates from South Africa as well as from other parts of Africa and abroad. A special welcome is extended to all distinguished invited plenary speakers. It is a great honour for the School of Physics to partner with the South African Institute of Physics and the International Commission on Physics Education to host this prestigious conference.

The School of Physics is the largest single campus physics department in South Africa and in the top 1% in the field worldwide. Almost 80% of its academic staff are rated by the National Research Foundation (NRF). The School engages in internationally competitive research in a wide scope of research areas, including theoretical and experimental high-energy physics, gravity and cosmology, materials physics, condensed matter physics, nuclear physics, radio astronomy and astrophysics, high-throughput electronics, photonics, space propulsion, and physics education. The School hosts three Department of Science and Technology – National Research Foundation (DST-NRF) Research Chairs, is home to the Materials Physics Research Institute with significant experimental infrastructure, the Mandelstam Institute for Theoretical Physics and a Wits Centre of Excellence in Particle Collider Physics, It plays an important role in the DST-NRF Centre of Excellence in Strong Materials, and hosts the Gauteng node of the National Institute for Theoretical Physics. In addition, the School has an active teaching programme that reaches over 3000 undergraduate students annually, close to 140 MSc and PhD students and an outreach programme that includes a Planetarium.

It is encouraging to note that the conference participants includes postgraduate students, school teachers, researchers and university lecturers who will contribute presentations across many themes ranging from Physics at University, Physics at Primary and Secondary School Level, Curriculum: Design, Development and Delivery, Teaching and Learning of Physics Concepts, Teaching and Learning of Laboratory based Physics, ICT and Multimedia Revolution in Physics Education, Assessment and Evaluation of Teaching and Learning in Physics, Teacher Education and Training in Physics, Physics in an Informal and Non-Formal Environment, International Networks and Collaboration in Physics Education.

I have no doubt that the conference will be a most enriching experience for all delegates which will serve as a platform for dissemination of information, as a forum to promote development of high skills and will foster collaborations and networks.

Best wishes to all delegates and we hope that you will have an enjoyable and memorable conference.

Professor Joao Rodrigues

Head of the School of Physics, University of the Witwatersrand

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PLENARY SPEAKERS

Professor David Sokoloff - University of Oregon, USA

David Sokoloff is Professor of Physics, Emeritus at the University ofOregon. He began his studies of physics at Queens College of the City University of New York, and went on to earn his Ph.D. from the Massachusetts Institute of Technology. He was a faculty member at Western Illinois University and University of Michigan, Dearborn, and has held several visiting positions at institutions in the United States and elsewhere. His physics curriculum development work and extensive dissemination efforts include research into students' understandings of physics, and he has used the results of this research to develop active learning approaches to enhance student understanding in introductory physics courses. These curricula have been published, and make use of computer-based laboratory tools for data collection and analysis. He was the winner of the 2007 Robert A. Millikan award of the American Association of Physics Teachers (amongst other notable awards), and has served as Vice President and President of the American Association of Physics Teachers. His current research project is exploring the use of the inexpensive, self-contained, wireless computer-based data collection device for distance learning labs in introductory physics. His work on active has led tolearning workshops in a host of developing countries, under the auspices of UNESCO.

ABSTRACT

Adapting RealTime Physics for Distance Learning with IOLab - A Final Report

Coauthors: Erik Bodegom, Portland State University and Erik Jensen, Chemeketa Community College

The IOLab is a versatile, relatively inexpensive data acquisition device developed by Mats Selen and his colleagues at University of Illinois (1). It is self-contained in a cart that can roll on its own wheels, and it includes an optical encoder that measures motion quantities and a force sensor. It also contains sensors to measure a variety of other physical quantities. With a current cost of around $100, students can purchase their own individual device (like a clicker) and can-in theory-use it to do hands-on laboratory, pre-lecture (flipped classroom) and homework activities at home. We report on the results of a project (2) to develop distance-learning (DL) laboratories using the IOLab. We have adapted RealTime Physics Mechanics (3,4) labs for use with the IOLab and tested them in supervised laboratory environments and in distance learning mode at Portland State University and Chemeketa Community College. We will describe the labs and lab environments, and the significant FMCE (5) conceptual learning gains.

References

(1) See http://www.iolab.science/.
(2) Funded under U.S. National Science Foundation grant DUE – 1505086, July 1, 2015-June 30, 2017.
(3) David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, "RealTime Physics: Active Learning Labs Transforming the Introductory Laboratory," Eur. J. of Phys.: 28 (2007), S83- S94.
(4) David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, RealTime Physics: Active Learning Laboratories, Module 1: Mechanics, 3rd Edition (Hoboken, NJ, John Wiley and Sons, 2011).
(5) Ronald K. Thornton and David R. Sokoloff, "Assessing student learning of Newton's laws:
The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Curricula", Am. J. Phys.: 66, 338-352 (1998).

Professor Nicola Wilkin - University of Birmingham, UK

Nicola Wilkin's present position is Professor of Physics at the University of Birmingham in the United Kingdome. She is the Director of Educationin the College of Engineering and Physical Sciences, and as such she provides strategic leadership in the teaching a large student population in Science and Engineering. This includes work in on-line offerings, transnational education and in leading pedagogic design. In addition to her work in Science and Engineering Education, she is involved in work that promotes equality. This includes several contributions to the Women in Physics programme. Professor Wilkin's academic career began at the University of Southampton, where she completed a BSc in Physics and Mathematics. Her graduate studies were in Theoretical Physics, leading to a PhD from the University of Manchester. Her work in Theoretical Physics (Bose-Einstein Condensation) has produced several highly cited publications. She was awarded the Glaxo-Wellcome Westminster Medal for the best research poster presented in the United Kingdom House of Commons in 2000.

ABSTRACT

Educational technology for physics: what's useful? And how do we generate it?

My theoretical physics research is in ultracold gases, where the phenomena are predominantly quantum mechanical. My novel results have been discovered and analysed via computer algebra. This understanding of the power of computer algebra has transferred to my education practice - where it enables my team and I to design mathematically based questions that can be automatically marked. These questions better probe the depth of understanding than normal multiple choice, by enabling free form mathematics to be entered as the answer. But which questions? The choice and implementation is undertaken by summer student interns, and I will discuss how one harnesses their imagination and understanding of their peers' needs whilst ensuring that materials they generate are properly quality assured to be released to whole classes. And finally, how about equality? If the questions are to be inclusive and relevant to all we need to ensure we have an inclusive team writing them. Hence, I will discuss the importance of the student recruitment process.

PLENARY SPEAKERS

Professor Diane Grayson- University of the Witwatersrand, South Africa and formerly at the Council of Higher Education, South Africa

Diane Grayson is at present the Senior Director of Academic Affairs at the University of the Witwatersrand in South Africa. This follows a distinguished career in Science Education, in which she has held positions in academia, and in the public sector. She obtained her undergraduate degree at the University of Natal (South Africa), and followed this with a MSc at the same institution. Subsequently, she obtained both a MS and a PhD from the University of Washington. Following her return to South Africa she has held positions at a number of Universities, and has contributed to the development of education through her work in the public sector. During her academic career she has held several visiting fellowships and positions in diverse countries. She has a voluminous publication record, with a particular emphasis on Science Education in the African context. In recognition of her contributions to Science Education, Diane Grayson was awarded an Honorary PhD from Umeå University in Sweden, and has received numerous awards, including a Fulbright Scholarship to study in the United States of America.

ABSTRACT

Physics education for 21 st century graduates

The century in which today's students are growing up is different in a number of important ways from last century. This includes ubiquitous and increasingly sophisticated technology, climate change, globalisation, and the concentration of the bulk of the world's wealth in the hands of an ever-decreasing percentage of its population. And then there was the great recession of 2008. Taken together, these things impact on students' thinking patterns, behaviours, expectations, constraints and opportunities. Broad global developments, such as the fourth industrial revolution, the United Nations Sustainable Development Goals, as well as the recent rise of so-called fake news and popular rejection of evidence-based thinking, frame the context for what we can and must do in educating our students.

So what are the implications for Physics and Physics teaching? Physicists have always taken pride in the fact that we acquire ways of thinking and solving problems that have broad applicability. While that may be true, no human endeavour can ever be divorced from context. How is the teaching of Physics being affected by the global context, and how can Physics teaching contribute to addressing global challenges? In this presentation, I will make some suggestions, in broad terms, of what we ought to be teaching, what the key characteristics are of who we are teaching, and how we should teach in order to equip our students to be successful 21 st graduates. That means being able to navigate the complexities and uncertainties of a turbulent world, today and tomorrow, and, we hope, contribute to making it a better place for all of its inhabitants.

Dr Apriel Hodari - Eureka Scientific, Inc. Oakland, USA

Apriel Hodari, is a recognized expert in science, technology, engineering and mathematics (STEM) education research, STEM educational equity and workforce diversity; and the culture of STEM disciplines. Currently a Principal Investigator at Eureka Scientific, her current research includes conducting critical ethnographies of programs that have an established record of promoting success for women of color in STEM. She obtained a BS in Electrical Engineering from Purdue University and a MS and PhD in Physics from Hampton University, where she was the first African American woman to receive a PhD in Physics from the university. After completing her PhD, she joined the Physics Education Research Group at the University of Maryland as a National Science Foundation Postdoctoral Fellow, focusing on undergraduate physics learning at historically black colleges and universities, and at women's colleges. She has served the scientific community in several capacities. For example, she has served as a member of the American Physical Society's Committee on the Status of Women in Physics. Apriel Hodari has received a number of research grants, and has an impressive array of publications and conference proceedings.

ABSTRACT

Co-Creating Inclusion in Physics: Learning from What Helps Women of Color Thrive

Coauthors: Angela C Johnson, Ariel S Keene, Elizabeth A Mulvey, Vanessa S Webb, and Rose N Young

Centering marginalized voices has long been a tool for critiquing mainstream institutions and individual practices by feminist theorists and critical race scholars. In this paper, I will present findings from Centering Women of Color in STEM: Identifying and Scaling Up What Helps Women of Color Thrive (CWCS). The project studies predominantly white physics departments in which women of color thrive. Our ultimate goal is to provide insights into how physics spaces that were not created for women of color can become more welcoming of them, and thereby increase the success of all students.

In doing this work, our team considers broader notions of race and gender intersectionality via explicit engagement with ideas of family and identity beyond those traditionally considered. We use the Athena SWAN and Race Charter criteria to address inclusion in higher education through a robust engagement with the broad spectrum of gender and race expression. We apply Patricia Hill Collins' Domains of Power to situate our findings, and point to opportunities for intervention (Collins, 2009; Johnson, 2018). Findings from CWCS challenge us to co-create learning environments where excellence and inclusion work together, evidence of what inclusive environments look like. I invite audience members to consider how they can contribute to increased inclusion in their home institutions based on what they learn here.

REFERENCES

Patricia Hill Collins. 2009. Another Kind of Public Education: Race, Schools, the Media, and Democratic Possibilities: Beacon Press. Angela C Johnson. 2018. Intersectional physics identity framework. Physics Education Research Conference, Washington, DC.

PLENARY SPEAKERS

Professor Andrew Forbes - University of the Witwatersrand, South Africa

Andrew Forbes is a Distinguished Professor at the University of the Witwatersrand, South Africa. Prior to his appointment to an academic position, he worked in the private sector (where he helped build up a start-up company that was subsequently purchased by a major enterprise), and in the public sector (CSIR National Laser Centre in South Africa). He also had a short spell as a high school teacher early in his career. He did his undergraduate studies at the University of Natal in Durban, and followed this up with a Higher Diploma in Education at the same institution. He completed his MSc and PhD while working at the Atomic Energy Corporation on laser-based uranium enrichment, also while registered the University of Natal. In 2015 Andrew joined the University of the Witwatersrand on the Distinguished Professor programme and has started a new laboratory that focuses on Structured Light and its applications. He sits on several international conference committees and leadership panels, and has several notable publications in high profile journals. He and his students have been the recipients of numerous awards.

ABSTRACT

Blurring the classical-quantum divide

Interference, the quintessential property of wave optics, is a venerable topic that spans centuries of study, influencing how we understand both the classical and quantum worlds. Infact, little has changed since the seminal work of Young with his double slit experiment, performed even to this day in much the same way as he did it. In this talk we will revisit the central paradigms in classical and quantum interference and show how they can be bent, in some cases broken, and how this influences the way we teach such topics.

We will outline through simple demonstrations that interference may be observed in places one may not think to look, that quantum entanglement may be demonstrated with purely classical light, and that much of quantum mechanics can be taught in a practical manner without the need for complicated single photon experiments. In the process we will provide a complete resource for DIY experiments that incorporates modern digital tools with 3D printed components to bring the concepts alive in the laboratory.

Dr. Honjiswa Conana, University of the Western Cape, South Africa

Honjiswa Conana is the Teaching and Learning Specialist in the Faculty of Natural Sciences at the University of the Western Cape. Her role is to support teaching and learning initiatives in the Faculty. Prior to this appointment, she worked as an academic literacy practitioner in the Physics Department at the University of the Western Cape, working in collaboration with first and second year Physics lecturers. Her research interests lie in physics education and academic literacies, while her Doctoral research comprised an in-depth study of students' experiences of a curriculum that is explicitly designed to develop physics students' academic literacy and their access to the disciplinary discourse of physics. She obtained her Bachelor and Master degree from the University of Stellenbosch, South Africa, and her PhD from the University of the Western Cape. She has produced numerous publications and conference proceedings on Physics Education, particularly as it relates to undergraduate programmes.

ABSTRACT

Developing representational competence in first year physics: Implications for curriculum and classroom practices

Physics educators recognise that successful introductory physics learning depends on understanding and using the various 'representational modes' (i.e. semiotic systems) (see Airey and Linder 2017) which are characteristic of the communication practices in physics (for example, specialised language, symbols, graphs, sketches, diagrams, mathematics, and gestures). Physics Education Research has demonstrated that the explicit use of multiple representations in undergraduate physics teaching is important for helping students learn the 'disciplinary discourse' (Airey and Linder 2009; Lemke 1990, 2004) of physics, and thus explicitly shift the physics education focus to learning to 'think like a physicist' (van Heuvelen, 1991). It has been argued that this can be achieved through creating a 'representation-rich learning environment' (for example, see Rosengrant et al., 2009: 010108-2), which focuses on helping students learn and understand how to appropriately use physics representations; to appreciate why certain representations are useful, and to see the epistemological underpinnings of these representations, thus developing students' 'meta-representational competence' (for example, see Kohl and Finkelstein, 2008: 010111-11).

In this presentation, I discuss two different pedagogical approaches used in introductory physics courses; one more traditionally oriented and the other oriented towards developing students' 'representational competence' (see, Linder, Airey, Mayaba and Webb, 2014). The theoretical framing for this study draws on a particular Semantics perspective that was developed by Karl Maton at the University of Sydney, as part of his Legitimation Code Theory (Maton, 2014). The study examined how pedagogical approaches have an impact on the way that students approach physics problem tasks. The results illustrate how the adoption of a pedagogical approach that is based on an explicit unpacking of content through pedagogically designed 'moves' (Conana, 2016) between representations that includes making their underlying 'epistemological commitments' (Hewson, 1985) transparent, led to more sophisticated approaches being adopted by students when tackling physics tasks. Finally, I will discuss what I see being the usefulness of the methodology used in the study for providing rich educational insight into ways that curriculum and classroom practices that I argue can make a meaningful difference when seeking to generate optimal ways of supporting student learning in the challenges that they meet in undergraduate physics courses.

PLENARY SPEAKERS

Professor Richard P. Hechter - University of Manitoba, Canada

Richard Hechter obtained his Bachelor degrees at the University of Manitoba in Winnipeg, Canada. He followed this up with a MEd at the same institution, before pursuing his Doctoral studies at the University of North Dakota in the United States of America. His present appointment is as an Associate Professor (and Acting Departmental Head) in the Department of Curriculum, Learning and Teaching at his alma mater. He is the recipient of numerous grants for his research in Science and Engineering Education, and has a notable record in the service of professional societies. He has published extensively in the field of STEM (Science, Technology, Engineering and Mathematics) Education, with particularly notable contributions to improving teaching curricula and teaching practice at secondary schools.

ABSTRACT

Embracing the interconnectivity of people beneath the night sky: Where physics and culture meet

In Canada, like many other countries around the world, there has been an increased call for incorporating Indigenous knowledges within physics, and physics teacher, education. Coupled with this are dedicated efforts to foster learning environments where students grow to become problem solvers not only for physics-based problems, but for societal problems as well. Physics education, at all levels, and within formal and informal settings, is being reconstructed to increase the relevance and resonance of physics content matter for students on personal, community, and global levels. It is from this launch point that physics is now being taught and learned through lenses of multiple perspectives, modalities, cultures, and social justice and awareness. As such, a focused effort to introduce andragogical and philosophical approaches beyond the traditional methods of physics education is underway.

Through the contextual sharing of global and Indigenous star-lore and sky-lore legends and lessons, this talk will weave stories of ethnoastronomy of the aurora and constellations as an exemplar of assist learning about the globally shared night sky. It is through this vision that the hope of sharing and learning these stories in physics with our current and future students can create a better world.

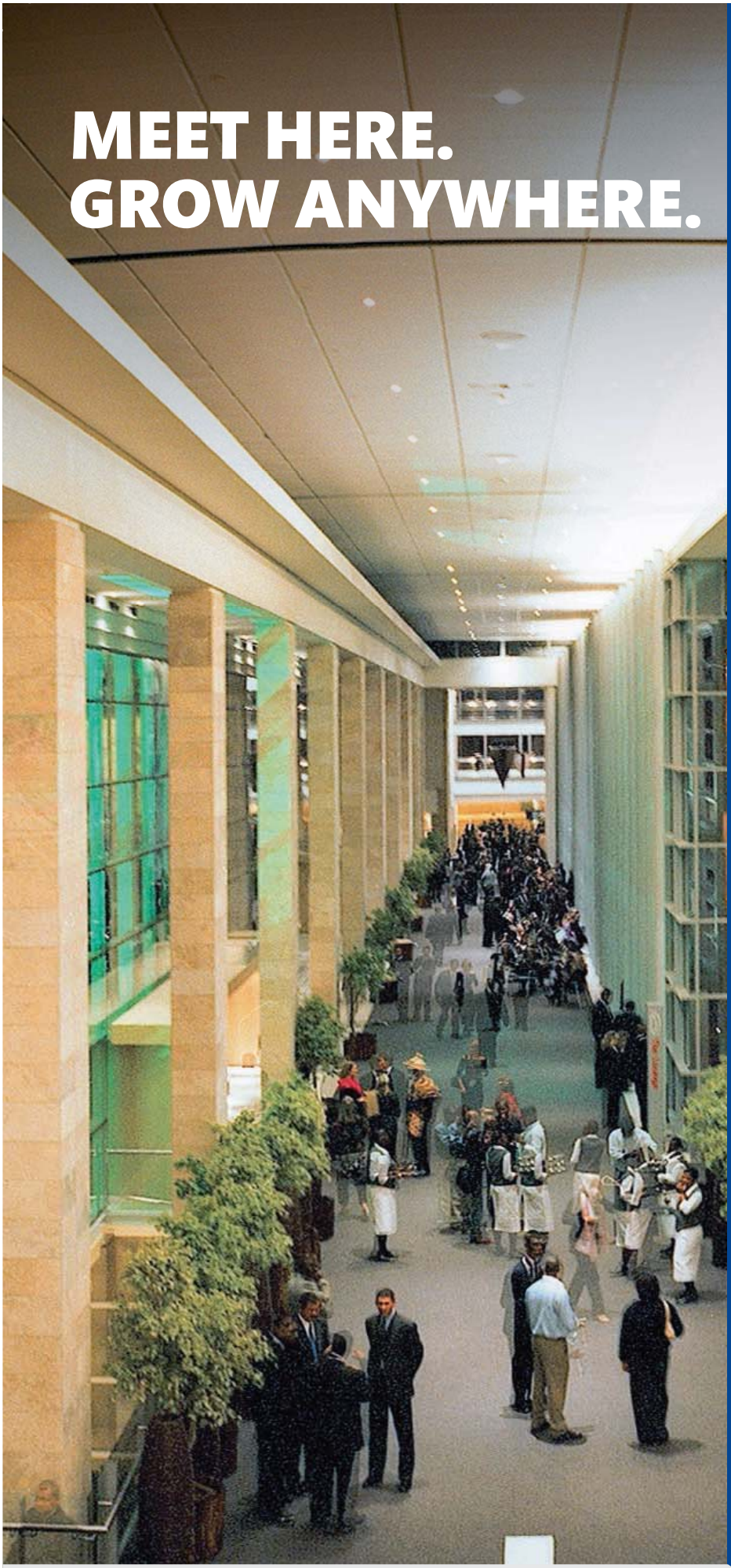
Professor Katemari Rosa - Federal University of Bahia, Brazil

Katemari Rosa holds a Ph.D. in Science Education (Columbia University, USA, 2012), a M.Sc. in Philosophy and History of Science and Science Education (Federal University of Bahia, Brazil, 2006), and a B.Sc. in Physics (Federal University of Rio Grande do Sul, Brazil, 2002). Currently, Dr. Rosa is a professor at Federal University of Bahia. She has been working on Physics Education Research and Physics Teacher Education. Her research interests include: physics education, teacher education, astronomy education, and the inclusion of underrepresented groups in science, particularly women, ethnic and racial minorities. She is particularly interested in debates in science education that consider interseccional approaches of race, gender and SES. Dr. Rosa is a member of the Brazilian Physical Society, where she integrates the Minorities in Physics Working Group and is a representative in the society Physics Education Commission. As a member of the American Physical Society, she was elected member of the Forum on the History of Physics Executive Committee (05/18 - 04/21). She is also part of the American Association of Physics Teachers, acting as member of the Committee for International Physics Education (2018-2021). Katemari is a member of the National Organization of Gay and Lesbian Scientists and Technical Professionals (NOGLSTP) and of the Brazilian Association of Black Researchers.

ABSTRACT

If Physics Education for Development is the Question, Black women are the answer!

Drawing from the conference theme, Physics Education for Development: a focus on context, I propose for this talk that we look at the role of women, particularly women of color, for the sustainable development of communities. There are several experiences of socioeconomic development programs around the world that focus on women for the programs' success. Similarly, businesses companies have found that profits increase when they invest in an inclusive and diverse workforce. Thus, scientific endeavor, and physics education, in particular, should consider the role of women and historically underserved or underrepresented populations when the goal is development. I will argue Physics lacks diversity and this could be hindering our progress. In general, we teach a physics that is usually disconnected from people's experiences, lacking role models that look like our students, and that is made somewhere far away - either geographically or in time. Increasing diversity in physics through women and underrepresented groups can be one way to help us creating and promoting a new and more inclusive Physics. I hope to share some ideas that support us to get there!



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GUIDELINES FOR SPEAKERS AND CHAIRS

In order to facilitate the smooth running of the conference scientific programme, please take note of the following.

SPEAKERS

- An **Invited Plenary Presentation**: 50 minutes followed by 10 minutes discussion.
- **Single Oral Presentation**: 15 minutes followed by 5 minutes discussion.
- A **Workshop:** 90 minutes (here the presenting author must use his/her discretion to allow for discussion during the presentation).

Please bring your presentation on a virus free memory stick to upload in the sessions in the specific venue where you will be presenting on arrival or in the morning before your presentation.

- **Poster Presentation:** is scheduled for 17h00 to 18h30 on Tuesday, 02 October 2018 in Pelindaba 2. These presentations should include a graphic presentation of your research work. Dimensions of poster (A0: 84.1 mm × 1189 mm in "portrait" format).

Please note that your poster(s) must be mounted on the poster boards before lunch on Monday, 01 October 2018.

Standard equipment that will be available for presentations at the conference includes:

- Data projector
- Screen
- Laptop with Office 2013 and Acrobat Reader
- VGA / HDMI cables

CHAIRS

- Chairs are kindly requested to confirm date, time and venue of their sessions.
- Chairs are expected to be at venue at least 5 minutes before the session commences. Time
- management of talks is important to ensure that parallel sessions are kept to scheduled times.
- Ensure that speakers have loaded their presentations into respective folders on the computer provided.
- Welcome all delegates. The following announcements should be made:
    - ✓ All cellphones should be switched to silent mode.
    - ✓ Introduce each speaker at the beginning of each talk and give title of presentation.
- Ensure that an indication is given to the speaker that he/she has 2 minutes remaining.
- Facilitate the questions and answers as per the presentation type above.
- Thank all speakers at the end of the session.

CONFERENCE THEME AND TRACKS

The theme of the conference is: "*Physics Education for Development: a focus on context*" with submitted contributions across *eleven tracks* to share:

- Physics Education Research (both empirical and theoretical)
- Research and development (including classroom ideas, practical issues, development etc.)
- Teaching and learning practices (classroom ideas with minimal research aspects)

TRACKS

- (•) Track A - Physics at University
- ( ) Track B - Physics at Primary and Secondary School Level
- ( ) Track C - Curriculum: Design, Development and Delivery
- ( ) Track D - Teaching and Learning of Physics Concepts
- ( ) Track E - Teaching and Learning of Laboratory based Physics
- ( ) Track F - ICT and Multimedia Revolution in Physics Education
- ( ) Track G - Assessment and Evaluation of Teaching and Learning in Physics
- ( ) Track H - Teacher Education and Training in Physics
- ( ) Track I - Physics and Interdisciplinary Issues
- ( ) Track J - Physics in an Informal and Non-Formal Environment
- ( ) Track K - International Networks and Collaboration in Physics Education
- ( ) Track L - Other (Please elaborate under comments below)

CONFERENCE PROGRAMME & ABSTRACTS

MONDAY 01 OCTOBER 2018

08:30 – 09:30 Registration: Foyer of Pelindaba 1

09:30 – 10:00 Opening Ceremony: Pelindaba 1

10:00 – 11:00 Plenary: Pelindaba 1
Chair: Prof. NAIDOO, Deena (University of the Witwatersrand)

Time	*Title*	*Presenter*
10:00	[**155**] Adapting RealTime Physics for Distance Learning with IOLab - A Final Report (01h00')	**Prof. SOKOLOFF, David** (University of Oregon)

11:00 – 11:30 TEA & COFFEE BREAK Venue: Foyer of Pelindaba 1

11:30 – 13:00 Parallel Session 1: Workshop – Venue: Pelindaba 1
Chair: Prof. GRAYSON, Diane (University of the Witwatersrand)

Time	*Title*	*Presenter*
11:30	[**19**] Good Vibrations: Sound Physics in Science Centres (01h30')	**Dr. FISH, Derek** (University of Zululand)

11:30 – 13:00 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK
Chair: Dr. CARLESCHI, Emanuela (University of the Johannesburg)

Time	*Title*	*Presenter*
11:30	[**53**] Choice of representations in the crafting of university physics teaching practice (00h20')	**Prof. LINDER, Cedric** (Uppsala University and University of the Western Cape)
11:50	[**17**] WHO NEEDS 3D WHEN LEARNING ABOUT THE UNIVERSE – PERCEPTIONS OF 3D AND ITS IMPORTANCE FOR TEACHING AND LEARNING PHYSICS AND ASTRONOMY (00h20')	**Dr. ERIKSSON, Urban** (National resource center for physics education, physics departement, Lund University, Lund, Sweden)
12:10	[**33**] FIRST YEAR PHYSICS STUDENTS' ALTERNATIVE CONCEPTIONS ON BERNOULLI'S PRINCIPLE (00h20')	**Dr. COETZEE, Annaretha** (Tshwane University of Technology)
12:30	[**69**] DEVELOPMENT AND EVALUATION OF A CONTEXTUALISED, ONLINE INTRODUCTORY PHYSICS COURSE (00h20')	**Dr. ANGSTMANN, Elizabeth** (UNSW, Sydney)

13:00 – 14:00 LUNCH : Boma Restaurant

14:00 – 15:00 Plenary: Pelindaba 1
Chair: Prof. NARDI, Roberto (UNESP)

Time	*Title*	*Presenter*
14:00	[**156**] If Physics Education for Development is the Question, Black women are the answer! (01h00')	**Prof. ROSA, Katemari** (Federal University of Bahia)

15:00 – 16:30 Parallel Session 1: Single Oral Presentations – Venue: Pelindaba 1
Chair: Dr. OUATTARA, Lassana (National Resource Center for Physics Education)

Time	*Title*	*Presenter*
15:00	[**51**] Construction of a Community of Practice in Undergraduate Physics (00h20')	**Dr. CANDELA, Antonia** (Center of Research and Advanced Studies, México)
15:20	[**49**] Education for development - "being transformed to transform" (00h20')	**Dr. LAWSON, Benjamin** (l'Université Chrétienne Bilingue du Congo)
15:40	[**24**] Support for an undergraduate physics program: A first year mainstream module (00h20')	**Dr. HERBERT, Mark** (University of the Western Cape)
16:00	[**18**] THE ALIGNMENT OF THE GRADE 12 PHYSICS EXAMINATION AND THE CAPS CURRICULUM: (NOVEMBER 2014 – MARCH 2018) (00h20')	**Mr. BHAW, Nishaal** (Unisa)

16:30-17:00 TEA & COFFEE BREAK Venue: Foyer of Pelindaba 1

15:00 – 16:30 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK
Chair: Prof. KRIEK, Jeanne (University of Pretoria)

Time	*Title*	*Presenter*
15:00	[**65**] SA Physics Olympiad goes on-line	**Mr. RIJSDIJK, Case** (SAAO (retd))
15:20	[**90**] From Helicopter to Lighthouse: The experiences of a lecturer in equipping first year university physics students to move away from 'answer making' towards 'sense making'	**Dr. WILLIAMS, Jennifer** (Rhodes University)
15:40	[**122**] Multiple choice question responses: beyond just right or wrong	**Dr. MASENDA, Hilary (School of Physics, University of the Witwatersrand)**

MONDAY 01 OCTOBER 2018 (Continues)

16:00	[**95**] nalysing assessments in introductory physics using Semantic Gravity: Refocussing the purpose	Dr. STEENKAMP, Christine (University of Stellenbosch)
17:00-18:30 **Parallel Session 1: Single Oral Presentations – Venue: Pelindaba 1** **Chair: Dr. ERIKSSON, Urban (National resource Center for Physics Education, Physics Departement, Lund University, Lund, Sweden)**		
Time	*Title*	*Presenter*
17:00	[**89**] CHANGES IN THE IMAGINARY OF FUTURE PHYSICS TEACHERS DURING THEIR INITIAL TRAINING	**Dr. NARDI, Roberto** (State University of São Paulo - UNESP - Brazil)
17:20	[**123**] Making Physics Relevant: Getting teachers to look beyond the Physics that they teach	**Dr. MUSHAYIKWA, Emmanuel** (University of the Witwatersrand)
17:40	[**131**] Gaps in Teacher Competencies Linked to Inquiry-Based Practical Work in Certain Resource-Constrained South African Physical Sciences Classrooms	**Dr. AKUMA, Fru Vitalis** (University of Pretoria)
18:00	[**84**] AN EXPLORATION OF SENIOR PHASE TEACHERS' MISCONCEPTIONS ON ELECTRIC CIRCUITS IN THE MOSES KOTANE AREA	**Ms. POTI, JOYCE** (NORTH WEST UNIVERSITY)
17:00-18:30 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK **Chair: Dr. CONANA, Honjiswa (University of the Western Cape)**		
Time	*Title*	*Presenter*
17:00	[**68**] ENCOURAGING INNOVATIVE THINKING AND CONCEPTUAL UNDERSTANDING IN THE BIUST FIRST-YEAR COURSE (00h20')	**Dr. DIENER, Jacobus** (Botswana International University of Science and Technology)
17:20	[**94**] An Alternate Approach to Execution of Second Year Thermodynamics (00h20')	**Mr. DIX-PEEK, Ross** (NMMU)
17:40	[**104**] Google it: why, what, and how should instructors teach if students can find everything online? (00h20')	**Mrs. FOURIE, Linley** (University of the Free State)
18:00	[**48**] The practical teaching of undergraduate quantum mechanics (00h20')	**Prof. CHETTY, Nithaya** (University of Pretoria)
18:30 - 19:15 BREATHER		
19:15 - 21:00 Welcome Reception Venue: Pelindaba 1		

TUESDAY 02 OCTOBER 2018

08:30-10:00 Parallel Session 1: Single Oral Presentations – Venue: Pelindaba 1
Chair: Prof. GOLDSTEIN, Kevin (University of the Witwatersrand)

Time	*Title*	*Presenter*
08:30	[**110**] From the recovery of mathematical inadequacies to the development of transversal skills for physics students (00h20')	**Dr. MONTALBANO, Vera** (Department of Physical Sciences, Earth and Environment, University of Siena)
08:50	[**136**] DC CIRCUITS: CONTEXT AND SENSE-MAKING (00h20')	**Dr. JOHN, Ignatius** (CPUT)
09:10	[**20**] The role of mathematics and self-efficacy in learning quantum mechanics (00h20')	**Dr. KONTRO, Inkeri** (University of Helsinki)
09:30	[**14**] Exploring Physics Student Graduate Preparedness vis-à-vis the 2018 SAIP Benchmark Statement (00h20')	**Mr. AUDU, Bako Nyikun** (University of the Western Cape)

08:30-10:00 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK
Chair: Prof. ROSA, Katemari (Federal University of Bahia)

Time	*Title*	*Presenter*
08:30	[**133**] Exploring how students in Physics Education can bring awareness on the importance of accessing solar energy in Namibian's rural areas (Case Study) (00h20')	**Dr. KALENGAY, Mbela** (UNAM)
08:50	[**129**] PROBING INTRODUCTORY ASTRONOMY STUDENTS' NOTIONS OF RELATIVE SIZE AND DISTANCE OF CELESTIAL OBJECTS. PART I (00h20')	**Ms. MAKWELA, Tshiamiso** (Department of Astronomy, University of Cape Town, Rondebosch, South Africa, 7701)
09:10	[**130**] Probing introductory astronomy students' notions of relative size and distance of celestial objects. Part II (00h20')	**Mr. SIVITILLI, Alexander** (University of Cape Town)
09:30	[**148**] The meeting place: Physics for development (C13) and Physics education (C14) (00h20')	**Prof. DIALE, Mmantsae Moche** (University of Pretoria)

10:00 – 11:00 Plenary: Pelindaba 1
Chair: Prof. ALLIE, Saalih (University of Cape Town)

Time	*Title*	*Presenter*
10:00	[**157**] Educational technology for physics: what's useful? And how do we generate it? (01h00')	**Prof. NICOLA, Wilkin** (University of Birmingham, UK)

11:00 – 11:30 TEA & COFFEE BREAK Venue: Foyer of Pelindaba 1

11:30 – 13:00 Parallel Session 1: Workshop – Venue: Pelindaba 1
Chair: Prof. CHETTY, Nithaya (University of Pretoria)

Time	*Title*	*Presenter*
11:30	[**70**] THE "OPEN DISCOVERY OF STEM LABORATORIES" WORKSHOP: AN INQUIRY-DRIVEN MOOC APPROACH IN TEACHING PHYSICS (01h30')	**Dr. PERSANO ADORNO, Dominique** (Dipartimento di Fisica e Chimica, Università degli Studi di Palermo**) Dr. PIZZOLATO, Nicola** (Istituto di Istruzione Superiore "Pio La Torre", Palermo, Italy)

11:30 – 13:00 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK
Chair: Dr. FISH, Derek (UNIVERSITY OF ZULULAND)

Time	*Title*	*Presenter*
11:30	[**9**] Game Development for Teaching Physics (00h20')	**Prof. KORTEMEYER, Gerd** (Michigan State University)
11:50	[**102**] Practical preparation videos on a zero Rand budget (00h20')	**Mr. FOURIE, Antonie** (University of the Free State)
12:10	[**30**] Programming: A tool for meaning-making and a transductive link between semiotic systems. (00h20')	**Mr. SVENSSON, Kim** (Lund University)
12:30	[**85**] A case for miniature demonstration apparatus (00h20')	**Dr. CLERK, Douglas** (School of Physics, University of the Witwatersrand)

TUESDAY 02 OCTOBER 2018 (Continues)

13:00 – 14:00 LUNCH: Boma Restaurant		
14:00 – 15:00 Plenary: Pelindaba 1 **Chair: Prof. GLEDHILL, Irvy (University of the Witwatersrand)**		
14:00	[**158**] Co-Creating Inclusion in Physics: Learning from What Helps Women of Color Thrive (01h00')	**Dr. HODARI, Apriel K** (Eureka Scientific, Inc. Oakland, USA)
15:00 – 16:30 Parallel Session 1: Single Oral Presentations – Venue: Pelindaba 1 **Chair: Prof. KEARTLAND, Jonathan (University of the Witwatersrand)**		
Time	*Title*	*Presenter*
15:00	[**97**] INTEREST OF PHYSICAL SCIENCE GRADE 12 LEARNERS TO UNDERTAKE STUDIES AND CAREERS WITHIN THE FIELD OF SCIENCE (00h20')	**Dr. DUKHAN, Shalini** (School of Animal, Plant and Environmental Sciences, Faculty of Science, University of the Witwatersrand)
15:20	[**77**] A new spin on an introductory quantum mechanics course: flipping the class (00h20')	**Prof. GOLDSTEIN, Kevin** (University of the Witwatersrand)
15:40	[**62**] Let us improve students understanding of Physics and beyond (00h20')	**Prof. DIALE, Mmantsae** (University of Pretoria)
16:00	[**50**] Challenges and solutions for quality STEM education in eastern Congo (00h20')	**Mr. VITSWAMBA, Othy Kasereka** (Université Chrétienne Bilingue du Congo)
15:00-16:30 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK **Chair: Dr. KHAPARDE, Rajesh (HBCSE, TIFR)**		
Time	*Title*	*Presenter*
15:00	[**141**] Perceived self-efficacy as a factor to realize choice-satisfaction towards post-compulsory Physical Sciences (00h20')	**Mrs. VENTER, Elizabeth** (University of the Free State)
15:20	[**81**] Activities to enhance students understanding of acceleration (00h20')	**Mr. MOLEFE, Paul** (University of Johannesburg)
15:40	[**75**] Putting the "Science" back in Science Education in South Africa (00h20')	**Dr. KAR, Deepak** (University of Witwatersrand)
16:00	[**96**] AN ANALYSIS OF PRE-SERVICE SCIENCE TEACHERS' ATTITUDES TOWARDS PHYSICS LEARNING POST-INTERVENTION WITH VIRTUAL LABORATORY SIMULATIONS (00h20')	**Mrs. PENN, Mafor** (University of Johannesburg)
16:30-17:00 TEA & COFFEE BREAK Venue: Foyer of Pelindaba 1		
17:00-18:30 Poster Session – Venue: Pelindaba 1		
Time	*Title*	*Presenter*
17:00	[**12**] The use of Mathematics Linear Graphs and Functions in understanding and interpretation of Kinematics Graphs in Physics (00h01')	**Mr. PHAGE, Itumeleng** (Honorary)
17:01	[**13**] TRANSFER MATRIX METHOD FOR ELECTRON-IO-PHONON INTERACTION IN MULTI-INTERFACE HETEROSTRUCURE SYSTEMS (00h01')	**Prof. YAN, ZUWEI** (College of Science, Inner Mongolia Agricultural University, Hohhot 010018, PR China)
17:02	[**23**] A COMPARATIVE STUDY ON LEARNING IMPROVEMENTS FROM SCALE-UP PEDAGOGY AND REFORMED LECTURES (00h01')	**Dr. SCHILTZ, Guillaume** (ETH Zurich)
17:03	[**26**] An overview of a teacher's development program for in-service teachers (00h01')	**Dr. HERBERT, Mark** (University of the Western Cape)
17:04	[**27**] AXIOMATIC SYSTEM OF THERMO-PHYSICS THEORY - A TEACHING MODEL OF THERMODYNAMICS AND STATISTICAL PHYSICS (00h01')	**Prof. LIANG, Xixia** (Inner Mongolia University, China)
17:06	[**44**] Perceptions of physics - Are we placing too much emphasis on technical skills? (00h20')	**Ms. BRAY, Amy** (Rhodes University)
17:26	[**46**] Experimental and General Solution of Buquoy's Problem (00h01')	**Dr. RIHA, Jan** (Palacky University in Olomouc, Faculty of Science) **Dr. RICHTEREK,** Lukas (Palacky University in Olomouc, Faculty of Science)

TUESDAY 02 OCTOBER 2018 (Continues)

Time	*Title*	*Presenter*
17:27	[**52**] The ψ(1S) and ψ(2S) Mesons in a Double Pole QCD Sum Rule (00h01')	**Dr. MAIOR DE SOUSA, Mikael** (Universidade Federal de Roraima)
17:28	[**54**] Enabing Astronomy (00h01')	**Dr. DIAZ MERCED, Wanda** (Office of Astronomy for Development) **Dr. GASTRO, MIchael** (Human Sciences Research Council)
17:29	[**57**] TECTONIC IMPLICATION OF MAJOR EARTHQUAKES ON THE LOCAL GEODYNAMICS OF RIFT VALLEY IN DR CONGO (00h01')	**Prof. NGINDU BUABUA, David** (Université Pédagogique Nationale(UPN))
17:30	[**66**] INFORMAL PHYSICS TEACHING FOR A BETTER SOCIETY: A MOOC-BASED AND CONTEXT-DRIVEN EXPERIENCE ON LEARNING RADIOACTIVITY (00h01')	**Dr. PIZZOLATO, Nicola** (Istituto di Istruzione Superiore "Pio La Torre")
17:31	[**71**] TEACHER PROFESSIONAL DEVELOPMENT IN THE CONTEXT OF THE "OPEN DISCOVERY OF STEM LABORATORIES" PROJECT (00h01')	**Dr. PERSANO ADORNO**, **Dominique** (Dipartimento di Fisica e Chimica, Università degli Studi di Palermo)
17:32	[**76**] An active interdisciplinary learning path on measure in a vocational school (00h01')	**Dr. MONTALBANO, Vera** (Department of Physical Sciences, Earth and Environment, University of Siena)
17:33	[**80**] THE "E3D+VET" ERASMUS+ PROJECT: INTERDISCIPLINARY TEACHING AND LEARNING IN VET CENTRES THROUGH 3D PRINTING (00h01')	**Dr. PIZZOLATO, Nicola** (Istituto di Istruzione Superiore "Pio La Torre", Palermo, Italy)
17:34	[**83**] Exploring quantum mechanical kinetic energy on a local scale (00h01')	**Dr. SALAGARAM, Trisha** (University of Cape Town)
17:35	[**87**] ANCIENT MESOPOTAMIAN'S SYSTEM OF MEASUREMENT: POSSIBLE APPLICATIONS IN MATHEMATICS AND PHYSICS TEACHING (00h01')	**Mr. DE ABREU KASPRIK, Lucas** (Universidade Tecnológica Federal do Paraná - UTFPR)
17:36	[**92**] Does the diagram that you draw tell its meaning? (00h01')	**Mr. SATO, Minoru** (Tokai University)
17:37	[**93**] Contributions of History and Philosophy of Science course for undergraduate physics teachers students (00h01')	**Dr. MÜLLER, Maykon** (Instituto Federal de Educação, Ciência e Tecnologia Sul-rio-grandense)
17:38	[**98**] xperimentation in primary school: Discover and understand or verify what is expected? (00h01')	**Ms. SGUILLA, Silvia** (Consejo de Formación en Educación, ANEP, Uruguay)
17:39	[**100**] Project Method in the Educational Background: A Review of Recent Literature (2000 - 2013) (00h01')	**Prof. PARISOTO, Mara Fernanda** (Parisoto) **Mr. RABELO, Alysson Mateus Rabelo Kiessow** (UFPR)
17:40	[**101**] LEARNING BY PROJECTS: theory and practice in Brazilian teachers education (00h01')	**Prof. PARISOTO, Mara Fernanda** (UFPR)
17:41	[**103**] The use of data triangulation as a resource to find a better strategy to teach concepts of physics applied to medicine (00h01')	**Prof. PARISOTO, Mara Fernanda** (UFPR)
17:42	[**105**] Development of methodologies for reducing dropout in courses in the Exact Sciences (00h01')	**Dr. PARISOTO, Mara Fernanda (UFPR)**
17:43	[**108**] SCIENCE IN 4D: A SUMMER SCHOOL FOR PROMOTING ACTIVE LEARNING IN AN INTERDISCIPLINARY APPROACH (00h01')	**Dr. MONTALBANO, Vera** (Department of Physical Sciences, Earth and Environment, University of Siena)
17:44	[**109**] A New Trial of Physics/Science Short Lab Class for Non-Science Cources Students in Kagawa University (00h01')	**Prof. TAKAHASHI, Naoshi** (Kagwa University, Japan)
17:45	[**115**] An evaluation of student's understanding of DC circuit concepts through students' written explanations (00h01')	**Mr. KHWANDA, Mphiriseni** (UJ)
17:46	[**118**] QUANTUM TUNNELING INDUCING AC AND DC EFFECT IN A MODIFIED JOSEPHSON JUNCTION (00h01')	**Mr. NGUENANG NGANYO**, Pernel (student)
17:47	[**127**] SCHOOL CONTEXT AND ITS RELATIONS TO HIGH SCHOOL STUDENTS' DISCOURSE ABOUT PHYSICS CLASS (00h01')	**Dr. BOZELLI, FERNANDA** (UNESP/FEIS)
17:48	[**134**] Solar system at your fingertips: an interdisciplinary learning path (00h01')	**Dr. MONTALBANO, Vera** (Department of Physical Sciences, Earth and Environment, University of Siena)

TUESDAY 02 OCTOBER 2018 (Continues)

Time	*Title*	*Presenter*
17:49	[**139**] Effect of Problem Posing Teaching Strategy on Prospective Physics Teachers' Conceptual understanding and Problem Solving Behaviour in Some Selected Concepts of Physics (00h01')	**Dr. ABUBAKAR, Sa'adatu** (Tafawa Balewa University, Bauchi State Nigeria)
17:49	[**140**] Poster presentations as an approach to implementing a 'flipped learning' pedagogy in introductory physics (00h01')	**Dr. SQUARE, Lynndle** (University of the Western Cape)
17:50	[**142**] What is your favourite particle and why? (00h01')	**Dr. WIENER, Jeff** (CERN)
17:51	[**144**] Overview of Modern Physics Learning Objects in Brazilian Government Repositories (00h01')	**Dr. ANDRÉ, Ary Leonel** (Federal University of Santa Catarina)
17:52	[**146**] A comparative analysis of school physics curriculum content in selected countries (00h01')	**Dr. RAMAILA, Sam** (University of Johannesburg)
17:53	[**149**] Physics teaching and learning: A case for Indigenous Knowledge in Physics (00h01')	**Dr. OTULAJA, Femi** (University of the Witwatersrand)
17:54	[**151**] An assessment of students' understanding of Newtonian Mechanics (00h01')	**Prof. GOLDSTEIN, Kevin** (University of the Witwatersrand)
17:55	[**152**] South African science students' perceptions of physics as a fundamental discipline (00h01')	**Dr. REDDY, Leelakrishna** (University of Johannesburg)
17:56	[**163**] WHAT DOES EMOTIONAL ENGAGEMENT OF UNDERGRADUATE STUDENTS WITH EXPERIMENTS DEPEND ON? (00h05')	**Prof. SHARMA, Manjula** (The University of Sydney)
18:01	[**164**] Using spreadsheets to improve student engagement in the laboratory (00h20')	**Prof. SHARMA, Manjula** (The University of Sydney)
18:30 - 19:15	**BREATHER**	
19:15 - 21:00	**Carnivores Dinner Venue: CARNIVORES RESTAURANT**	

WEDNESDAY 03 OCTOBER 2018

08:30-10:00 Conference Site & Off-Site visits– Buses depart at 08h30 from Misty Hills Conference Centre to the University of the Witwatersrand

10:00 – 11:00 Plenary: ORIGINS CENTRE, UNIVERSITY OF THE WITWATERSRAND
Chair: Prof. NICOLA, Wilkin (University of Birmingham, UK)

Time	*Title*	*Presenter*
10:00	[**159**] Physics education for 21 st century graduates (01h00')	**Prof. GRAYSON, Diane** (University of the Witwatersrand)

13:00-20:00 Conference Site & Off-Site visits: Buses depart at 13h00 from the University of the Witwatersrand to the Lion and Safari Park. Buses depart at 17h00 from the Lion and Safari Park to Lesedi Cultural Village for Dinner and Show.

THURSDAY 04 OCTOBER 2018

08:30-10:00 Parallel Session 1: Single Oral Presentations – Venue: Pelindaba 1
Chair: Dr. HERBERT, Mark (University of the Western Cape)

Time	*Title*	*Presenter*
08:30	[**126**] APPRAISAL OF SENIOR SECONDARY SCHOOL PHYSICS TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE (00h20')	**Mr. MUSTAPHA, Hassan Junaidu** (Abubakar Tafawa Balewa University Bauchi Nigeria)
08:50	[**150**] Active learning, student numbers, and formal session attendance in Statistical Physics III at the University of the Witwatersrand (00h20')	**Prof. KEARTLAND, Jonathan** (University of the Witwatersrand)
09:10	[**91**] IMAGINARY FORMATIONS OF TEACHERS OF THE INITIAL YEARS OF ELEMENTARY EDUCATION ON PHYSICS AND THEIR TEACHING IN A CONTINUED TRAINING PROGRAM	**Dr. CORREA DE LIMA, SORANDRA** (Federal University of Uberlândia)
09:30	[**28**] WHAT ARE EXPERIMENTAL SKILLS? A STUDY WITH IN-SERVICE TEACHERS (00h20')	**Dr. KHAPARDE,** Rajesh (Homi Bhabha Centre for Science Education, TIFR, Mumbai, India)

08:30-10:00 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK
Chair: Prof. PERSANO ADORNO, Dominique (Istituto di Istruzione Superiore "Pio La Torre")

Time	*Title*	*Presenter*
08:30	[**132**] General Physics for Earth Sciences, an undergraduate introductory physics course for first-year students majoring in the earth sciences at the University of Johannesburg (00h20')	**Dr. CARLESCHI, Emanuela** (Department of Physics, University of Johannesburg)
08:50	[**45**] Thai pre-service physics teachers' understanding about seeing an object (00h20')	**Dr. KAEWKHONG, Kreetha** (Department of Curriculum, Teaching and Learning, Faculty of Education, Chiang Mai University, Thailand and Thailand Center of Excellence in Physics, Commission on Higher Education, 328 Si Ayutthaya Road, Bangkok 10400, Thailand)
09:10	[**111**] RETOOLING PHYSICS INSTRUCTION THROUGH CONTEXT-BASED STRATEGY (00h20')	**Dr. AFOLABI, FOLASHADE** (Department of Sciene Education, Distance Learning Institute,University of Lagos, Nigeria)
09:30	[**125**] An investigation of the effectiveness of using analogies to develop a robust understanding of direct current (DC) electric circuits in first-year university students (00h20')	**Mr. BACELA, Collin** (Nelson Mandela Univeristy)

08:30-10:00 Parallel Session 3: Single Oral Presentations – Venue: IMPALA
Chair: Dr. LAWSON, Benjamin (l'Université Chrétienne Bilingue du Congo)

Time	*Title*	*Presenter*
08:30	[**107**] RESEARCH ABOUT THE ADAPTATION PROCESS OF ASTRONOMY DIDACTIC MATERIAL – THE DIARY OF SKY – FROM THE CONTEXT OF THE NORTHERN HEMISPHERE TO THE SOUTHERN HEMISPHERE (00h20')	**Dr. NARDI, Roberto** (UNESP – Brazil)
08:50	[**22**] REFLECTIONS ON DIDAKTIK ANALYSIS OF PHYSICS TEACHING METHODS (00h20')	**Prof. ISHAK, Mohd Zaki** (University Malaysia Sabah)
09:10	[**21**] PRE-SERVICE PHYSICS TEACHERS' STEM INTEGRATIONS (00h20')	**Ms. CANER, FATMA** (Marmara University)
09:30	[**39**] A STUDY OF STUDENT TEACHERS' MISCONCEPTIONS ON UNIFORM CIRCULAR MOTION (00h20')	**Dr. MUTSVANGWA, Andrew** (North-West University)

10:00 – 11:00 Plenary: Pelindaba 1
Chair: Prof. SHARMA, Manjula (The University of Sydney)

Time	*Title*	*Presenter*
10:00	[**160**] Blurring the classical-quantum divide (01h00')	**Prof. FORBES, Andrew** (U. Witwatersrand)

11:00 – 11:30 TEA & COFFEE BREAK Venue: Foyer of Pelindaba 1

11:30 – 13:00 Parallel Session 1: Workshop – Venue: Pelindaba 1
Chair: Prof. SOKOLOFF, David (University of Oregon)

Time	*Title*	*Presenter*
11:30	[**11**] Exploring the connection between science and business: an approach from the Institute of Physics (01h30')	**Ms. CLARK, Linsey** (Institute of Physics)

THURSDAY 04 OCTOBER 2018(Continues)

11:30 – 13:00 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK **Chair: Dr. OUATTARA, Lassana (National Resource Center for Physics Education)**		
Time	*Title*	*Presenter*
11:30	[**16**] PHYSICS IN THE DISCIPLINE OF MEDICAL RADIATIONS IN AN AUSTRALIAN UNIVERSITY (00h20')	**Dr. DEB, Pradip** (School of Health and Biomedical Sciences, RMIT University, Australia)
11:50	[**120**] AN ANALYSIS OF THE INFLUENCE OF THE INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS ON THE SELF-EFFICACY BELIEFS OF PHYSICS TEACHERS (00h20')	**ARAUJO, Rodrigo** (Programa de Pós-graduação Interunidades em Ensino de Ciências- USP)
12:10	[**165**] AssessING laboratory SKILLS: SHARING something WE TRIED THIS YEAR (00h20')	**Prof. SHARMA, Manjula** (The University of Sydney)
12:30	[**47**] The African School for Electronic Structure Methods and Applications (ASESMA) (00h20')	**Prof. CHETTY, Nithaya** (University of Pretoria)
11:30-13:00 Parallel Session 3: Single Oral Presentations – Venue: IMPALA **Chair: Dr. REDDY, Leelakrishna** (University of Johannesburg)		
Time	*Title*	*Presenter*
11:30	[**32**] Active-learning in oscillations with high – speed video analysis (00h20')	**Dr. WATTANAKASIWICH, Pornrat** (Thailand Center of Excellence in Physics)
11:50	[**34**] STUDENT-CENTERED, INTEGRATED APPROACH TO A FRESHMAN SCIENCE COURSE (00h20')	**Dr. KANEKO, Yuki** (Sabanci University)
12:10	[**128**] PHYSICS LITERACY THE MISSING LINK TO SUSTAINABLE DEVELOPMENT IN KENYA (00h20')	**Dr. KIGO, Josephat Kariru** (Lecturer Kenya Methodist University)
12:30	[**135**] CHANGES IN STUDENTS' PROBLEM-SOLVING SKILLS: THE ROLE OF A FOCUSED TEACHING INTERVENTION BASED ON SEQUENTIAL MULTIPLE REPRESENTATIONS (00h20')	**Mr. BALA MUSA, Suleiman** (Abubakar Tafawa Balewa University Bauchi, Bauchi State, Nigeria.)
13:00 – 14:00 LUNCH: Boma Restaurant		
14:00 – 15:00 Plenary: Pelindaba 1 **Chair: Prof. LINDER, Cedric (Uppsala University)**		
14:00	[**161**] Developing representational competence in first year physics: Implications for curriculum and classroom practices (01h00')	**Dr. CONANA, Honjiswa** (University of the Western Cape)
15:00-16:30 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK **Chair: Dr. ANGSTMANN, Elizabeth (UNSW, Sydney)**		
Time	*Title*	*Presenter*
15:00	[**79**] Methods of evaluation in natural science education verified by the practice of lower level at grammar school (00h20')	**Mr. KONECNY, Martin** (Department of Physics Education , Faculty of Mathematics and Physics, Charles University, Prague)
15:20	[**25**] In-cooperating a two-stage tests in physics learning (00h20')	**Dr. HERBERT, Mark** (University of the Western Cape)
15:40	[**119**] Studio Teaching Model for an Introductory Engineering Physics Course on Classical Mechanics (00h20')	**Ms. BELKEBIR, Nada** (Ecole Mohammadia d'Ingénieurs / Al Akhawayn University in Ifrane)
16:00	[**43**] Death of an outcome – the role of stigmergy in our examination system (00h20')	**Dr. CLERK, Douglas** (School of Physics, University of the Witwatersrand)

THURSDAY 04 OCTOBER 2018(Continues)

15:00-16:30 Parallel Session 3: Single Oral Presentations – Venue: IMPALA
Chair: Dr. KONTRO, Inkeri (University of Helsinki)

Time	*Title*	*Presenter*
15:00	[**10**] Incorporating Computational Exercises into Introductory Physics Courses (00h20')	**Prof. KORTEMEYER, Gerd** (Michigan State University)
15:20	[**42**] ALTERNATIVE APPROACHES IN DIGITAL ERA TO HANDLE UG PHYSICS (MECHANICS) LABORATORY: A CASE STUDY OF MOMENT OF INERTIA OF A FLYWHEEL EXPERIMENT (00h20')	**Dr. SHARMA, SAPNA** (St. Bede's College Shimla India) **Prof. AHLUWALIA, P.K**. (Himachal Pradesh University)
15:40	[**78**] EFFECTIVENESS OF VIDEO – BASED INSTRUCTIONAL STRATEGIES ON SENIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENTS IN PRACTICAL PHYSICS IN LAGOS STATE, NIGERIA (00h20')	**Dr. BABAJIDE, Veronica** (University of Lagos)
16:00	[**106**] ALTERNATIVES TO CLASSICAL LABORATORY ACTIVITIES (00h20')	**Mrs. GALLEGO, Juana I** (UNLP)

16:30-17:00 TEA & COFFEE BREAK Venue: Foyer of Pelindaba 1

17:00-18:30 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK
Chair: Dr. CLERK, Douglas (University of the Witwatersrand)

Time	*Title*	*Presenter*
17:00	[**137**] Probing the nature of student explanations of visual phenomena: a pilot study (00h20')	**Mr. ABUBAKAR, Ishiyaku** (University of Cape Town)
17:20	[**138**] Student ideas on vector direction in kinematics graphs (00h20')	**Dr. KUDINHA, Martin** (CPUT) **Dr. JOHN, Ignatius** (CPUT)
17:40	[**40**] KNOWLEDGE AND KNOWER CODES AND THE INTEGRATION OF MATHEMATICS CONCEPTS WHEN CONDUCTING PHYSICS EXPERIMENTS (00h20')	**Mrs. CHEHORE, Toliwe** (Cape Peninsula University of Technology) **Mrs. SCHOLTZ, Zena** (Cape Peninsula University of Technology) **Ms. VAN STADEN, Vannessa** (Cape Peninsula University of Technology) **Dr. BOOI, Kwanele** (Cape Peninsula University of Technology)
18:00	[**56**] Preservice teacher's understanding of the concept of acceleration (00h20')	**Mr. KHWANDA, Mphiriseni** (University of Johannesburg)

17:00-18:30 Parallel Session 3: Single Oral Presentations – Venue: IMPALA
Chair: Dr. HODARI, Apriel K (Eureka Scientific, Inc. Oakland, USA)

Time	*Title*	*Presenter*
17:00	[**147**] THE INSTRUMENTATION FOR TEACHING PHYSICS AT INITIAL TEACHER TRAINING: ASSUMING AUTHORITY IN THE PHYSICS TEACHING-LEARNING PROCESS (00h20')	**Dr. LEONEL, André Ary** (UFSC)
17:10	[**73**] TRAINING FOR PHYSICAL SCIENCE TEACHERS (00h20')	**Prof. WOLFE, David** (UK Institute of Physics)
17:40	[**88**] xploring Pre-Service Science Teachers Physics Pedagogical Orientations towards Their Own Classroom Teaching (00h20')	**Mr. SONDLO, Aviwe** (University of Johannesburg)

18:30 – 19:15 BREATHER

19:15 – 21:00 Conference Banquet Venue: PELINDABA 1 & 2

FRIDAY 05 OCTOBER 2018

08:30-10:00 Parallel Session 1: Single Oral Presentations – Venue: Pelindaba 1 **Chair: Prof. TAKAHASHI, Naoshi (Kagawa University)**		
Time	*Title*	*Presenter*
08:30	[**31**] INTERACTIVE ENGAGEMENT AND SEMIOTIC RESOURCES IN A CLASSICAL MECHANICS LESSON SETUP (00h20')	**Dr. OUATTARA, Lassana** (National Resource Center for Physics Education)
08:50	[**143**] PHYSICS AND HUMANITY (00h20')	**Prof. GLEDHILL, Irvy** (Igle) (U. Witwatersrand)
09:10	[**112**] Gender Differences in Performance in Physics Practicals (00h20')	**Dr. VISAYA, Maria Vivien** (University of Johannesburg)
08:30-10:00 Parallel Session 2: Single Oral Presentations – Venue: SPRINGBOK **Chair: Dr. WATTANAKASIWICH, Pornrat (Thailand Center of Excellence in Physics)**		
Time	*Title*	*Presenter*
08:30	[**72**] CONCEPTS IN CONTEXT	**Dr. SOUTHEY, Philip** (Stellenbosch University)
08:50	[**58**] A CLASSIFICATION SCHEME FOR BASIC PHYSICS CONCEPTS: LEARNING AND THINKING FROM NEURODEVELOPMENTAL SCIENCE PERSPECTIVE	**Prof. CHEKURI, Nageswar Rao** (Woodbury University)
09:10	[**117**] NATIONAL HIGH SCHOOL EXAM (ENEM) LIKE A FORMATIVE ASSESSMENT OF PHYSICS EDUCATION IN BRAZIL	**Prof. MARCOM, Guilherme S.** (UNIVERSIDADE ESTADUAL DE CAMPINAS - UNICAMP)
09:30	[**166**] Riddles in VERITASIUM: Making sense of how students reflect	**Prof. SHARMA, Manjula** (The University of Sydney)
10:00 – 11:00 Plenary: Pelindaba 1 **Chair: Prof. KORTEMEYER, Gerd (Michigan State University)**		
Time	*Title*	*Presenter*
10:00	[**162**] Embracing the interconnectivity of people beneath the night sky: Where physics and culture meet	**Prof. HECHTER, Richard** (University of Manitoba, Canada)
11:00 – 11:30 TEA & COFFEE BREAK Venue: Foyer of Pelindaba 1		
11:30-13:00 Parallel Session 1: Single Oral Presentations – Venue: Pelindaba 1 **Chair: Dr. RAMAILA, Sam (University of Johannesburg)**		
Time	*Title*	*Presenter*
11:30	[**60**] CAEN: Tools for Discovery (00h20')	**Dr. MATTONE, Cristina** (CAEN S.p.A.)
11:50	[**59**] SENSOR SCILAB 3.0: STUDENTS UPGRADE A PHYSICS LAB USING NEW TECHNOLOGIES (00h20')	**Ms. DEL SORBO, MARIA ROSARIA** (IS "LEONARDO DA VINCI")
12:10	[**61**] Charged liquid droplets in electromagnetic fields - An experiment for developing conceptual understanding during student activity	**Mr. JOHANSSON, Andreas** (University of Gothenburg)
12:30	[**153**] Teaching and Learning Approach - Concepts and Quantitative Tools	**Prof. CORNELL, Alan** (NITheP)
13:00-13:30 Closing Ceremony: Pelindaba 1		
13:30 – 14:30 LUNCH: Boma Restaurant		

Parallel Session 2 / 9

Game Development for Teaching Physics

Prof. KORTEMEYER, Gerd [1]

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The talk describes two computer games developed using the Unity 3D platform: "A Slower Speed of Light," designed to teach Special Relativity, and "Kirchhoff's Revenge," designed to teach circuit laws. The talk includes a short demo of both games, a discussion of the effort required to develop immersive game and learning environments, experiences and research results using these games in physics lessons at both college and high school level, as well as information informally gathered from "Let's Play" videos on YouTube.

Parallel Session 3 / 10

Incorporating Computational Exercises into Introductory Physics Courses

Prof. KORTEMEYER, Gerd [1]

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The talk describes the incorporation of computational exercises into introductory physics courses: mechanics, electricity and magnetism, and modern physics. While these courses traditionally emphasize symbolic and numerical calculations, as well as experimental methods, over the last decade, increasingly computational methods are incorporated into the curricula. The talk discusses opportunities for and examples of incorporating VPython projects, as well as logistics, learning outcomes, and student feedback.

Parallel Session 1 / 11

Exploring the connection between science and business: an approach from the Institute of Physics

Author: Ms. CLARK, Linsey [1]

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Physics and business are renowned subjects in their own right, but when combined have the potential to achieve extraordinary things. This concept is something the Institute of Physics (IOP) believes in and has dedicated over a decade to programmes within this area, including a series of entrepreneurship training courses for hundreds of scientists and engineers around the world.

For many years the training focused on university students who were studying a STEM subject, and scientists and engineers with commercially viable inventions or ideas. However, upon reflection, research and conversations with in-country partners, we questioned what happened to students who did not attend university. Through that we came to the realisation that with our experience, along with our partners and volunteers, we could work with students at a younger age and explore their interest in a STEM subject, their plans for the future and how the two might be connected. With that in mind, in 2017 the IOP, in partnership with several other organisations, initiated the Future STEM Business Leaders programme. It is specifically for final year secondary school students in Tanzania, who are studying STEM subjects in some capacity, and would like to explore what can be achieved when applying an education in science to business.

The seven month programme begins with a three day training course, which is dedicated to practical physics, how to conduct business in Tanzania and how the two are linked. This is all demonstrated through interactive workshops, sessions with business owners, and a group activity which tasks students with developing their own physics based business, based on an example that we provide. Once the students have completed this training they are then given the opportunity to apply everything they have learnt to their own business ideas, through support from business mentors and incubators in Dar es Salaam. The programme ends with students pitching their business plans, with the best plan receiving an internship with a science based business in Tanzania.

This programme is an excellent example of developing physics education and demonstrating what can be achieved with an education in a STEM subject, in this case the creation of a business. The programme is currently completing year one and year two will begin in September 2018, and as a result we will be in a good position to present the programme and findings at the conference. Our proposal is to run a 90 minute workshop; we will begin with an introduction to the programme, including its history and impact and end with our future plans. The majority of the time will be spent taking attendees through examples of the three day programme, i.e. a science communication workshop, developing a business model canvass and/or pitching skills. We hope that those who attend the workshop understand the essence of our programme but, most importantly, see the link between an education in physics and business.

Poster Session / 12

The use of Mathematics Linear Graphs and Functions in understanding and interpretation of Kinematics Graphs in Physics

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Students at tertiary level seem not to be able to relate their Mathematical understanding of graphs with graphs in Physics especially from Kinematics concepts. This has resulted in most students being unable to understand and interpret Kinematics Graphs or present a clear graphical report from their Lab experiments and interpret them.

Mathematics is an essential tool in studying physics, i.e., it will be difficult to study Physics without the sound basics of Mathematics. It is even called the "language of physics" (Redish, 2005). Physicists blend conceptual physics with mathematical skills and use them to solve and interpret equations and graphs. For instance, in kinematics, different aspects from mathematics such as knowledge of functions and the solving ofequations are combined with physics concepts.

Many introductory physics students perform poorly on the use of mathematical skills and interpretations of graphs in physics. Two possible reasons may be:

- Students lack the necessary mathematical skills needed to solve the physics problems.
- Students do not know how to apply and relate their mathematical skills in the context of physics.

These possible reasons were investigated in a Masters Research project, which probed first year university students' interpretations of graphs in kinematics and in mathematics. This paper will use the idea of Beichner's standardized questionnaire on kinematic graphs. From this questionnaire, an equivalent questionnaire was devised in the context of Mathematical equations and graphs. The responses were analysed statistically. The results of the investigation tend to indicate the deficiencies in the students' mathematical conceptual knowledge as well as in their transfer of mathematical skills they possess to solve kinematic equations and graphs.

Poster Session / 13

TRANSFER MATRIX METHOD FOR ELECTRON-IO-PHONON INTERACTION IN MULTI-INTERFACE HETEROSTRUCURE SYSTEMS

Prof. YAN, ZUWEI [1]

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In a conventional solid state physics teaching material, the optical phonon mode and its interaction with electrons is an important problem[1, 2]. It is usually used to solve the optical phonon model by using the Born-Huang equation[3] and obtain the Hamiltonian of electron and phonon interaction for bulk material. But multi-layer systems of polar semiconductors, it is well known that the electron-optical-phonon interaction in heterostructures is strongly affected by the presence of heterointerfaces, which give rise to new modes of optical phonons localized in the vicinities of interface and called the interface optical (IO) phonon modes. A detail investigation for the IO phonons and their coupling with electrons is more complicated in multi-layer systems, and students have difficulty in learning.

In the present paper, we study the electron-IO-phonon interaction in multi-layer systems of polar semiconductors in solid state physics teaching. Within the framework of the dielectric continuum model we use a transfer-matrix method[4] to obtain the electrostatic potentials, dispersion relations of IO-phonon modes in the systems and then derive the corresponding electron-phonon interaction Hamiltonian. It is found that there are two branches of interface phonon modes in each interface, and coupling with the electrons traveling in the system besides the confined longitudinal optical (LO) phonon modes. The dispersion relation and the electron-IO-phonons coupling functions for several typical systems are given and discussed. The advantage of transfer-matrix method is discussed in solving the physical problems of multilayer heterogeneous materials, It is clear seen that more complicated problem is easy to solve, and the physical meaning is clear, and convenient for the teaching. Such as semiconductor multi-barrier quantum tunneling can also be solved well.

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Parallel Session 1 / 14

Exploring Physics Student Graduate Preparedness vis-à-vis the 2018 SAIP Benchmark Statement

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The 2018 SAIP Benchmark Statement (SAIP 2018, 22-23) has many similar fundamental "graduate attributes" to the British (IOP 2014) and the American (American Association of Physics Teachers 2011; American Center for Physics 2014; Heron and McNeil 2016) benchmark statements. Some of these graduate attributes are extremely difficult to evaluate in terms of implementation practices (how these get written into module descriptors and how teachers implement these) and how student experience these SAIP intended attributes. These are difficult to evaluate because they deal with human capabilities as a function of physics knowledge and working practices both in physics and in society. Of particular relevance for this presentation are the recommended ethical, communicative, problem solving, ICT, analytical, investigative, and personal skills (see p.22, SAIP 2018).

The presentation will propose a novel methodological way of doing this that has empirical components that are built on substantive theorizing of Human Capability (Alkire and Black 1997, 263-279; Fraser and Greenhalgh 2001, 799-803; Hart 2012, 275-282) rather than on rhetorical statements. This approach will be illustrated with case study data collected from one of South Africa's leading departments of physics, and the implications of such research outcome will be discussed.

Key words: SAIP Physics benchmark statement, Human Capability, graduate attributes, novel methodology. References

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Parallel Session 2 / 16

PHYSICS IN THE DISCIPLINE OF MEDICAL RADIATIONS IN AN AUSTRALIAN UNIVERSITY

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X-ray imaging has become fundamental diagnostic tool in healthcare. More than four billion medical images are being captured globally in each year for clinical purpose by using ionizing radiations. There is an increasing demand for delivery of additional diagnostic and therapeutic services from medical radiations and imaging sectors worldwide as the population is growing. For high-quality healthcare a sustainable medical radiations and imaging technology workforce is absolutely important. Medical radiations and imaging are highly technologically driven professions. Adequate knowledge in physics is the basic requirement for any medical radiation technologists working in medical radiation centres where ionizing radiations are used. The purpose of this paper is to discuss courses of physics we teach and the challenges we face in teaching physics to the undergraduate students in the discipline of medical radiations in an Australian University. Although laws of physics are applied in the development and use of diagnostic and therapeutic medical equipment, the physics is not loved by the students as a subject as it should be. There are 13 medical radiations physics courses (including radiography, nuclear medicine, radiotherapy, CT, MRI, and Ultrasonography) are taught in undergraduate medical radiations program in our discipline. In this paper teaching methods of medical radiation physics will be discussed and students' approach to learn this subject in this department will be analysed. The teaching techniques and initiatives will be discussed along with their success and failure. It is evident that students in medical radiations program look at physics differently compared to the students in other physics programs. In medical radiations students are eager to see more direct applications of physics compared to the basic theory behind it. Some students believe that it is possible to be a good radiological technologist without having proper understanding of physics. Some students have a general repelling attitude toward learning physics in this discipline. But this attitude can be changed with the modification of traditional method of physics teaching by showing its application in the field of medicine.

Parallel Session 2 / 17

WHO NEEDS 3D WHEN LEARNING ABOUT THE UNIVERSE – PERCEPTIONS OF 3D AND ITS IMPORTANCE FOR TEACHING AND LEARNING PHYSICS AND ASTRONOMY

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When entering the discipline of physics, and in particular astronomy, students are faced with many challenges. Not only do they need to learn to "read" and "write" the "language of the discipline", built by all the semiotic systems and resources (tools, representations, and activities) used by the discipline, but also to learn to think spatially, or extrapolate three-dimensionality from 1D and 2D input (Eriksson et al., 2014), e.g. mathematics, diagrams, images, etc. Although identified as very important (eg. Hegarty, 2014; Lindgren & Schwartz, 2009; NRC, 2006; Plummer, 2014; Uttal & Cohen, 2012), extrapolating three-dimensionality is a severely overlooked competency in both physics and astronomy education that poses a real challenge to novice students in their meaning-making; they are often left by them self to try to imagine what an astronomical object may look like in 3D. Furthermore, from the physics and astronomy education research literature, only very few other efforts have been identified to address the challenges associated with extrapolating three-dimensionality (eg. Heyer et al., 2013). Hence, extrapolating three-dimensionality becomes an important educational aspect to consider when teaching physics and astronomy.

In this paper we report on an international study where perception of the third dimension, depth, in astronomical 2D imagery and psudo-3D simulations has been the main focus. We have chosen to focus on astronomical nebulae, because these are very common in astronomy textbooks/teaching material and teaching situations. Astronomy students and professors have been asked about their noticing of depth from astronomical 2D images and psudo-3D simulations in order for us to map their competency in extrapolating three-dimensionality in their minds. In analyzing their responds, we use a standard qualitative research method, and take as our point-of-departure Eriksson et al. (2014) hierarchical categories for multidimensionality discernment. Our preliminary results suggest that the competency to "read" depth in astronomical image/simulation is very limited by new-to-the-discipline students but also that simulations, where motion parallax is offered, could help students in their meaning-making and extrapolation of three-dimensionality in their minds. Implications in regards to our findings will be discussed.

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Parallel Session 1 / 18

THE ALIGNMENT OF THE GRADE 12 PHYSICS EXAMINATION AND THE CAPS CURRICULUM: (NOVEMBER 2014 – MARCH 2018)

Author: Mr. BHAW, Nishaal [1]

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In order for the South African education system to compete globally, the best practices of the global education leaders must be adopted to achieve success in STEM education. Policy changes in the education system and Government investment on STEM education must be realised. The Department of Basic Education (DBE) has associated the poor pass rate in the National Senior Certificate (NSC) Physical Sciences to the learners' lack of practical work and the inability to solve problems by integrating their knowledge from different topics in Physical Sciences. The CAPS (Curriculum and Assessment Policy Statement) is central to the planning, organising and teaching of Physical Sciences. The NSC Physical Sciences Examination Diagnostic Report 2017, refers to the CAPS on only one occasion. The reference was made to the learners' lack of knowledge of Physical Sciences definitions. Considering that definitions in the NSC Physical Sciences: Physics (P1) November 2017 weighed only 11%, and more than a third of the learners achieved below 30% in the examination there seems to be a lack of references to CAPS. It was also suspected that the poor performance could possibly be due to a disjointed alignment between the CAPS and the P1. There have been no previous studies investigating the alignment between the CAPS and the P1, this study aims to fill that gap. A case study research strategy was used in this study. A purposive sampling procedure included the CAPS Grades 10–12 Physical Sciences document; the Physical Sciences Examination Guidelines Grade 12 documents and the final and supplementary P1 examinations for the period starting November 2014 to March 2018. A summative content analysis research technique was conducted using the Surveys of Enacted Curriculum (SEC) research method. The SEC method employed the use of the four topics of Physics and the four non-hierarchical levels of cognitive demand as described in the modified version of Bloom's taxonomy. This study found that there was a 100% of categorical coherence, a 67.3% balance of representation, a 79.6% cognitive complexity and a Porter's alignment index of 0.76 between the CAPS and the P1. The overall inter-rater Kappa for all the documents analysed was 0.88. The results of this study indicated that the CAPS over-emphasized the "Mechanics" topic content and the P1 over-utilised the "Applications and Analysis" cognitive demand based questions. The highest level of cognitive demand, "Synthesis and Evaluation" was not used in the CAPS or the P1. An interpretation of this is the CAPS and the P1 foster an environment of lower order thinking. In order to foster higher order thinking and increase the alignment between the CAPS and the P1 it is a recommendation of this study that firstly, the CAPS decreases "Mechanics" content. Secondly, the CAPS and the P1 increase the cognitive demand of "Synthesis and Evaluation" at the expense of" Recall". Thirdly, the CAPS must include the concepts, content and skills of the school based Physics practical assessments whilst decreasing the focus on Physics definitions.

Parallel Session 1 / 19

Good Vibrations: Sound Physics in Science Centres

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This workshop explores effective physics teaching by evaluating an aspect of the work done by interactive science centres in South Africa. The focus of the study was grade 9 students from three different school groups: urban, township and rural visiting the Unizulu Science Centre (in Richards Bay, South Africa) and attending a science show "Good Vibrations" which presents concepts in sound and waves through the medium of musical instruments. The principal author's long experience at Unizulu Science Centre has indicated that the three groups above have very different experiences during a visit which relate to their prior experience and educational opportunities. The different groups were compared and contrasted in terms of: General attitude; conceptual and visual difficulties with respect to sound; and prior knowledge and learning during the show. The implications of this study for the design and presentation of science shows (and for Physics teaching in general) were then considered in the light of these findings.

The initial study of the show (conducted towards a Masters' degree) used a combination of qualitative and quantitative probes to measure learning and other outcomes. Valuable lessons were learnt about how well these probes performed in the evaluation of a science show, which will be extremely valuable to practitioners. The probes showed encouraging evidence of significant learning taking place during the show, and significant knowledge gains with two of the three groups doubling their pre-test score in the post-test. We found that the show worked well for urban and township students, but not very well for rural students, due to issues of language, cultural background and prior knowledge.

Design Based Research (DBR) claims to provide solutions to real educational challenges by refining both the interventions offered by communicators and the instruments used to test their effectiveness. As an extension to the study mentioned above (conducted towards a doctoral degree) the author used the data from the initial study to refine the show and to attempt to boost learning achieved by the students – especially in the weaker rural group. The survey instruments used were simultaneously refined to try to avoid ambiguity and misunderstanding of the questions. Students were presented with the "new improved" show and then tested using the refined instruments. Learning was contrasted with that previously achieved and significant gains were noted. While performed in the context of science shows in science centres, this study nevertheless has relevance to all Physics teaching. It offers a feedback instrument (using DBR) to assist teachers in refining their message (and the instruments used to evaluate it) to suit the different groups they present to.

In this interactive workshop session: some aspects of the show will be performed, data and conclusions from the two studies will be presented and discussed, and participants will be guided through the effective creation, evaluation and improvement of a Physics show (or lesson).

Parallel Session 1 / 20

The role of mathematics and self-efficacy in learning quantum mechanics

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Quantum mechanics (QM) is a complex and often difficult topic for physics students. To make sense of the topic, the students need to grasp both the physical interpretation and the mathematical formulations [1-2]. Quantum theory is based on the notion of vector spaces and their features, which makes linear algebra part of the necessary mathematical toolbox.

At the University of Helsinki, the QM curriculum begins in the first or second year of studies, depending on study track. The first course, Basics of quantum physics, covers the basics from the historical background up to a qualitative treatment of the hydrogen atom. Many students struggle with the mathematics on the course, and, partly to address this, the curriculum was changed to include a linear algebra course simultaneously to Basics of quantum physics. Hence, the QM course in 2018 was taken by both students who studied linear algebra at the same time, and students who had taken linear algebra earlier.

To study the effect of this change we administered a mathematics pre-test and a self-efficacy questionnaire based on [3] and adapted for QM, and correlated the results with learning outcomes (exercise and exam scores, N = 50).

Surprisingly, the preliminary results indicate that neither the self-efficacy nor the initial mathematics skills of students correlate with the learning outcomes in Basics of quantum physics. For the first year students, the students who reported theoretical physics as their study track had equal initial mathematics level to their "physics" peers, but had higher self-efficacy beliefs and scored higher in the exercises and exams. Second-year "physics" students scored even lower in all measures. The explanation is likely a selective effect: the "physics" students who take the course in their first year are more comfortable with more advanced physics and mathematics content.

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Parallel Session 3 / 21

PRE-SERVICE PHYSICS TEACHERS' STEM INTEGRATIONS

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One of the most problematic topics for STEM researchers is that there are different interpretations of STEM integration and STEM education. As stated in many studies, STEM education has been described in a variety of ways from disciplinary approaches to disciplinary approaches. Bybee (2013) argues that it is necessary to determine where we are to get details of where we want to go. For this reason, how STEM disciplines, science, technology, engineering and mathematics disciplines are related is important.
Bybee (2013) demonstrates that this integration can be done in different ways to create a STEM curriculum as STEM 1.0 (one discipline), STEM 2.0 (two disciplines), STEM 3.0 (three disciplines) and STEM 4.0 (four disciplines). The study lasted for 13 weeks and STEM training was given to pre-service physics teachers including STEM philosophy, engineering design process, computational thinking and technology. At the end of the 13th week, they were asked to perform a STEM activity from the teacher candidates as micro-teaching. 14 teacher candidates, 10 girls and 4 boys, participated in the study. Pre-service physics teachers' perspectives are categorized as nested, transdisciplinary, sequential, siloed and others through using pre-service teacher STEM Education Survey, developed by Radloff and Guzey. As a result, STEM integration model is related to the perspectives of pre-service physics teachers. For instance, pre-service physics teachers who have transdisciplinary perspective integrated using STEM 4.0 integration model in their micro-teaching. On the other hand, pre-service physics teachers should also be encouraged to use technology such as simulations, WEB 2.0 tools to build STEM 4.0 integration.
(Conclusions will be shared during the presentation of the conference.)

Parallel Session 3 / 22

REFLECTIONS ON DIDAKTIK ANALYSIS OF PHYSICS TEACHING METHODS

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It is about a decade the researcher started introducing didaktik tradition in his undergraduate course, the physics teaching methods. Prior to didaktik tradition, physics teaching methods at the Faculty of Education equipped pre-service teachers with pedagogical strategies which is commonly focus on understanding learning. Here, the specific content is not treated as problematic in the teaching and learning of physics as physics courses are taught by the Faculty of Science. As the meaning of didaktik is based on the notion of Bildung (the formation of the learner on his or her development), and it concerns the process of transforming and developing the physics content structure from the contexts primary source of scientific knowledge into the contexts of schooling knowledge and subsequently enhancing the practice of teaching and learning in the classroom, thus the researcher employs one conception of Didaktik that is didaktik analysis. Didaktik analysis in physics teaching methods involves with: conceptual analysis of specific physics content as contained in the curriculum specifications and textbooks; analysis of literature on students' alternative conceptions; developing a lesson plan; developing teaching sequences that involve teaching and learning activities, and reflection. Since then, the researcher begins to reflect more thoughtfully on his actions at the end of conducting physics teaching methods course, during pre-service physics teachers' teaching practices in the microteaching (seven weeks) and their practicum (14 weeks) in secondary schools, and during presenting papers at the national and international conferences. The researcher engages in 'technical reflection', where the focus is on the physics teaching methods course and teaching practice issues in the microteaching and practicum, and in 'practical reflection', where the focus is on didaktik analysis issues. The researcher finds that although pre-service physics teachers did their didaktik analysis assignment on mechanics, energy, optics, electricity and electromagnetism, and implemented these in their lesson plans and teaching sequence in the micro-teaching. Their lesson plans did consist of 'learning outcomes', a teaching sequence, assessment procedures, and reflections. However, during practicum their lesson plans developed were not strongly based on didaktik analysis, but were more in accord with the textbooks and curriculum specifications. Pre-service physics teachers seem bound by the physics content contained in the curriculum specifications, and subsequently this impacted on their lesson plans and teaching sequence in the classroom during their teaching practice in secondary schools. It would seem then that having experiences with didaktik analysis assignments and teaching practice, are not enough alone to ensure that pre-service physics teachers will actually use didaktik analysis-based teaching practice in their future teaching. In addition, comments or feedbacks from the participants during the conferences about didaktik tradition said that didaktik and pedagogy are almost similar and the terms are commonly used in teacher training programmes. Generally, the researcher finds that educational contexts have influenced on pre-service physics teachers in their teaching practice on didaktik analysis in the classroom as didaktik is strongly culture-bound.

Keywords: didaktik tradition, pedagogy, didaktik analysis, teaching methods, teaching sequence, technical reflection, practical reflection.

Poster Session / 23

A COMPARATIVE STUDY ON LEARNING IMPROVEMENTS FROM SCALE-UP PEDAGOGY AND REFORMED LECTURES

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In the past, many large physics lectures have been reformed and supplemented by active learning elements such as Peer Instruction [1]. A different approach consists of breaking up large lectures into smaller classes and shifting to highly interactive flipped learning settings. Studio Physics and SCALE-UP are well-documented implementations of this approach [2]. Running multiple parallel classes, however, implies substantial investment efforts (rooms, faculty) [3] and it is advisable to gain insights on expected learning improvements before deciding on either reformed lectures or small interactive class settings. A comparative study of student achievements between these two different settings is needed in order to guide pedagogical decisions going forward.

For this reason, we have conducted a pilot study within a physics lecture class of 370 students at a major Swiss research university. In a one-year undergraduate physics course, we divided the student cohort into two parallel teaching settings. During one semester, we offered a highly interactive SCALE-UP environment to one group of 52 students and a reformed lecture to the remaining 318 students. In the following semester, all students were taught in the same lecture setting without a SCALE-UP alternative. Within the 14-week parallel teaching period, we compared students' performance in both settings and could draw conclusions on immediate differences. Eight months after the SCALE-UP intervention, all students had to sit the same high-stakes final exam, which consisted of topics throughout the entire year, including topics from the previous intervention. We related the final exam results to the former performance results and gained insights on medium-term effects based on the two teaching settings. We also addressed questions on gender differences. In addition, we analyzed student feedback that included data related to class attendance, out-of-class preparation, level of intellectual challenge, and other items.

In this poster, we present the major results of our study and draw conclusions on implementing SCALE-UP pedagogy compared to a typical reformed lecture setting.

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Parallel Session 1 / 24

Support for an undergraduate physics program: A first year mainstream module

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First year students entering the mainstream undergraduate physics program are at different levels of preparedness which have impact on their learning at the university, in particular, their learning of physics which influence their retention, performance and success in the subject. In a survey done most students reported that they find the physics interesting but difficult and that they needed more guidance and support in their learning of physics inside and outside the lecture periods and tutorial. In response to this, the lecturer in the first year mainstream undergraduate physics align the curriculum, i.e. the teaching and learning activities to guide students learning as well as to provide a collaborative and supportive learning environment inside and outside the lecture periods and tutorial. This paper describes the initiatives implemented in the mainstream undergraduate physics program to enhance guidance and support of students learning of physics inside and outside the lecture periods and tutorial. The paper examines the role of tutors in the initiatives implemented as well as successes achieved and challenges encountered with the implementation of the initiatives. Tutors as well as students' experiences of the initiatives were surveyed and are presented and discussed. The paper concludes that tutors have an important role to play in providing the mainstream undergraduate physics students a collaborative and supportive learning environment inside and outside the lecture periods and tutorials to enhance the learning of physics.

Parallel Session 2 / 25

In-cooperating a two-stage tests in physics learning

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This paper reports on work that has been done in the Physics Department at University of the Western Cape (UWC). The mainstream mechanics physics first year module centers its focus on improving students' success by giving them epistemological access to the study of physics. Central to the module teaching philosophy and pedagogy is the socio-cultural perspectives on learning in the sciences. This has guided the development of our intervention strategies to direct students' learning toward gaining access to the 'ways of knowing' of the discipline. Such perspectives suggest that an exclusively individual or cognitivist approach may need to be complemented by those that recognize the social contexts in which science learning takes place, and which places a greater emphasis on learning as participation and identity development.

This paper reports on the two-stage tests used to support physics learning. The two-stage exam is a way to encourage students' to participate and reflect on their learning by providing immediate formative and summative assessment of their learning. An overview of the mainstream mechanics physics first year module teaching and learning approach as well as the results of a survey of students' experiences of the two-stage test will be presented anddiscussed.

Poster Session / 26

An overview of a teacher's development program for in-service teachers

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Since the mid-nineties, South Africa schools have been in a state of education reform. At the centre of the reform was the establishment of the comprehensive curriculum project named Curriculum 2005. Deficiency in the Curriculum 2005 resulted in the establishment of the National Curriculum Statement in 2008. Curriculum reform as required by the National Curriculum Statement for grade 10-12 physical sciences teachers implied that teachers have a deep understanding of the highly structured content knowledge as well as the pedagogical content knowledge to transform the content for effective teaching. How every research has indicated that teachers found the curriculum challenging and that they were concerned that they did not have the necessary skills to deal with the content.

The South Africa Institute of Physics (SAIP) in its draft document "Strategic Plan on the enhancement of Physics Training in South Africa" recommended that Physics Departments at South Africa Universities plays a more active role in teacher training. This paper reports on the University of the Western Cape, Department of Physics and Astronomy's teachers' program to help address the curriculum challenges teachers faces in terms of content and pedagogical content knowledge. An overview of the program as well as teachers experiences of the program will be presented and discussed.

Poster Session / 27

AXIOMATIC SYSTEM OF THERMO-PHYSICS THEORY - A TEACHING MODEL OF THERMODYNAMICS AND STATISTICAL PHYSICS

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As a course of theoretical physics, "thermodynamics and statistical physics" is often complained hard to learn and teach by some university students and teachers in China. To a certain extent it is related to the current knowledge system of the course, in which the macroscopic theory-"thermodynamics" and microscopic theory
- "statistical physics" are separated from each other [1,2]. Students usually dull perception of the relation between the macro- and microscopic theories, and sometimes fell the contents multifarious and disorderly.
We reformed the course of "thermodynamics and statistical physics" and constructed a new knowledge system - the axiomatic system for teaching the theory of thermo-physics [3]. The macro- and microscopic theories are fused together and the microscopic theory plays a leading role in the system. The theory starts from an axiom (postulation)——the equal-probability hypothesis——the basic hypothesis of the statistical physics, and is tested and verified well by experiments. The ensemble theory is into the main line throughout the course. The macroscopic laws of thermodynamics are straightforward derived by the equal-probability hypothesis. Thermodynamic potentials for the micro-canonical ensemble, canonical ensemble as well as the grand-canonical ensemble are obtained based on the basic postulation, and the properties of various thermodynamic systems can be easilydiscussed.
The new system is more reasoned and self-consistent in theory. Its application in teaching "thermodynamics and statistical physics" enables students systematically know statistical physics and clearly understand the relationship between the macro- and microscopic theories. And then they can use the thermo-physics theory flexibly to solve many practical problems.

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Parallel Session 1 / 28

WHAT ARE EXPERIMENTAL SKILLS? A STUDY WITH IN-SERVICE TEACHERS

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The teaching and learning of physics is incomplete and inadequate unless students gain a significant experience in experimental physics through a well-planned laboratory courses. The physics laboratory training is supposed to develop in students, a variety of important cognitive and psycho-motor abilities related to experimental physics. It is very well accepted that developing and nurturing 'experimental skills' is an important goal of laboratory courses. The authors, In the process of development of a laboratory course felt that it is important to identify details of specific skills and abilities which students should develop through that particular laboratory course.

As part of an ongoing survey with teachers, a need was felt to understand what do teachers and lab instructors understand by the term 'experimental skills'. Do they associate only psycho-motor skills or they include other analytical, cognitive skills under the title 'experimental skills'.

The authors, in this paper reports the results of a pilot study with 38 teachers from across the country, who were directly involved in teaching laboratory courses at various schools and colleges for at least 8 years. In the first interaction, teachers were asked to a) describe what are 'experimental skills' required in experimental physics and b) to identify and make an exhaustive list of experimental skills which they would like their students to develop through laboratory courses from grade 8 till undergraduate level. To our surprise, we noted that teachers were not able to separate psycho-motor, cognitive and affective abilities and skills. Based on their lists, we prepared a list of 83 skills and abilities and asked the same teachers to confirm if they would identify as 'experimental skill' or 'other abilities' for each of the 83 skills and abilities. The results indicate that teachers do not have clear understanding about the psycho-motor, cognitive and affective abilities and skills. Thus the authors felt a need to design a learning module for in-service teachers on objectives and goals of laboratory courses in which each aspect will be discussed and illustrated with required details. This is essential because the tasks, methods, contents and learning processes involved in the development of these psycho-motor, cognitive and affective skills and abilities are different and should be appropriately emphasized during the designing of a laboratory course and strategy for instruction and assessment.

Parallel Session 2 / 30

Programming: A tool for meaning-making and a transductive link between semiotic systems.

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Programming is an integral part of modern physics and, at the same time, gaining increased interest in modern education. More and more students are being taught programming at schools. In upper secondary schools in Sweden, where, after the first of July 2018 [1], students are required to experience and use programming in both mathematics and technology. This elevation of programming from a specific subject to a semiotic system used within other subjects, is an indication that programming has entered the "common knowledge"-domain, similar to mathematics or reading and writing.

However, little is known on what programming may offer as a semiotic system for meaning-making in physics when used to create interactive visual representations in 2D and 3D. Therefore, in this project, we ask what disciplinary-specific meaning-making gets constructed by students as they engage with programming as a semiotic system [2] in relation to their disciplinary discernment from the created visualizations [3].

The epistemological starting-point is that students may construct a better understanding for how different semiotic systems and resources are used together for meaning-making to explore and explain a particular phenomenon, and that programing may work as a transductive link between different semiotic systems [2].

To investigate students' meaning-making, we have devised a workshop, based on variation theory [4], where upper secondary students use programming in physics to construct models and create visual representations. In the workshop the participants are guided through the creation of a particle system that follows Newton's laws of motion [cf. 5]. This particle system is then used to explore interactions between particles, such as elastic forces, electrostatic forces, gravitational or other forces.

We have collected video and audio data of students working in groups of three, solving different physics problems. The data analysis is still ongoing, using a qualitative method, and preliminary results suggest that students, with no prior programming knowledge, are able to follow the implementation of models of physical phenomena with little to no problem. This suggests that programming may indeed be a powerful semiotic system very useful for meaning-making in physics. Further analysis will focus on what programming per se means for physics meaning-making and how it works in relation to other semiotic systems used in physics.

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Parallel Session 1 / 31

INTERACTIVE ENGAGEMENT AND SEMIOTIC RESOURCES IN A CLASSICAL MECHANICS LESSON SETUP

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In this paper we present an investigation of what meaning first-year university physics students make of force and motion when discussing elevation, velocity and acceleration during trampoline bouncing. A mathematical analysis of trampoline bouncing is provided in [1,2]. We aim to develop a better understanding of how students can overcome difficulties in understanding those central concepts of classical mechanics.

As a starting point, we used an assignment based on Rosannagh MacLennan's gold medal trampoline routine. She used 19 seconds (as extracted from the video [3]) to complete the routine of 10 jumps. The score board shows that 16 of these seconds were 'flight time'. Several groups of students were video-recorded as they worked to discern the different types of motion involved. They were asked to draw approximate graphs of elevation, velocity and acceleration during two full jumps of the routine with the approximation that all jumps are similar.

Previously [4], we found that students rarely made use of earlier kinaesthetic experiences of trampoline bouncing. To encourage that connection, another cohort of first-year university physics students were asked to work in small groups to create short movies of themselves bouncing and also explaining the forces involved during the motion, as well as draw graphs of elevation, velocity and acceleration during the jumps. They were also invited to use their smartphones for data collection [5,6].

The video-recordings were analysed using a naturalistic methodology with respect to the use of various semiotic resources and how the students interact with each other in discussing the assignment. Also we looked for students´ understanding and conceptions concerning disciplinary knowledge, kinaesthetic experience and (pre-/alternative-) conceptions. In addition, we analysed how the students explain force and motion, when asked to create a short movie of themselves bouncing.

An analysis of these discussions will be presented and implications for teaching classical mechanics will be discussed.

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Parallel Session 3 / 32

Active-learning in oscillations with high – speed video analysis

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An oscillation is a basic topic covered in either mechanics or vibration and wave course in undergraduate physics. Physics education research studies over five years indicated that most students have difficulties with visualization, so they are often capable of solving the equations without relating to real situations. Thus activities using high-speed videos have been constructed and designed based on active-learning approach. Numerous high-speed videos (such as oscillations with massive springs, damped oscillations in glycerin and self-oscillators etc.) were recorded and distributed to students. Students were taught to use Tracker and spread sheet software to analyse videos. Both quantitative and qualitative research studies were conducted to evaluate effectiveness of these activities over the past three years. Student understanding in several concepts were improved, but many students still had difficulties in concepts such as phase, quality factor and normal modes etc.

Parallel Session 2 / 33

FIRST YEAR PHYSICS STUDENTS' ALTERNATIVE CONCEPTIONS ON BERNOULLI'S PRINCIPLE

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Part of a larger project, first year students' alternative conceptions relating to Bernoulli's principle were investigated. In order to develop teaching interventions using constructivist principles, students' prior understanding is important as new knowledge is linked to their prior knowledge. In most of the secondary schools, flow dynamics is not part of the curriculum and therefore very little research regarding alternative conceptions concerning Bernoulli principle has been conducted. An explanatory case study design was followed, by identifying the most prevalent alternative conceptions relating to the Bernoulli principle, which describes pressure of fluids in motion. The study was done amongst 71 first year physics students at a University of Technology in South Africa. Both qualitative and quantitative research methods were used to determine these students' alternative conceptions. Three instruments were used to collect the required data: (i) a questionnaire with structured multiple choice questions before the intervention, (ii) a tutorial where students had to solve applicable problems using the continuity equation and Bernoulli's principle during the intervention and (iii) a test with multiple choice questions, followed by a motivation for each choice, as well as two open-ended questions, after the intervention. The motivations and open-ended questions sought to elicit the students' views regarding flow dynamics, and to gain more original responses than would have been the case had the students been asked to respond to already pre-conceived statements regarding flow dynamics. Although quantitative data were collected, the main thrust of data analysis for this study was on the qualitative data.. The analysis of the students' responses did not focus on the knowledge, per se, but the underlying conceptions behind the respondents' answers. The results showed that the students held many alternative conceptions concerning the equations of continuity and Bernoulli's principle in a dynamic fluid system, which include the following notions: pressures are equal when flow speeds are equal, without taking different altitudes in consideration; pressures are equal where cross-sectional areas are equal, without taking different altitudes in consideration; pressure in a fluid is the same throughout the fluid (a misconception from Pascal's Principle); in a pipe with different altitudes the speed increases due to gravitational acceleration; the depth in static fluids and the height due to potential energy cause confusion. These answers were further categorised into six themes namely naïve physics; lateral alternative conceptions, ontological alternative conceptions, Ohm's p-prims; mixed conceptions and loose ideas. Even fundamental concepts of static liquids were not mastered and recommendations are made. Due to the multiple alternative conceptions in these different categories, the importance of the larger project to design an instructional intervention with constructivist principles which focuses on teaching sequences to address the alternative conceptions relating to Bernoulli's' principle, isclear.

Parallel Session 3 / 34

STUDENT-CENTERED, INTEGRATED APPROACH TO A FRESHMAN SCIENCE COURSE

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Traditional teaching methodologies and non-integrated contents of freshman physics courses are often inadequate in preparing students for coping with real-life challenges. To address this, we redesigned our two-semester introductory science course into active-learning format and with integrated contents, to equip the students with scientific knowledge and skills for contending real complex contemporary challenges. This course is one of the core curriculum courses taken by all freshmen students (>1000 per semester) regardless of their prospective majors. The aim of the course is to initiate curiosity and scientific thinking in students, and at the same time introduces some of the basic concepts of physics, chemistry, and biology and their interconnections. The new version of the course takes a modular structure designed around four open science questions closely related to everyday life: 1. “Are we alone in the Universe?”, 2. “Is antibiotic resistance a big threat for the humankind?”, 3. “Are humans causing climate change?”, and 4. “Can we ever comprehend the workings of the brain?”. Within these modules, basic physics concepts such as kinematics, dynamics, energy, electricity, magnetism, thermodynamics, and a brief introduction to quantum mechanics, are scattered throughout and discussed in various contexts. When designing, we adopted backward design model with students at our focus, and the learning activities are done in classrooms specifically designed for collaborative learning. Specially-trained graduate and undergraduate assistants facilitate discussions among students while they work on problem sets, which also benefits the assistants to become better educators, leaders, and learners themselves. Through such course design and integrated contents relevant to their lives, we emphasize on promoting teamwork, critical thinking, problem solving, and scientific literacy skills, valuable for all professionals of tomorrow. Moreover, since 2016 the course has been offered in a flipped format, in which students work on a preparation set (video lectures, readings, and quizzes) before coming to the class. This allows for more in-class activities and instructor-student interaction time, benefiting both parties. Such an innovative approach, including the core curriculum educational model, applied at such a large scale is deemed especially progressive in the region, and consequently, we have overcome a number of unique challenges specific to our students. We present the design, implementation, and example physics activities of the course, together with preliminary results of learning outcome comparison between traditional and non-traditional approaches using both quantitative and qualitative analyses. We find considerable increase in the attendance rates, which contributes to a change in the course grade distribution and general attitude. The qualitative feedback indicates positive impact on students’ learning culture.

Poster Session / 37

CHARGED LIQUID DROPLETS IN ELECTROMAGNETIC FIELDS - AN EXPERIMENT FOR DEVELOPING CONCEPTUAL UNDERSTANDING DURING STUDENT ACTIVITY

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for the students to learn in this experimental setup:
Electric Field-Strength, Electric Force, Electric Charge, Projectile-motion

Introduction
What is the relative impact on learning, when the abstraction in lessons changes?
Things that are small and/or invisible to the human eye need to be visualized to be well understood. The visualisations can be made with digital tools, introducing at least a layer of abstraction. The visualizations could also be made by observing and experimenting with an analog macroscopic object that behaves in the same way as the desired object of study. This is the main idea behind the experimental setup that we have developed in our team.

Experiment

Charged macroscopic liquid droplets falls through an electric field that can be controlled and varied by the observer, giving learners the opportunity to experience ideas and concepts that otherwise only appear as particle-projectile-motion exercises in the Physics textbook. When shun by a strong light-diode the 20 microns in diameter droplet is visible with the human eye, and by a simple web-camera we can directly observe and record an enlarged image of the droplet moving down a curved path between the charged plates of ITO-prepared glass.

Students are able to change a number of parameters and simultaneously observe how the changes affects the behavior of the droplets, we investigate in this study how this experience will enhance the learning of students.

Output

What can students learn about the concepts and properties of electric fields, electric charge, electric force, Newtons laws of motion, gravity, air-resistance when they visually can observe and experience how charged droplets act, moving through static electric fields?
Does students gain long-term learning results from different types of learning-experiences such as direct observations, movie clips or theoretical studies? And if so, which is the way for educators to prefer?
Are there social factors affecting the learning in the lab and how can we compensate for them or take that into account?

In addition to the above goals we are going to use interactions and video-taped observations to further develop how to use the experimental setup as a tool for teaching students about the concepts mentioned above. The questions that will guide our perception are the following:

- What Scientific content and which concepts can be explained with the experiment?
- Does the students learn anything unintended?
- How can we to a higher degree achieve the learning goals with the experimental setup?
- What set of knowledge does the students need to grasp the experiment/movie clip?

We will discuss our first results and give suggestions for further studies to improve the teaching situation.

Parallel Session 3 / 39

A STUDY OF STUDENT TEACHERS' MISCONCEPTIONS ON UNIFORM CIRCULAR MOTION

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Uniform circular motion is one of the key mechanics topics in Physics that students fail to comprehend and master. In South Africa, uniform circular motion is currently not taught to Physical Sciences Matriculate learners and thus students are only introduced to it at university level. It is common cause that poor comprehension of fundamental concepts and tenets of uniform circular motion leads to difficulties in understanding related topics such as Rotational Kinematics and Rotational Dynamics. This study aims at investigating student teachers' misconceptions about uniform circular motion and its pertinent underlying concepts such as tangential acceleration and centripetal acceleration. The study will also attempt to figure out the source(s) of the ensuing misconceptions. The sample of the study consists of 45 second-year Physical Sciences student teachers at a South African university. A multiple-choice test consisting of 20 questions on uniform circular motion will be administered. Simple and explanatory statistical techniques will be employed to analyse the data and appropriate intervention methods will be proposed to curtail the identified misconceptions.

Parallel Session 2 / 40

KNOWLEDGE AND KNOWER CODES AND THE INTEGRATION OF MATHEMATICS CONCEPTS WHEN CONDUCTING PHYSICS EXPERIMENTS

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Lack of mathematical knowledge has often been considered responsible for high failure and drop-out rates in Physics, both at school and higher education levels. Failure in problem solving has frequently been used as evidence for inadequate mathematical knowledge, since mathematical concepts are used as a tool for physics problem solving. Physics knowledge is underpinned by physical theories that originate from observed phenomena, but are explained using mathematical language, such that mathematical concepts are incorporated into the physics knowledge structure. In addition, experiments are an integral component for knowledge formation and conceptualization.. The problem is that the structural role of mathematical concepts, together with experimentation are ignored during teaching and learning of physics. The purpose of this study was to identify how mathematical concepts are integrated into the knowledge building process using experimentation in the understanding of mass density at introductory physics level.

The investigation was carried out using pre-services teachers being trained to teach Natural Sciences. The pre- service teachers were then interviewed in terms of their attitude towards physics, and how it should be taught and who should learn it, which revealed their dispositions to the subject. Generally, those who scored low marks in the experiment had a negative attitude towards the subject, felt that they naturally, physics was not their subject and were studying it because it was a compulsory module. Those who scored higher marks answered the questions from a physics perspective and understood the mathematical nature of the concept of density. The research used the Legitimation Code theory as a theoretical framework. The analysis of the results suggested that the mathematization stage could be the most difficult because it requires visualization skills and understanding a phenomenon from a physics perspective.

The investigation was important in that it highlighted the importance of not only experimentation, but understanding that mathematical concepts, in physics but are an integral part of the structure, have physical meaning and are used within the constraints of the physical situation they represent.

Parallel Session 3 / 42

ALTERNATIVE APPROACHES IN DIGITAL ERA TO HANDLE UG PHYSICS (MECHANICS) LABORATORY: A CASE STUDY OF MOMENT OF INERTIA OF A FLYWHEEL EXPERIMENT

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With the invasión of Digital Era on all activities of life, alternative approaches are emerging to explore a single situation in a variety of ways offering new opportunities and insights about learning behavior of the student. It is expected that this is going to impact traditional laboratory practices in a variety of ways. The moot question is can these alternative explorations be used for enhancing learning experiences of the learners, make laboratory a more engaging place and tuning learners alternative conceptions with the conceptions of an expert. In this case study we present three ways to perform an experiment to calculate the moment of inertia of a flywheel in a typical undergraduate Mechanics (Physics) laboratory: (i) the traditional way using a stopwatch and a meter rod as basic measuring tools, (ii) by using a video analyser of a typical setup of the experiment and (iii) a modelling software available in a web-based virtual laboratory. The Physics education research strategies are applied to observe the pedagogical value of performing the same experiment in three ways together. To go ahead with this approach, implemented through pre-post test methodology, a concept inventory has been devised to identify the alternative conceptions around the moment of inertia, theorems of the moment of inertia and flywheel as a mechanical device to control rotational motion in a day to day life. An effort has been made to address the alternative conceptions during the performance of the same experiment in three distinct ways. Finally, a perception survey was also carried out to know about this multi-representational approach's (a) pedagogical effectiveness, (b) effect on laboratory climate, (c) expectations of students, (d) laboratory engagement and (e) instructor-studentrelationship.

Parallel Session 2 / 43

Death of an outcome - the role of stigmergy in our examination system

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This presentation reports the results of a study inspired by perceived shortcomings in the 'problem-solving' abilities of undergraduate physics students. Evidence in support of this perception is found in both the relevant literature (Gil-Perez, Dumas-Carré, Caillot, & Martinez-Torregrosa, 1990) (Mayer, 1998) (Tuminaro & Redish, 2003) and in analysis of student performance in relation to the type of question being answered.

An analysis of examination papers at both matriculation and first-year level was carried out over several years and reveals evidence of a bias: there is a favoured question-type that can explicitly be taught and relatively easily mastered - and which typically makes up a sufficiently large fraction of an examination that candidates can pass without having to demonstrate any real problem-solving ability. What examination candidates are required to demonstrate instead is a well-developed ability to expedite routine operations (at various levels of complexity)–which does not fit our espoused definition of problem-solving. (Martinez, 1998)

It is argued that this bias has over the years become established stigmergically, (Heylighen, 2011) via a feedback process - sometimes called 'backwash', to which candidates, examiners and instructors have all been party. Candidates learn what kind of questions to expect, examiners learn what kind of questions candidates can be expected to answer, and instructors learn what kind of questions need to be taught, by traces left in the system's environment by those who function in it.

These findings could perhaps go some way toward explaining the shortcomings in student problem solving abilities.

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Poster Session / 44

Perceptions of physics - Are we placing too much emphasis on technical skills?

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The South African Institute of Physics and the Council on Higher Education
identified that there are many challenges associated with physics teaching and learning. We report on the results of a pilot study that attempted to identify the perceptions of first-year students studying physics at Rhodes University in 2017. Academics were interviewed, a questionnaire was created and a survey of first-year students was conducted. Focus groups were run with the second- and third-year students to acquire qualitative data to help understand the quantitative data received from the first-years. Emotional issues were identified as the largest contributing factor to students' perceptions of physics. A high correlation between study skills and students' understanding and problem-solving abilities was also observed. Under-preparedness was recognised as an important issue that needs further investigation.

Parallel Session 2 / 45

Thai pre-service physics teachers' understanding about seeing an object

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The purpose of this study is to investigate understanding of 50 Thai pre-service physics teachers, Faculty of Education, Chiang Mai University about seeing an object. The samples in this study were collected by asking for volunteers. They were asked to answer the 4 tasks about seeing in various situations by interview, 1) seeing an object which can illuminate light by itself, 2) seeing an object reflecting light from around a light source 3) seeing an object in a dark room (light cannot pass through) and 4) seeing a beam of LASER. Their responses, in each task, are determined and classified into groups related to their understanding. The results revealed that they were confused about scientific models used for explanation of what light is. Besides, most of them still have some misconceptions about the eyes and scattering of light. All results are determined for designing an instruction that helps Thai pre-service physics teachers to have a better understanding in the topic of seeing for the future work.

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Experimental and General Solution of Buquoy's Problem

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The Buquoy problem represents an interesting example of a one-dimensional motion of a uniform thin fibre which is pulled upwards from a horizontal plane by a constant vertical force exerted against the homogeneous gravitational field. The solution of the problem includes several interesting concepts that are often developed within the introductory university physics course – a motion with a variable mass, utilization of the effective potential and a solution of a non-linear ODE of the second order, which provides an opportunity for some kind of numerical modelling of the motion. In this sense it is an appealing and rich problem, which represents a specific example of damped oscillations and according to our experience it can be discussed e.g. in a classical mechanics course.
Our contribution concentrates on the correspondence between a theoretical model and an experimental realization of this problem which can be demonstrated in a standard classroom. In our set, the upward force is represented by a buoyancy acting on a helium filled balloon. We briefly discuss a suitable material for the fibre and the determination of the fibre linear density. The experiment helps to support some other competences of the students – a video analysis of the motion with a Tracker video analysis and modelling tool and the fitting of the theoretical model parameters to match with the video analysis data. The experiment also naturally leads to a little more general theoretical model and an equation for this kind of oscillatory motion that counts in the constant mass of the used helium ball.
In this way we would like to draw attention to an interesting physical problem the solution of which is more complicated than standard damped linear harmonic oscillator, but still accessible for undergraduate physics majors and provides an opportunity to discuss some aspects in a wider context.

Parallel Session 2 / 47

The African School for Electronic Structure Methods and Applications (ASESMA)

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Solid State Physics/Materials science is arguably the most important discipline in the physical sciences that should be developed in Africa given its rich resources of minerals, energy and biological diversity. Developing materials science should therefore be an important goal for Africa with important opportunities for economic benefits and quality people development. There are already many successful materials science activities that are underway in Africa. This needs to gain wider international attention and should become contact points for international collaborations. The African School for Electronic Structure Methods and Applications (ASESMA) is one such successful initiative that has been in existence for the past decade. ASESMA has shown that it is possible to build a network across sub-Saharan Africa with world-class research with a relatively low budget. The greatest asset is the commitment of the lecturers and mentors, the team-work of the local organisers and the idealism of the participants who rank amongst the brightest of young minds from Africa, many of whom come from impoverished backgrounds but still dare to reach for the stars. The author is one of the principal organisers of the ASESMA.

Parallel Session 2 / 48

The practical teaching of undergraduate quantum mechanics

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It is more than a hundred years since some of the most basic notions of quantum mechanics were founded, but the subject still remains largely a mystery and conceptually a difficulty for many first time students. Some treatments of the introductory material tend to lean more toward the formalism and the theoretical underpinnings of the subject. Yet, today, quantum mechanics is a very practical tool that has been applied successfully to a wide range of research areas in physics, such as in condensed matter physics, solid state physics, nuclear physics, etc., and increasingly now in areas outside physics such as in chemistry, biology, etc. And so, the question must be asked whether our teaching of the subject has kept up with developments at the high end of research. The author has endeavored to bring more excitement to the subject by focusing on practical applications, including computational examples. Drawing close parallels with the classical world, which undergraduate physics students are usually more accustomed to, has proven to be invaluable in making the teaching of quantum mechanics more tangible, practical, and understandable to first time students. For example, the classical particle in a 1-D box corresponds to the particle simply bouncing back and forth at constant speed. The classical probability density p(x)=1/a where a=width of the box. It is useful in this example to discuss the meaning of this probability density from a classical standpoint which is related to the time-averaged motion of the particle. The quantum mechanical probability for this system, namely p(x)=|phi(x)|^2, has some useful similarities and differences. The interpretation of the quantum mechanical probability density is related to an ensemble average and not a time average. Furthermore, it is useful to see how the classical result for p(x) emerges from the quantum mechanical result for high quantum number. The same approach is useful for the harmonic oscillator, and other simple systems.

Parallel Session 1 / 49

Education for development - “being transformed to transform”

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Despite vast natural resources and foreign investment, the Democratic Republic of Congo is among the world’s least developed countries. Physics education has a crucial role to play in developing Congo in order to cultivate expertise in the hard sciences and engineering, which is paramount for creating value-adding industries, a domestic technical workforce, and the general problem solving skills and creativity that are natural by-products of the physics classroom.

However, even with a high quality physics classroom, Congo is faced with the problem of brain-drain where the best and brightest of the young Congolese talentpool leave for more promising work in the west and elsewhere in more developed parts of Africa. Therefore, the challenge is twofold - how do you develop a high quality STEM program in Congo that does more than just empowering an elite few to escape their situation without changing it?

In our university physics classroom, we are aiming to implement pedagogy based on the philosophy “being transformed to transform”. In this manner, our program aims to create strong ties between the students and the local community, so that the students learn content and thinking skills by solving real problems in the community and by imagining ways they can change their situation. In addition, by cultivating a love for problem solving, students will be motivated to stay where there are many difficult problems to be solved. Through contextualizing the classroom experience and the overall university experience, we are seeing alumni remaining engaged in their local community and even returning to it after achieving post-graduate degrees outside of Congo.

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Challenges and solutions for quality STEM education in eastern Congo

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There are a number of challenges for proving a strong university education in D.R.Congo. Academia in DRC suffers from a lack of qualified teachers in STEM and access to information is very limited since the internet is both costly and unreliable. In addition, students come from secondary schools with very limited study skills and weak problem-solving skills. Targeting the real cause of these problems is not straightforward due to the chronic conflicts and violence which have created insecurity and have had negative effects on the population. At our university, we are building strategies to produce conscientious capable graduates despite the challenges mentioned above. Graduates from our program finish with strong academic skills, new mind sets, and they strive to transform the country through creative and innovative technological solutions. Yet we are still looking to improve. We are in process of implementing new pedagogical strategies by utilizing some our best alumni as teaching assistants and by applying active learning methodologies such as flipped classroom, incorporating reading and writing in the physics classroom, and a philosophy of learn a little and apply a lot to foster self-learning through creativity and innovation. Because we still have a limited access to laboratory materials, we are actively investigating digital tools that could be used to enable students to have hands on experience in the physics classroom. We are in the midst of developing a renewable energy research lab to provide students the opportunity to learn through solving real problems that are highly relevant to their context. Through some of our new strategies, we are seeing more and more educated innovators and young long life learners who strive to find solutions and make Congo a better place to live.

Parallel Session 1 / 51

Construction of a Community of Practice in Undergraduate Physics

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This presentation is ethnography of physics lessons at the University in order to analyze how the social interaction among teachers and students construct a community of practice (Lave & Wenger, 1991). The work is grounded in Sociology of Scientific Knowledge perspective (Gilbert & Mulkay, 1992) that studies how physicists make sense of their practices in their own voices (teaching physics, in this case), developing science as a social construction (with their students). I take practice as a mutual compromise in action and learning as participation in social practices (Lave, 2011). A discourse analysis of extracts of three physics teachers' lessons to the same generation of students is done. The analysis shows how they communicate the historical construction of the purpose of physics as a discipline that tries to understand the natural phenomena, giving special importance to the historical context. The teachers make especial emphasis in the personal attributions (a little bit of vanity, fall in love with the research topics, thinking about them day and night, being perseverant) the physicists have to develop in order to be successful. Other results deal with the construction of possible futures for students opening expectations for their trajectories. It is also shown how these teachers explain students some features of everyday job at the discipline as its complexities, and the mutual compromise and responsibility among physicist sharing task that cannot be solved individually. Some final reflections emphasized on the shared repertoires that the teachers communicate to the students about what constitutes the disciplinary practices. This work also presents examples of students work in studding groups that show their appropriation of some of those practices. The community of practice is then constructed as an identity place that provide shared trajectories. This work represents an example of how even expositive lessons centered in the teachers discourse (Rogoff, Matusov & White, 1995) can develop a community of learning when they work with dialogic discourse (Bakhtin, 1982) of the teachers.

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The ψ(1S) and ψ(2S) Mesons in a Double Pole QCD Sum Rule

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In 1977, Shifman, Vainshtein, Zakharov, Novikov, Okun and Voloshin created the successful method of QCD sum rules (QCDSR), which is widely used nowadays. With this method, we can calculate many hadron parameters such as: mass of the hadron, decay constant, coupling constant and form factors in terms of the QCD parameters as for example: quark masses, the strong coupling and nonperturbative parameters like quark condensate and gluon condensate. The main point of this method is that the quantum numbers and content of quarks in hadron are represented by an interpolating current, where the correlation function of this current is introduced in the framework of the operator product expansion (OPE). To determine the mass and the decay constant of the ground state of the hadron, we use the two-point correlation function. On the QCD side, the correlation function can be written in terms of a dispersion relation and on the phenomenological side can be written in terms of the ground state and several excited states. The usual QCDSR method uses an ansatz that the phenomenological spectral density can be represented by a form pole plus continuum, where it is assumed that the phenomenological and QCD spectral density coincides with each other above the continuum threshold. In this work we use the method of double pole QCD sum rule, which is basically a fit with two exponentials of the correlation function, where we can extract the mass and decay constant of mesons as a function of the Borel mass. We apply this method to study the mesons: ψ(1S) and ψ(2S).

Parallel Session 2 / 53

Choice of representations in the crafting of university physics teaching practice

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This case study looks at reflective dialogue about the choice of disciplinary representations* in relation to the crafting of teaching practice that is skilful, knowledgeable, and conceptually based. The data (n=15) comes from a purposeful sample of teachers drawn from Sweden, South Africa, Germany, Canada and the United States who are responsible for introductory level classes in physics at their respective universities. The analysis involves the construction of qualitatively different categories that characterise how physics teachers are guided in their choice of disciplinary representations for the crafting of their teaching practices. These categories are epistemically anchored in teaching and learning pragmatism, personal experience of learning, disciplinary teaching style, and learning benefits of using multiple semiotic systems (multimodality). Discussion is centred on thinking about how semiotic systems may be used to optimize the possibility of learning.

*For the purposes of this study disciplinary representations are taken to be the collection of semiotic systems (modalities) that constitute the physics classroom communication that is used for sharing physics knowledge and practices. Examples of these semiotic systems for physics education are written language, spoken language, three-dimensional models, pictures, graphs, diagrams, mathematical formulae, and gestures.

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Enabing Astronomy

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Globally the percentage of disabled and impaired learners completing school is suboptimal when compared to abled peers. School incompletion detains the progress to Higher Education and in many cases to longer term contributions to the economy once in the work-field. The situation worse in the natural and branching sciences specially if heavily based on mathematics or visualisations like physics and astronomy. In this abstract we present a project carried by the Office of Astronomy for Development and the Human Science Research Council, seeking to assess the effect of access on equal participation and progress into all the process of the natural sciences. In this poster we will propose measurement tools, the framework, work carried at the Athlone School where we use astronomy to elicit the interest of the learners and provide a baseline experience for the development of skills and progress into the field.

Parallel Session 2 / 56

Preservice teacher's understanding of the concept of acceleration

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Challenges in the teaching and learning of physics existed as far as education existed worldwide. During the period, various approaches were continuously suggested and implemented but the learning gains were always disappointing, and physics was labelled as a difficult subject for the chosen few and that idea encouraged instructors accept high failure rate in physics as normal. Departing form that belief that physics is for the chosen few. The current study explored how pre-service teachers understand the concept of acceleration. Google form was initially used to collect data that informed the instructor about students' prior understanding of the concept of acceleration. Data collected were used to determine if acceleration is also threshold concept. Threshold concepts open productive ways of thinking in a domain and are troublesome in nature. Troublesome knowledge is said to be knowledge that is "alien, or counter-intuitive or even intellectually absurd at face value". Learning can be blocked if learners are experiencing difficulties in grasping a certain threshold concept. Threshold concepts were rationally classified into liminal states. The aim of this paper was to:

1. Explore if acceleration is a threshold concept and,
2. Categorizepre-servicestudents'knowledgeofaccelerationintermsofliminalstates Keywords: Preservice

teachers, acceleration, threshold concepts and troublesome knowledge

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A CLASSIFICATION SCHEME FOR BASIC PHYSICS CONCEPTS: LEARNING AND THINKING FROM NEURODEVELOPMENTAL SCIENCE PERSPECTIVE

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During structured actions on an event in physical-sociocultural (PSC) environments, peripheral neurosensors capture patterns and changes in variety of PSC-environmental energies and convert into electric signals. These signals travel through specified neural paths to various brain areas where they persistently fire neighboring neurons to form neural circuits by synapsing with them. A neuron "persistently firing" to synapse with the other neurons is called neural learning, which follows specific rules. The persistent firing depends upon the level of neurotransmitters, which are responsible for emotions. The paper draws an analogy between the neural and electriccircuits.

The earliest synaptic connections are found around 5 weeks and simple neural circuits are observed between 18-22 weeks of gestation age. After formation, the neural circuits continue to modify owing to further relevant sensory experiences. The biochemical traces the signals leave in the circuits during the formation and their modification is storage of learning, which is memory.

Structured relations are associated in real time emotional context to the active neural circuits through a self-regulating, holistic "structured" process that reaches a level of equilibration with its environment, and does not further undergo genetic change. The "structure" and its development are the result of probabilistic epigenetic process triggered by the environmental affordances for the purpose of survival. We begin learning to associate since birth and continue thereafter throughout lifetime. These associations lead to uni-and multimodal-associated learning. The structured process, which is called "thought process," transforms external structured actions into a particular kind of internal structured relations, which are "thoughts" and these are internal representations of the events. Such thoughts are expressed using semiotics, which include meanings and feelings. The thought process, which is learnt, and the thoughts continue to undergo nonlinear developmental changes owing to the new associations to the continuously modifying neural circuits that result from further relevant sensory experiences. The new thoughts thus generated are hierarchically more complex than the previousones.

This paper utilizes Fischer's Developmental Model to explain how simpler thoughts transform into complex thoughts, including how the thought processes also undergo developmental changes.

Using the Fischer's model, this paper analyzes basic physics concepts to classify them into a hierarchically complex classification scheme. The paper proposes a mechanism for how a physics concept is associated to a set of patterns in the information that corresponds to the patterns in the event, and how simpler concepts develop into more complex concepts. Furthermore, it explains what transformation rule develops a set of simpler concepts into a particular complex concept, and how the "newly" developed complex concepts relate to the "prior" simpler concepts, as well as how to identify the sets of required patterns from vast database of information in order to associate a concept. The paper argues that this classification helps develop student skills to learn how to develop complex physics concepts from simple concepts as well as how to help students to identify sets of required patterns from the sensoryinformationtoassociatewithaconcept.

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SENSOR SCILAB 3.0: STUDENTS UPGRADE A PHYSICS LAB USING NEW TECHNOLOGIES

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Student labs of scientific disciplines, in educational practices, aims to build knowledge through recursive reshaping of concepts in a repeated approximation to correct and complete competences of learners. Students, under teacher's supervision, foresee and plan a path of investigation, reflect and make choices, design models and hypotheses and verify them according to collected and processed data, observe unexpected phenomena and modify initial models of the reality [1].

'Sensors Sci.Lab 3.0' is an ongoing project aiming at using the most innovative technologies to help students to realize a complete makeover of the scientific laboratory's instruments.

This can be considered as an instance of a project-based learning educational experience [2], where students are encouraged to pursue medium-term objectives with concrete solutions of authentic problems. This approach, combined with action research, allows students to learn how to manage complexity, interdisciplinarity and teamwork more practically, thus fostering their training in order to support their ability to overcome future challenges.

The main idea of the project is to provide scientific laboratory with equipment, based on microprocessor boards [3],[4] and sensors, assembled and programmed by second, third and fourth years' students of a Scientific High school under the supervision of expert teachers.

Scientific curricula would be deeply updated both in instruments, extremely flexible and suitable to inspire and develop new experimental ideas, and in methodology completely different from teaching approaches based on lectures and passive memorization of formulas. This experience can motovate students to exploit new technologies to perform their tasks more easily [5]. In particular, the Web, full of tutorials and multimedia contents, can support students in analysis and also push them to conceive and compare alternative solutions, to communicate and present their ideas and projects more effectively.

More in details the basic steps which make up the project are the following:

1. Analysis of tools available in the laboratory;
2. Training in the operation of the programmable cards with microcontrollers and microprocessors;
3. Division into working groups for the study of different branches of Phyics;
4. Design and identification of the most suitable devices and technique to realize experimental setups;
5. Realization of accurate multimedia documentation for the execution of experiments with the various devices.
6. Organization of demonstration events on stage to spread the practice of lab equipment and to engage the entire school population;
7. Share all materials developed over time in a cloud platform.
8. Measure and evaluate the impact of the project on students and teachers.

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Parallel Session 1 / 60

CAEN: Tools for Discovery

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CAEN S.p.A. is an important industrial spin-off of the INFN (National Institute for Nuclear Physics), since 1979. CAEN is pleased to present company and its activities in educational field. CAEN brings the experience acquired in almost 40 years of collaboration with the High Energy & Nuclear Physics community into the University educational laboratories by providing modern physics experiments based on the latest technologies and instrumentation.

CAEN realized different modular Educational Kits, developed together with the University of Insubria (IT) and University of Aveiro (PT). The set-ups are all based on Silicon Photomultipliers (SiPM) state of-the-art sensor of light with single photon sensitivity and unprecedented photon number capabilities. The Educational Kits, provided with a dedicated Control Software, are modern and flexible platforms for teaching the fundamentals of Statistics, Particles Detection and Nuclear Imaging.

Moreover, CAEN developed a series of experiments with different difficulty level, from basic experiments to more complex applications. The idea is to target the experiment depending on the student educational level. With this approach, the experiments proposed can be performed at high school level (grade 11, 12) science classes up to undergraduate physics laboratory and PhD courses. The main goal is to inspire students and guide them towards the analysis and comprehension of different physics phenomena with a series of experiments based on state-of-the art technologies, instruments and methods.

Parallel Session 1 / 61

Charged liquid droplets in electromagnetic fields - An experiment for developing conceptual understanding during student activity

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What is the relative impact on learning when the abstraction in lessons changes?

Things that are too small to be seen by the human eye need to be visualized to be well understood. Visualisations can be realized with digital tools but at the cost of introducing a higher level of abstraction. The visualizations could also be made by observing and experimenting with an analog macroscopic object that behaves in a similar way as the object of study, and this is the main idea behind the experiment presented in this work.
We limit our study to scientific questions, whereas social factors affecting learning in the lab is left for future studies.

Research questions
What can students learn about concepts and properties of electric fields, electric charge, electric force, Newton's laws while building their experience on direct observations of charged droplets moving through electric fields?

What kind of teaching, such as direct observations during experiments, pre-recorded videos of experiments or classical theoretical studies with literature and lectures, presents the subject in a way that enables the students to learn efficiently, which we interpret as students having obtained long-term knowledge of the subject matter.

Physical experimental setup
During the study, an experimental setup was used to teach the above mentioned concepts. The experimental set-up consist of: charged macroscopic liquid droplets that fall through an electric field that can be controlled by the observer. This gives the students the opportunity to experience ideas and concepts that otherwise only appear as particle-motion exercises in the Physics textbook. When illuminated by a strong light-diode the 20 microns in diameter droplets are made visible for the human eye. By a simple web-camera we can directly record and observe the motion of of the dropleta sit moves a curved path in an electric field created.

Students are able to change a number of parameters and simultaneously observe how the changes affects the paths of the droplets. We investigate in this study how work with this experimental system affects the learning of the students.

Design of Study
All students performed a pre-test.
Three groups of students got an equal amount of teaching-time:
Group one: Short introduction to the concepts in the lab while the teacher uses the experimental setup as a teaching tool. Students can interact with the setup.
Group two: Short introduction while the teacher is showing a short video of the experiment. Held in ordinary classroom.
Group three: A theoretical lecture about the concepts in an ordinary classroom.
All three groups then received the same task: "Design an experiment where a charge droplet will move in a circle." This task was conducted in groups of two or three students.
All these lessons were recorded with video cameras.
The post-test was given within two weeks after the lessons.

We will discuss our first results and give suggestions for further studies to improve both the understanding of the teaching situation and the knowledge gained by the students.

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Let us improve students understanding of Physics and beyond

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The type of students we receive at University are digital, have a device at all times in their hands, do not even know how to fast social media. Many of them cannot work without a calculator, though their matric results are excellent. We have been engaged in first year teaching for over a decade, with the number of students majoring in physics increasing. The increase in numbers has also resulted in increasing the quality of students in the main stream. The lecturers' inputs have shown to directly affect the results of students. Using different resources available due to technology, with traditional teaching methods led to a conclusion that more students are capable of majoring in physics. The other group of students who continued in medicine and engineering have excelled in their way of learning, proving that the teaching methods we have used have benefited students beyond physics. Students' feedback were accompanied by personal letters from students and parents appreciating the inputs academics have used to improve students learning. In this workshop we will discuss the type of students are accept for first year at University, how we are using available teaching resources to improve learning and how have changed the laboratory experiences to improve hands on activities for students success.

Parallel Session 2 / 65

SA Physics Olympiad goes on-line

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South Africa, SA, like every other country around the world, has a huge, latent talent, much of it in the rural areas, that needs to be identified, nurtured and monitored. Olympiads and Competitions have the capacity to do this, but to give access to many learners to enter these Olympiads and Competitions means that Multiple Choice Questions, MCQ, need to be used. The SA Agency for Science and Technology Advancement, SAASTA, runs a very successful SA National Youth Science Olympiad, SANYSO. This Olympiad tests learner's knowledge of both Physics and Chemistry as SA teaches Physical Science. It reaches up 30 000 learners each year from both SA and some of the SADC Countries, and notably, many from rural areas.

During the International Year of Physics, in 2005, the SA Institute of Physics, SAIP, launched the SA Physics Olympiad, SAPhO, by selecting learners from the SANYSO and other Olympiads and Competitions in SA. The aim here was to identify learners with an above average ability in Physics. It has worked most successfully as a 50 MCQ Olympiad, using the usual pencil-and-paper grid approach. After a most successful trial run last year, for a limited group of learners, with an on-line Olympiad, SAPhO 2018 will be an on-line Olympiad.

In this presentation I will look at different forms of MCQ assessments made possible by taking the digital route and how the on-line SAPhO will give a superior assessment of a learner's Physics ability. There are of course still challenges, the principal one lies in setting the paper; not in finding the questions, but in providing the detractors to assist in the final assessment. It becomes a time consuming exercise but I am confident that the time is well invested and the rewards will hopefully show this.

Poster Session / 66

INFORMAL PHYSICS TEACHING FOR A BETTER SOCIETY: A MOOC-BASED AND CONTEXT-DRIVEN EXPERIENCE ON LEARNING RADIOACTIVITY

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Scientific literacy is a main target and recommendation of many National Standards of Education around the world, strongly convinced that a scientific culture can foster the development of better and safely lives. Teaching physics has the general objective of providing the learners with an adequate wealth of knowledge, in terms of both interdisciplinary scientific concepts and practical skills, in order to make them able to address the scientific problems they might face in the context of everyday life. In this work, we report the experimental evidence, collected during a first year physics class in an upper secondary technical school, for the urgent necessity to adopt an informal and inquiry-based strategy to teach physics effectively, in particular to all those students living in degraded socio-economic environments. Within the pedagogical framework of "Learning by Doing" and the paradigm "Learning by Teaching", we have explored the benefits of the students' participation to an informal ICT-based learning experience and, subsequently, as scientific speakers to a national science exhibition where the majority of the secondary schools in the region presents their scientific exhibits. A sample of 33 students from an upper secondary school has been involved in this experimentation. First, they attended a two-week long MOOC-based laboratory focused on the topic of radioactivity, where they had the opportunity to learn the basic concepts of a radioactive decay and carry out real measurements into a remote lab, challenging themselves through an inquiry-based learning path suitably developed in the context of the European Erasmus+KA2 project "Open Discovery of STEM Laboratories". Before participating to the exhibition, the students also built a model of atomic nucleus, alpha and beta particles, and practiced the use of a Geiger-Muller counter device for measuring natural radioactivity. After the lab, they trained themselves for a week to present the exhibit to the audience, firstly introducing the basic concepts of ionizing radiation and then the main medical applications, imaging/diagnosing, of radioactive isotopes. About three months after the participation to the scientific exhibition, the students answered to a questionnaire about these issues. Their answers have been analyzed in comparison with those provided by the students who attended a traditional lecture-based instruction. A significant improvement in the memorization of the main aspects concerning a radioactive decay, such as the definition of isotope, particle and electromagnetic radiation, the understanding of the radioactivity process at microscopic level, as well as a stronger view of the useful aspect of radioactivity in the everyday life have been definitely achieved by the students involved in this study. A final discussion about the overall benefits of the "Learning by Doing-and-Teaching" educational strategy within an informal inquiry-based laboratory is also reported.

Parallel Session 2 / 68

ENCOURAGING INNOVATIVE THINKING AND CONCEPTUAL UNDERSTANDING IN THE BIUST FIRST-YEAR COURSE

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In Botswana, a drive is underway to transform the country's economy from being mining/resource-based to research and technologically driven. In aid of this cause, the Botswana International University of Science and Technology (BIUST) was recently established, with classes starting in 2012.

With few large-scale industries, the formal employment possibilities of graduates in Botswana are limited. Therefore, encouraging innovation and innovative thinking amongst students are priority areas of the university.

The approach adopted in this first-year Physics course aims to enable students to transfer the gained knowledge and skills to new contexts, thus enabling innovation. The achievement of this conceptual understanding is a key factor in terms of the teaching approach and the assessment criteria of the course. The teaching approach is guided by Kolb's learning cycles. The objective is to equip the students to apply Kolb's learning cycles as a way to reflectively assess/gauge their progress. Furthermore, it should also assist students to identify areas in their understanding that need improvement, which in turn would encourage more self-directedness amongst the students. The overall aim of the intervention is to foster greater ownership by the individual of his/her learning experience.

In support of the above objective the course's assessment criteria is expanded to include reflective exercises and an increased focus on conceptual understanding. In practice the number of formal assessments is increased, but the assessments, compared to that of the previous academic year, are much shorter in length and more focused on specific aspects of the curriculum.

My presentation will elaborate on the approach and implementation as well as discuss the preliminary results.

Parallel Session 2 / 69

DEVELOPMENT AND EVALUATION OF A CONTEXTUALISED, ONLINE INTRODUCTORY PHYSICS COURSE

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In this talk I will discuss the development of an introductory contextualised online physics course and the methods that have been used to measure its effectiveness. The course, entitled "Everyday Physics", has been running since 2013. The course consists of twelve topics, one per week, based on everyday objects and phenomena. For example, students learn about thermal physics in topics called "Why does your kettle boil?" and "How does a hot air balloon work?". Being online, it is very easy for students to disengage as there are no scheduled classes, using contexts relevant to the students has kept them engaged in the course over the semester.

During the course students complete experiments at home with common household equipment and submit reports for marking. In the kettle topic they measure the specific heat of water by timing how long it takes to boil different volumes of water. Lectures are presented as short videos which are available through YouTube. Most lectures comprise of theory which is linked to the relevant phenomenon, demonstrations and worked examples to demonstrate how to solve problems. Each week the students have a set of tutorial problems to solve, worked solutions are provided to them.

The assessment comprises of six experiments students complete at home, four quizzes and a report they write about an experiment they have designed themselves to investigate they physics behind a phenomenon of interest to them. During the course they peer review the reports of their class mates which gives them an opportunity to learn from their classmates about many different applications of physics but also helps build their confidence as they get feedback on their report before submitting the final version to their tutor for marking.

The course has been very popular with students. It is an elective course, not required by any degree program. Over 800 students chose to take this course during 2018, the numbers have been increasing since its introduction in 2013. The participation rate of female students in the course is over 40%. Over this time I have been using the Force Motion Concept Evaluation (FMCE) survey to collect data on the learning gains of students. I have compared this with the learning gains measured in our face-to-face algebra based introductory physics course, taken by around 400 students each year. The learning gains measured in the online course are a little higher than in the face-to-face course.

Parallel Session 1 / 70

THE "OPEN DISCOVERY OF STEM LABORATORIES" WORKSHOP: AN INQUIRY-DRIVEN MOOC APPROACH IN TEACHING PHYSICS

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The "Open Discovery of STEM Laboratories" (ODL) has been an Erasmus+KA2 project aimed to implement teacher collaboration in creating and using micro-MOOCs (very short version of Massive Open Online Courses, MOOCs) for the insertion of STEM remote/virtual laboratories in the everyday teaching practices (http://opendiscoverylabs.eu). In order to support educators on creating innovative STEM school curricula by employing new technological teaching/learning tools, the ODL consortium offered to the teachers the opportunity of acquiring both technological and pedagogical skills for assembling separate educational materials within coherent learning paths. The consortium defined a methodology for the micro-MOOC design by adopting the well-known 5E model of instruction within an inquiry-based approach of science education. The most innovative aspects of the project include the use of online remote and/or virtual laboratories, the development and re-use of open education resources (OERs), the sharing of teaching/learning good practices. From November 2015 to April 2018, the project educators created more than 100 multidisciplinary micro-MOOCs and, during the multiplier events, they trained about 500 European teachers to design their own micro-MOOCs and implement them in their classrooms.

Starting from the guiding idea of sharing expertize, two educators from the ODL project team will introduce the participants attending this workshop to the main pedagogical aspects of the ODL project and will engage them into a practical BYOD-based working session. The ODL team will briefly report the outcomes from the pilot studies on the classroom experimentation of those micro-MOOCs focused on Physics topics. The feedback from both teachers and students highlighted that the use of micro-MOOCs enriches the lessons and raises student interest in the subject, encouraging and motivating these latter to learn. The students appreciated very much the exploration phase by the use of online virtual/remote laboratories. Globally, they enjoyed very much the micro-MOOC-based class, wishing to attend similar lessons in the future. The most part of the workshop will be devoted to a fruitful interaction with the audience, supporting participants working in small groups aimed at designing and implementing their own inquiry-based micro-MOOC. At the workshop, the participants will have the chance to make them familiar with the edX-based ODL platform and to convert their scenarios into educational resources. The method on how to incorporate their micro-MOOCs into STEM curricula will be also addressed. At the end of the workshop, all groups will present their micro-MOOCs and an overall discussion will support the sharing of participant experiences.

Poster Session / 71

TEACHER PROFESSIONAL DEVELOPMENT IN THE CONTEXT OF THE "OPEN DISCOVERY OF STEM LABORATORIES" PROJECT

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The "Open Discovery of STEM Laboratories" (ODL) project, funded by the European Erasmus+ KA2 program (Cooperation for Innovation and the Exchange of Good Practices - Strategic Partnerships for school education) for 30 months, starting from November 2015, was aimed at introducing the use of MOOCs in school curricula. In particular, it fostered teacher collaboration in creating and using microMOOCs (very short version of MOOCs with an overall educational activity of about 30 up to 45 min in the classroom) for the inclusion of STEM (Science, Technology, Engineering and Mathematics) online remote/virtual laboratories in the everyday teaching practices (http://opendiscoverylabs.eu). The project focused on teachers, educators and curriculum designers with the aim to strengthen their profile by supporting them to deliver high quality teaching practices and to adopt new methods and tools. Thanks to the project, in service and pre-service teachers had the opportunity to extend their knowledge about the inquiry-based science teaching approach, improve both digital skills and pedagogical competences, experience international collaborative work, explore attractive open education resources helpful to design creative lessons on STEM topics. During the project, the ODL team educators created more than 100 multidisciplinary microMOOCs and organized several multiplier events, national meetings and an international teacher summer school, where they trained about 500 European teachers to design their own microMOOCs and implement them in their classes. In particular, the ODL partners organized two rounds of Multiplier Events in each country: "MOOC in the school sector" and "MicroMOOC in your class", whose activities were aimed at making teachers familiar with the microMOOC scenarios and the edX-based ODL platform. During the workshops, the microMOOCs were presented as good examples of resources to be used in teaching practice. Teachers had the opportunity to learn how to convert their scenarios into educational resources and received useful suggestions on how to incorporate their microMOOCs into school curricula. The ODL training stimulated teachers to: (1) explore, collect and organize new open educational resources on Physics remote and virtual laboratories; (2) build microMOOCs on interdisciplinary STEM topics; (3) manage inquiry-based lesson plans, designing highly engaging student-centred learning activities, as laboratory and practical work.

The relationship between our training intervention and the teacher affective development and motivation to adopt new methods and tools has been quantified by means of a questionnaire suitably designed to assess the experience acquired by the participants in relation to a specific activity. The questionnaire was administered to the teachers at the end of the training activity and the collected answers provided us a general overview of the teacher satisfaction on a five-point Likert scale. At the ICPE-SAIP-WITS Conference, we will show and discuss the results from the ODL teacher training in Italy, showing the valuable feedback collected by teachers on the impact of the ODL pedagogical approach on Physics education at secondary school, highlighting strengths and possible weaknesses of the proposed methodology. The outcomes from the first pilot studies in classroom will be also presented and discussed.

Parallel Session 2 / 72

CONCEPTS IN CONTEXT

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This talk will critique the notions of “concept”, “context” and “transfer”; presenting both experimental data and theoretical argument which comprised the core of my PhD research. These notions are fundamental in educational discourse, yet they are often taken for granted. A common implicit metaphor is that a concept sits in a context, like a solid object in a surrounding environment. I will argue that this metaphor is both indispensable and problematic. Student understanding of the concepts of “subtraction”, “vector addition” and “density” will be discussed, including experimental data from my PhD. The theoretical perspectives of “Knowledge in Pieces” and “Cognitive Resources” will be suggested as excellent tools for the explication of the observed sensitivity to context. “Embodied cognition” will also be briefly introduced as a useful interpretative tool for particular data. In sum, I will argue that robust educational research requires a thorough interrogation of the question: “When I speak of a particular concept, what exactly it this “thing” I am referringto?”

Parallel Session 3 / 73

TRAINING FOR PHYSICAL SCIENCE TEACHERS

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The key to the advancement of society has always been an educated population. Thus the goal of every civilised government is the education of their people. There are, however, not enough countries for whom this is a sufficiently high priority. But the government of democratic South Africa seems keen to get this done.

As such, a collaboration has been created between the UK Institute of Physics and the South African Institute of Physics to establish teacher training workshops for secondary school teachers in physics. In this country, physical science is taught, a combination of both physics and chemistry and we include, wherever possible, chemistry instruction for the teachers as well.

We began in 2013 with workshops in Soweto, anywhere from two days to a week long. These had between 50 and 150 teachers. We have since started workshops in Eastern Cape and Limpopo provinces and would hope to expand to all 9 provinces in the country.

Some of us are old enough to have studied physics under the old chalk and talk lecture system. We want to take advantage of much of the research done in physics education and use more effective techniques such as developed by people such as Redish1, Mazur2, and many others. We emphasise multiple choice questions and divide the teachers into groups of 2 or 3 and give them sheets with A B C D for them to answer. This has proven popular with the teachers and we are trying to determine how many are using this in their classrooms. In addition, we have introduced many PhET videos to help them illustrate many physics principles when they lack the relevant demonstration equipment.

A very important part of our work is to train local people who have science backgrounds, to adopt these newer teaching methods, and to take over the training of school teachers in their areas. This is ongoing and there are local people now in these three areas who can do this work. This has been on a volunteer basis to the present but we are seeking funding to provide some support for local people who can do this training.

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Parallel Session 2 / 75

Putting the “Science” back in Science Education in South Africa

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Due to historical reasons, the interest in science education and research in South Africa is lower compared to other developing countries. However, in a recent discussion meeting it appeared that this problem is exacerbated by lack of understanding of what science means. To many, science is too western, and incompatible with every day experiences. That in turns leads to a feeling that science is an imposed set of rules to be memorised, rather than something that is application based. That means we lack the person power to drive science research and innovation in the country, which is an aim of NRF/DST. In fact South Africa now is collaborating with big international science projects such as CERN and SKA, so this is more critical than ever. We will discuss our approach to investigate how this problem can be addressed in classroom situations, especially tying science with indigenous knowledge systems to make science more accessible and interesting.

Poster Session / 76

An active interdisciplinary learning path on measure in a vocational school

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A learning path in an initial class of a vocational school in wellness is presented. The challenge was to engage students, whose interests were very far from science, in an active exploration on how a body can be measured. Students discovered the existence of uncertainties linked to the process of measurement and explored how they could be minimized.

Despite selected physics topics are essential for understanding many professional subjects and practices, their relevance in everyday situations, in which students will ultimately work, often remains hidden. Current practice is very different from one school to another. Sometimes laboratory is not properly equipped and usually physics and vocational teachers do not interact in their educational action. Thus, physics is usually perceived as a boring set of laws very far from professional experience.

Theories and empirical research about the interrelation of motivation and learning have a long tradition in education [1]. From an educational point of view, it is essential to understand why and how students become interested in new content and subject areas [2]. Interest and motivation are seen as basic concepts to describe students' learning in a physics classroom. Empirical findings suggest that an interest-based motivation to learn positively influences both how learners realize and organize a given learning task (e.g., the kind of learning strategies used) and the quantity and quality of learning outcomes [3]. Exploring and understanding how transfer of knowledge can be made more effective in vocational education is an unavoidable step for improving the learning process in this context [4].

A learning path on measurement was designed within a regional project aimed at developing the teaching/learning process in science through innovative laboratory activities. The learning path was realized in the context of the Hygiene and anatomy initial classroom (age 15) of a professional school in wellness (beautician).

The initial activities were an individual reflection on what measures to carry out to evaluate the physical form and a collective discussion on the usefulness of the proposed measures,. Measurement were realized in practice: students proceeded by trial and error, gradually highlighting the problems that led to an autonomous method of measuring.

Since the laboratory was performed in classroom with an everyday life tool, the approach was very effective in the vocational school context.

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Parallel Session 1 / 77

A new spin on an introductory quantum mechanics course: flipping the class

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Faced with a low pass rate, poorly prepared and disengaged students, we tried a so called "flipped" approach to teaching a 3rd year quantum mechanics course. Rather than having traditional lectures, the students where given online reading assignments on the Perusall platform. The students, could annotated the notes, pose questions and discuss the material with peers on the platform. To encourage student participation, they where assigned a grade (calculated by AI) based on the assessed quality of their annotations. The students where also assigned exercises which filled in some of the details of the notes as well as more difficult problems. During class time, we discussed questions students posed online, went over the exercises and students where asked to present solutions to some problems on a randomised roster. While there was a large increase in the pass rate over the previous year, a significant fraction of students expressed rather negative sentiments after the course. We'll present the good, the bad and the ugly results of this teaching "experiment".

Parallel Session 3 / 78

EFFECTIVENESS OF VIDEO - BASED INSTRUCTIONAL STRATEGIES ON SENIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENTS IN PRACTICAL PHYSICS IN LAGOS STATE, NIGERIA

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The dominant system of instruction in teaching practical Physics is the conventional method of demonstrating experiments in Nigeria senior secondary schools, which had promoted teacher-centered instruction. Thus, this study is initiated to solve the prolonged persistent problem of teacher-centered instruction to student centered instruction. Therefore, this study was designed and conducted to determine the effectiveness of Video - Based Instructional Strategies on Senior Secondary School Students' Achievements in Practical Physics in Lagos state, Nigeria. A non-randomized pre-test, post-test control group quasi-experimental research design was adopted for the study. A sample of 315 Senior Secondary Two (SSII) physics students, drawn by both purposive and simple random sampling techniques from six co-educational schools in Educational district III was used for the study. Three validated research instruments: Practical Physics Achievement Test (PPAT) (r =
0.71 using KR – 20); Practical Skill Rating Scale (PSRS) (r = 0.89 using Scott Pi) were used to collect data for the study. Students in the experimental group followed the demonstration of the experiment using Video- based method while those in the control group followed the demonstration of the experiment using the conventional method. The data collected were analyzed using Analysis of Covariance (ANCOVA) and Estimated Marginal Means at 0.05 level of significance. The students in the experimental group (Video based) instructional strategies had a higher mean in both the achievement and acquisition of practical skills than their counterparts did in the control group (Conventional) instructional strategy. Hence, this study recommend the use of video – based instructional strategies in teaching physics practical for better achievement for secondary school physics students.

Parallel Session 2 / 79

Methods of evaluation in natural science education verified by the practice of lower level at grammar school

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The contribution deals with autors experiences with evaluation of their own physics and chemistry teaching. Autor of contribution obtain experiences during teaching at Mensa grammar school, especially in lower lever of school education system (Mensa grammar school is focus on gifted students). The methods of evaluation can be apply in normal schools too. Autor of contribution deals with methods of work in physics and chemistry lessons and with evaluation of this methods by methods, which was verified during science teaching practice at Mensa grammar school. One part of contribution deals with authors own methods, for example notice list for subject, evaluation of teachers work, special questions in tests or phasing and drawing pictures of experiments. The system of work with final evaluation is introduce, and autor deals with ideas for own personal development in teaching abilities.

Poster Session / 80

THE "E3D+VET" ERASMUS+ PROJECT: INTERDISCIPLINARY TEACHING AND LEARNING IN VET CENTRES THROUGH 3D PRINTING

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The "E3D+VET" (Erasmus+ for the immersion in 3D printing of VET centres) is a project supported by the European Commission through the Erasmus+ programme, Key Action 2 - Strategic Partnership for vocational education and training on Development of Innovation. The aim of the project is to develop educational tools for the VET system, which will provide new competences to both teachers and students and will serve as important means of innovation and acquisition of effective knowledge on interdisciplinary STEAM topics. The project started on the first day of October 2017 and it will last 30 months, up to the end of March 2020. The main objectives of the project can be summarised as: (1) train teachers non-computer design (CAD) skilled in VET centres with the aim of using 3D printing across almost of all subjects, (2) improve student transversal abilities through the use of 3D printing, (3) heighten concentration of students with Attention Deficit Disorder, (4) improve 3D printing skills of VET teachers without technologic background as the best way to transfer this innovative knowledge to 21st century students. The activities that the project team has planned to carry out are mostly related to the development of a common methodology to improve the key competences in VET learners, create innovative education practices by means of the model-based 3D printing industrial technology, introduce systematic approaches to, and opportunities for, the initial and continuous professional development of VET teachers, trainers and mentors in both school and work-based settings. The expected results will cover the development of a methodology for defining 3D printing exercises suitable for transversal education, a set of 3D printing exercises for VET-school lessons in different subjects, a networking community tool for teachers using 3D printing for immersion of 3D printing in European education and training. At the conference, all the main pedagogical aspects of the project will be presented, together with the 3D printing exercises involving physics topics and their application as interdisciplinary educational resources for teaching and learning in a wider perspective. A plan for classroom pilot test of the teaching design-based materials will be also presented, together with the evaluation of the efficacy of the global formative process.

Parallel Session 2 / 81

Activities to enhance students understanding of acceleration

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According to literature, the most important factor in education is to determine what students already know and to consider when teaching them. Unfortunately, there is a body of knowledge from physics education research revealing that we cannot simply build onto all existing knowledge that students have, because they contain misconceptions that differ from the accepted scientific understanding. As an example, students understand acceleration as an increase in the magnitude of speed or velocity. Based on that understanding, a brake pedal and a steering wheel of a motor car are not regarded as accelerators because they don't increase the magnitude of speed. That is caused by the everyday usage of the term which differs with a scientific understanding. Other examples in mechanics where students have lack of understanding is their understanding of the concept of force. Literature revealed that students believe that a constant force causes an object to move with a constant speed, some force always acts in the direction of motion and that a larger mass falls faster towards the earth than a small mass Some physics education researchers argue that productive elements in learners' existing knowledge should be determined and used as bases for building scientific knowledge. Despite an earlier teaching of the concepts of motion in relation to acceleration from high school and in their first-year of physics at university, many of the students have difficulties in the problem solving required for the acceleration assessments. It is against this background that this paper presents and evaluates the impact of the activities that were designed to enhance students' understanding of the concept of acceleration. The evaluation of the impact of intervention was done through Google forms. Preliminary analysis of the results reveals that if the vector nature of acceleration is emphasized, students would also value the importance of including the change in direction as the result of acceleration. The results implied that teaching mechanics should starts with the impact of force in our everyday life since acceleration is the visible impact of force.

Keywords: Acceleration.

Poster Session / 83

Exploring quantum mechanical kinetic energy on a local scale

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The quantum mechanical energy of a single-particle system comprises the sum of the expectation values of the kinetic energy operator and the potential energy operator, each of which is defined in terms of an integral. By dropping the integrals, we effectively define corresponding kinetic energy and potential energy densities. In this work, we explore the usefulness of using these quantum mechanical energy densities, and investigate the computation of meaningful physical results despite the non-uniqueness of these entities. In the case of the kinetic energy density, we are able to define two different energy densities, the one involving the $-\hbar^2/2m\ \phi^*(x)\nabla^2\phi(x)$ and the other involving $+\hbar^2/2m\ |\nabla\phi(x)|^2$. Since the difference of these two approaches includes a boundary term, we specifically explore the kinetic energy current densities at the boundaries and demonstrate why the first form gives more physically meaningful results than the second form.

Parallel Session 1 / 84

AN EXPLORATION OF SENIOR PHASE TEACHERS' MISCONCEPTIONS ON ELECTRIC CIRCUITS IN THE MOSES KOTANE AREA

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This study aims at revealing senior phase teachers' misconceptions about electric circuits. It also seeks to explore the source of the misconceptions amongst the teachers. Available literature is replete with evidence that most of the misconceptions on electric circuits arise from one's initial knowledge of electricity and hence the need to further explore and probe these claims. A conceptual comprehension test that consists of ten open-ended questions will be administered and semi-structured interviews will also be conducted. The interviews will primarily be employed to seek and interrogate the source of the ensuing misconceptions. The collected data will be qualitatively analyzed using relevant exploratory techniques and appropriate intervention methods will be proposed to address the misconceptions that will be revealed.

Parallel Session 2 / 85

A case for miniature demonstration apparatus

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A challenge that is perhaps common to many universities is that of large class sizes, particularly at the first-year level, with ever-larger lecture venues being needed to accommodate the ever-larger classes. As a result of this trend, physics teaching staff in our university have increasingly found themselves teaching in venues that are not only remote from their usual "home territory" but are usually not structurally suited to teaching physics – especially not for doing lecture demonstrations - even though in most cases they were quite well suited to teaching - or at least to lecturing - in a very broad generic sense. The remote locations of some of these venues and the difficulty of moving demonstration apparatus – which is of necessity usually large in scale – has resulted in the lecture demonstration increasingly becoming a thing of the past. A possible solution to this problem is to make the demonstration apparatus small enough to carry - and to project an image of the apparatus in action using a portable document camera. The document camera needs to have a short focal length so that the depth of field is reasonably large, otherwise it becomes impossible to focus on more than a very thin plane of the apparatus at any one time.

While the efficacy of lecture demonstrations as a teaching tool has been much debated (Crouch, Fagen, Callan, & Mazur, 2004) - the consensus does seem to be that they can be of value provided that the students are not expected simply to watch passively (Sharma et al., 2010; and Miller, Lasry, Chu, & Mazur, 2013).

The presentation will show the feasibility of this solution, using a small sample of suitable apparatus in conjunction with a portable document camera. Other potential uses of the document camera as a teaching tool will also be mentioned.

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Poster Session / 87

ANCIENT MESOPOTAMIAN'S SYSTEM OF MEASUREMENT: POSSIBLE APPLICATIONS IN MATHEMATICS AND PHYSICS TEACHING

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The study of the ancient Mesopotamian units of measurement and the mathematics involved in it provides several components that could be used for physics, mathematics and history of science teaching. Studying the known clay tablets it is possible to learn their mathematics, how the art of teaching started, how the first numbers were represented and what were their purposes, as the ancient calculus of area, volume, weight, time and others and learn the origin of other mathematics and science concepts. The circle with 360 degrees, watches with 12 divisions and the year made of 12 months are some examples of the influence of the Mesopotamian'smathematics and system of measurement in our culture, what can be very interesting for students that have no interest in math and physics classes and even more to who have interest in those matters, this paper have the purpose of showing some knowledge in that area and some possible uses of that for teaching.

Parallel Session 3 / 88

Exploring Pre-Service Science Teachers Physics Pedagogical Orientations towards Their Own Classroom Teaching

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Most of the South African universities attract their pre-service teachers' cohort from previously disadvantaged schools, either from the township or rural areas. This cohort of pre-service teachers lacks knowledge of science content due to their previous school conditions of limited resources such as science laboratories, availability of science teachers, large numbers of under-qualified physical science teachers and overcrowded classes. Again, teachers limited Pedagogical Content Knowledge in the subject they are teaching plays a role in learner's lack of science knowledge. At university, these pre-service teachers are expected to transform their teaching styles to accommodate inquiry-based learning and other teaching approaches that are often learner-centered. This can be done by either exposing them to reading materials, observing each other teaching during micro-teaching, watching recorded videos or creating lesson plans for assessment purposes while they are not being exposed on different ways of teaching science topics for different contexts and including the elements of inquiry-based. A key dimension in science education is being investigated which is referred to as teacher's pedagogical orientations. Orientations are teachers' knowledge and beliefs about the purposes and goals of teaching science at a specific grade level.

The aim of this study was to explore pre-service science teacher's physics pedagogical orientations towards their own classroom teaching and identify factors that influence their orientations. There are various classifications of pedagogical orientations in literature, however, based on research by Ramnarain and Schuster (2014) in South Africa orientations were divided as follows; direct approaches into (direct didactic and direct interactive) and inquiry approach into (guided inquiry and open inquiry). The pedagogy preferences of pre-service science teachers were measured using an instrument comprised of three items that portrayed an actual teaching scenario for physics concepts. The items had four alternative teaching methods; participants were expected to select the most appropriate and the most inappropriate options and space was provided for them to justify their preferences. Therefore, a mixed method approach was employed, where a questionnaire was administered to all 2018 Bachelor of Education 4th year physical science students which they were 35 in total at a South African university. In the final year of study, students take a year module on the methodology of physical sciences teaching. One of the core themes is to enable students to understand the nature and significance of physical sciences and then develop competencies necessary for successful and effective teaching in physical sciences.

The results revealed that pre-service teacher's preferences from the three items portrayed an actual teaching scenario for physics concepts were an inquiry approach, which is aligned with the guided inquiry and open discovery. A small number of participants preferred teacher-centered teaching approach; direct didactic. Apart from teacher's knowledge, factors such as the availability of resources, class sizes were found to influence their pedagogies. This invokes the need to establish to what extent the preferred pedagogical orientation of pre-service teachers aligns with an inquiry-based pedagogy.

Parallel Session 1 / 89

CHANGES IN THE IMAGINARY OF FUTURE PHYSICS TEACHERS DURING THEIR INITIAL TRAINING

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The research presents a longitudinal study that sought to accompany a group of undergraduates students in Physics of a Brazilian Public University, from the beginning until the conclusion of this program, designed to physics teachers and called physics 'licenciatura' in Brazil. It aims to understand how the imaginary of these future physics teachers changed during their initial formation and how the program contributed to their formation. The research data was collected using questionnaires, applied at the beginning of each school year, in certain disciplines of the program. The theoretical foundation that supports the data analysis was the Discourse Analysis in its French approach.

Four data collections were carried out during the last years (2014-2018). All questions were retained, except in the first questionnaire, where we are concerned to understand, besides the questions that would serve as analysis, the personal and student profile of each of these undergraduates. Initially, forty-nine undergraduates participated in the first data collection; in the second year, this number decreased to eleven undergraduates; in the third data collection, just eight answered the survey; in the last questionnaire only three undergraduates from the initial sample participated. At the end of the program, only one of these students graduated within the expected time. Although it seems to us a very unusual data, it corresponds to the previous research carried out by Kussuda (2012) that in his research was showed the dropout of the course of Physics in the same University.

The results of the analysis of the profile of these undergraduates and how their imaginaries were modified in relation to the questions that involve assessment, the role of the teacher in the classroom and the skills that an exemplary teacher must own were presented at some important events in the area. The only student who completed the graduation within the expected time, studied his basic education in private school and the reflection of this environment, in the construction of his discourse, is evident. In the first two years of the program, the student makes various references and defense to the traditional education model in his speech, highlighting the ability to treat didactic material as something fundamental for an exemplary teacher, in addition to starting the undergraduate program defending the traditional model of learning assessment. During his graduation, after studying different disciplines that approach this subject, we perceive some changes in the imaginary of this student, where in the last year he comes to understand the assessment as a continuous process.

The conditions of production of the discourses were the elements that made possible the change in the future Physics teachers' imaginary. Just because the material conditions of discourse are directly linked to the institution, language and imaginary formations in which this student is inserted.

Parallel Session 2 / 90

From Helicopter to Lighthouse: The experiences of a lecturer in equipping first year university physics students to move away from 'answer making' towards 'sense making'

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As the South African universities become more inclusive and the number of students entering increases, the range of backgrounds of these students is also broadening. The physics departments have noticed that students are 'not well prepared' for university studies (SAIP & CHE, 2013). The physics departments realised that while there are many people engaged in trying to improve the school system, things will not change anytime soon and that we must commit to teaching the students 'we have and not the ones we wish we had'. This paper explores the experiences of an undergraduate physics lecturer as she tries to equip students who enter university as 'answer makers' to move towards leaving as 'sense makers'. While the lecturer concerned is speaking about her experiences with reference to lecturing first year university physics, the pedagogical approach employed and the underlying teaching philosophy transfer easily to high school physics.

This approach is built on Vygotsky's concept of the zone of proximal development complemented with Bruner's concept of scaffolding. In addition, we acknowledge the importance of the theories of epistomological access (Boughey, 2005) to increasing the success of students at university in general and at physics in particular. We try to do this by enabling students to think about their learning in a metacognitive way by being explicit not only about the content of the curriculum but also about the learning actions that we expect from them and the cross-curricular skills that we are trying to help them to develop (Ellery, 2016).

The challenge faced by the lecturer in these case studies is to engineer the learning environment so that sense-making is encouraged over answer-making. We desire students to realise early on that many of the learning methods which they are used to employing need to be changed. As lecturers we realise that we cannot just expect students to realise this on their own but that we need to scaffold the process so that students do not become discouraged by repeated failure (Scott, 2009). If we are serious about "equal access for all" then we as educators need to seriously consider our pedagogy so that there is also an equal chance of success for all without compromising our exit standards.

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Parallel Session 1 / 91

IMAGINARY FORMATIONS OF TEACHERS OF THE INITIAL YEARS OF ELEMENTARY EDUCATION ON PHYSICS AND THEIR TEACHING IN A CONTINUED TRAINING PROGRAM

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We present here part of a research outcomes that was carried out in a public school, through a partnership with the university, which was willing to advise teachers of the initial years of elementary education, acting in the first and second cycles, in matters related to the teaching of Sciences, particularly physics. The design of the program was determined through the "imaginary formations" presented by the teachers during the realization of an Initial Focus Group (IFG), which allowed to ascertain the teachers' training needs, conceptions and desires related to Physics and Science Teaching. The study had as theoretical-methodological reference notions of Discourse Analysis in the French line. The main imaginary formations detected related to Science Teaching in the context of the course were: "experiment draws attention of the student and breaks the routine of the common classes"; "Themes of Science related to the Universe are attractive for the student"; "The advice of a specialist in the area has helped a lot"; "Unlike a lecture given when a specialist shows up at school." In addition, the IFG allowed us to verify imaginary formations present in the teachers' discourses, full of discrepancy between what the Curriculum of Sciences proposes in the initial and final cycles of the initial years of elementary education in the State of Minas Gerais and how teachers understand it for the preparation of lesson plans. Regarding the "imaginary formations" of teachers related to science, we found at the beginning and at the end of the program that aspects of an empirical-inductive vision prevailed (the role of observation and experimentation are highlighted), a rigid view of scientific activity scientific method is considered as a set of steps to be followed). And we understand that there were signs of "imaginary formations" of science as the work of geniuses, but scientists do not have to live "isolated" from the world, for they are ordinary people, like a teacher, and research phenomena that do not necessarily have to be investigated in the laboratory. In addition, we realize at the end of the process that the teachers of the sample show that there is evidence of a constant reconstruction of Science.

Poster Session / 92

Does the diagram that you draw tell its meaning?

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Schematic diagrams representing physical concepts do not necessarily define how to draw. For example, arrows are used for the various meaning in physics education. There is a possibility that the learner who saw the schematic diagrams containing arrows does interpretation different from the true intention by which they were drawn. The confusion of learners formed by the disagreement of such interpretation may be one of the reasons that making learning of physics difficult. However, such difficulties in visual communication are hard to grasp as compared to linguistic communication. For example, discrepancies in linguistic communication are grasped by the fact that the conversations do not mesh, but such a process does not exist for visual communication. Therefore, if the learner does not understand the contents, in the case of linguistic communication the teacher can repeat the explanation until the learner can understand, but in the case of visual communication the teacher cannot notice that the learner does not understand. In other words, it seems that a schematic diagram, which is a typical example of visual communication, needs to be carefully drawn to be conveyed to the learner without misunderstanding. In order to know whether the intention of the schematic diagrams is conveyed to the learner without misunderstanding, the validity of existing schematic diagrams used in Newtonian mechanics was evaluated using an eye tracking device. In addition, the relation between understanding Newtonian mechanics concept and schematic diagrams understanding was examined.

Poster Session / 93

Contributions of History and Philosophy of Science course for undergraduate physics teachers students

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We live in a world widely influenced by Science, being perceptible its action in several areas of life. This overvaluation develops naive beliefs about the nature of Science and scientific work, impacting on science teaching that, after the end of the 50's, aimed to train student as "little scientists" through the scientific method. However, many studies in the fields of History, Philosophy and Sociology of Science, especially after the 70's, pointed out and criticized some deformities that science teaching could be playing, such as: the empirical and inductive conceptions, the infallible and ahistorical view of science, among other deformities. Understanding that contemporary visions of Science contribute to the improvement of Science teaching, it becomes important to analyze the perceptions of undergraduate physics teacher students in relation to the History and Philosophy of Science (HFS) course. Their perceptions about Science will impact their teaching and consequently the students' perceptions. In this perspective, this work presents results of an exploratory case study that investigated how the epistemological conceptions of a group of students evolved after the accomplishment of this course, as well as have been maintained over time. We attempted to answer the following research questions: in the context of the survey, how was the evolution of epistemological conceptions of the students? How this evolution has remained over time? The units of analysis were four undergraduate physics teacher students, from the Instituto Federal Sul-Rio-Grandense, in the city of Pelotas - Brazil. The study occurred after the first semester of 2017, when the compulsory course of HFS was taken. Two questionnaires were applied. The first after completion of the course. The other six months after the first. The answers obtained were compared in three aspects: the role of observation and experimentation in scientific research; possibility of transformations of scientific theories; and the role of error in scientific work. The students' answers showed a positive influence of the discipline for the construction of thoughts aligned with the contemporary epistemological conceptions. Science is seen, through these conceptions, as a human construction susceptible to error. Theory precedes observations, which are not neutral, and there is no rigid scientific method. We realized that, in general, these perspectives have been remained, presenting some maturity. The students had a more flexible idea about the role of observation and experimentation in scientific research. They also pointed out that the theories can change, thus contributing to the progress of Science. The same was observed with regard to the role of error in scientific work, where all the students stated that the error is present, since Science is built by individuals who can make mistakes. This work contributes to the discussion about the importance of the content of the HFS course to the initial formation of physics teachers, considering the indispensability of scientific literacy for the training of students as critical citizens, as well as understanding that teachersareabletoperformthenecessarytransformationsforthisprocess.

Parallel Session 2 / 94

An Alternate Approach to Execution of Second Year Thermodynamics

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The first and most important question with regards to any educational activity: 'What is the purpose of this activity?'. The simple answer to this to this question, in the terms of Physics education in South Africa, is the to develop the skills highlighted in the SAIP Draft Benchmark Statement. The second question is then: 'How do you best develop these skills?'. The purpose of this paper is to discuss an alternate, student-centric, self-directed, approach to the execution of a second year Thermodynamics course. The approach focusses on the benefit of the cooperation between the practical course and the theoretical course. The goal of such an approach is to not only ensure the development of the skills required from the course but to develop the individual student's abilities within a scientific context.

Keywords: SAIP Draft Benchmark Statement, student-centric, self-directed

Parallel Session 2 / 95

Analysing assessments in introductory physics using Semantic Gravity: Refocussing the purpose

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In physics it is required from students from first year onwards to be able to apply core concepts in different contexts, ranging from commonplace to highly specialised examples. Students also need to transfer their understanding of core concepts to subsequent years of study since physics hierarchically builds on these understandings as students progress in their studies. Cumulative learning has been defined as learning that facilitates the ability to "transfer knowledge across contexts and build knowledge over time" [K. Maton, British Journal of Sociology of Education 30, 43,2009].

Cultivation of cumulative learning during first year physics modules is critical and challenging, particularly in South Africa where student cohorts have highly diverse educational backgrounds. Assessment is a key aspect of learning that influences students' approach to learning. It is therefore important to ask whether our assessment practices encourage cumulative learning.

Legitimation Code Theory (LCT), developed by Maton and co-workers, provides a framework for analysis of educational practices [K. Maton, British Journal of Sociology of Education 30, 43,2009]. The Semantics dimension is one of the tools from LCT that facilitates distinction between levels of abstraction and complexity. Abstraction (termed semantic gravity) refers to the role of context in meaning, whereas complexity (termed semantic density) is related to the degree to which meaning is condensed into words or symbols. Maton argues that cumulative learning is facilitated by exposing students to appropriate ranges of complexity and abstraction in teaching and assessments. In this paper we illustrate how semantic gravity was used to critique the quality of assessments in introductory physics on university level, and how the results were then used to inform assessment practices.

We analysed past assessments of two mainstream first year physics modules over a five year period. The results revealed large variation in the range of abstraction that was assessed over this period. It also highlights challenges with regards to cumulative learning. The study was followed up by an intervention during 2017 consisting of real time analysis of the test and exam papers, in combination with interactive internal moderation sessions. The analysis empowered both the lecturers and internal moderator by providing a practical categorisation of questions. The process guided both lecturers and students to refocus on the teaching and learning of core concepts. Analysis of grades of cohorts before and during the intervention suggests that it has improved student understanding of the core concepts and advanced cumulative learning.

This study illustrates how semantic gravity can be used to guide the moderation of assessments and support the development of more consistent assessments over consecutive years.

Parallel Session 2 / 96

AN ANALYSIS OF PRE-SERVICE SCIENCE TEACHERS' ATTITUDES TOWARDS PHYSICS LEARNING POST-INTERVENTION WITH VIRTUAL LABORATORY SIMULATIONS

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This paper reports the preliminary findings of a wider study targeted at assessing the affordances of virtual and augmented reality in Physical sciences learning. In this preliminary study, we assess pre-service teachers' attitudes towards the use of virtual laboratories for learning of physics concepts. The study followed a sequential mixed-method design. In the first phase, a quantitative approach was employed in a survey design to assess pre-service teacher attitudes towards physics learning. Pre- and post- test was done using an adapted Physics Attitude Scale (PAS) questionnaire before and after an intervention with virtual laboratory simulations. In the second phase, semi-structured interviews were used to elicit elaborations on the use of virtual simulations for physics learning. Fifty third year pre-service teachers' were randomly selected to participate in the attitude survey after which Phet virtual laboratory simulations where used by the group in learning Faraday's law (magnetic fields and magnets), collisions, momentum and velocity. Findings revealed significant differences in pre-service teachers' attitude scores post intervention with virtual simulations. That is, result from paired sample t-test revealed a significant difference in preservice teachers' attitudes ($t(49) = 17.429$, $p < .01$) with the mean post-test attitude score ($M = 84.04$, $SD = 5.345$) being significantly higher than the mean pre-test attitude scores ($M = 58.42$, $SD = 14.444$). Semi-structured interviews further revealed that, the pre-service teachers found the use of simulation as a useful alternative for understanding abstract physics concepts. The pre-service teachers elaborated that, the aspect of repetition possible with the Phet simulations, made physics learning more interesting. Another aspect highlighted was the accessibility to simulations from anywhere and anytime, which facilitated learning during spare times. However, pre-service teachers noted that the simulations could not replace the experiences in an authentic situation. The implications of these findings for teaching practice are that, virtual simulations can be seen as supporting tool for learning physics concepts. The may not be able to replace hands-on authentic learning experiences, but can be used to complement the learning of abstract physics concepts. We recommend further research and larger scale studies on the epistemological positions, on the affordances of virtual laboratory simulations in science teaching and learning.

Parallel Session 1 / 97

INTEREST OF PHYSICAL SCIENCE GRADE 12 LEARNERS TO UNDERTAKE STUDIES AND CAREERS WITHIN THE FIELD OF SCIENCE

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Investment in Research and Development results in economic growth. Not selecting Science as part of one's school curriculum places learners at a disadvantage in terms of the range of tertiary qualifications accessible to them when they enter university, and in terms of their career choices.Literature has reported repeatedly that South African learners have the poorest literacy and numeracy skills according to global standards.Studies at Wits University indicate that unlike most subjects that learners take in Grade 12 in South Africa, Physical Science acts as a predictor for academic success at the level of first year.It is crucial to determine factors that learners perceive as supportive and constraining to their choice of qualification and career post-secondary school.

This study sets out to determine the extent to which career guidance at school, support from the home environment, peer-influence, and the students' aspiration to enter into Sciences as a career influence the Grade 12 Physical Science students to make this choice. Data collected in the form of a questionnaire from 75 learners across three schools, i.e. private school, fee-paying public school, and no-fee Dinaledi public school. A Dinaledi school receives a grant to improve the number and quality of passes in Mathematics and Physical Sciences.

Learners indicated their family would support their decision to attend university (60% of learners from no-fee school, 79% from fee-paying public school, 100% from private school).67% of learners from the no-fee school indicated they learnt about career options and requirements based on watching television, 55% from the fee-paying public school and 25% from the private school alluded to this. 81% of learners from no-fee schools indicated that their friends supported their choice of career, 75% of learners from the private school and 45% from the fee-paying public school expressed a similar belief.There is a substantial pool of students who would like to study Science at University (69-81%) but either do not believe that they have the grades to enter (25% from private school, 52% from fee-paying public school, and 57% from no-fee public school), the financial resources for their studies (17% from the fee-paying public school and 31% from the no-fee public school), and are concerned about their work ethic (17% from fee-paying public school and 40% from no-fee public school).Compared to learners in the private school (75%) and fee-paying public schools (83%),only 31% of learners taking Physical Science at the no-fee public school believe that a career in Science is accessible to them. This means that there is a reduction in the pool of potential talent available for the R&D; industry that stems from the level of secondary school.If current trends in Science in the South African landscape continue, the research and development industry in South Africa will be negatively impacted. Thus the deep-seated reasons for students studying Physical Science at school need to be investigated.

Poster Session / 98

Experimentation in primary school: Discover and understand or verify what is expected?

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Science education in primary schools in Uruguay is still a pending task. Frequently, only biological science is taught in class and concerning Physics, topics like light and energy are the most commonly studied. Often activities, even in biology, are reduced either to look for information without experimentation, or very guided experimental activities with little space for actual research where results may differ from what expected and new questions might come up. As a result, children have a partial and sometimes wrong concept of science. The idea of science as something distant from reality and ordinary life, holding absolute results and truth,is reinforced.

There is a lot of research in science didactic about the role of the experimentation in order to improve scientific competences in the students.

In this project that is still in process, we analyze the role of experimentation during science class as well as the speech of the teacher in relation to his objectives with the planned didactic sequence. A qualitative methodology was used, through classroom observations and interviews with teachers. We choose a case study to inquire how the experiments are used in a science class and what is the role of experiments proposed by the teacher. To collect the data, recordings of classes was used and in-depth interviews were conducted with the teachers.

We found that in experimentation is used for verify a concept or a theory provided by the teacher or to conduct children to classify objects according their properties and characteristics.

This study let show up: the teacher´s conception of science and its teaching, the teacher´s ideas about how the children learn and the cognitive processes that in fact are encouraged by the teacher. What we found was a conception of science that still reminds a positivism way. Children are then introduced to a wrong view of science, which probably reinforces dislike and low interest for scientific issues.

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Poster Session / 100

Project Method in the Educational Background: A Review of Recent Literature (2000 - 2013)

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Although Project Methodology is known to be an effective tool in teaching physical concepts while at the same time fostering essential skills, it received surprisingly little academic interest over the last years. For this comprehensive review of research published on Project Methodology and closely related didactic methods during the years 2000 to 2013, we looked at the 26 international and 14 national (Brazilian) journals on physics education considered the most important (Qualis rated with A1, A2 and B1) by the Brazilian funding agency CAPES. We found that the topic is not only under-researched in general, particularly in Brazil, but that important aspects of such student centered approaches require more attention in both academic research and its application at day-to-day teaching, such as: Conceptual development, teachers resistance against increased student autonomy, effectiveness of Project Methodology different educational levels, and teacher training strategies that encourage more teachers to really implement student centered approaches in class, to name but few. This review itself aims at helping interested teachers and researchers to gain an overview and deeper understanding of Project Methodology, as well as summarizing the current discussion on the subject in the scientific literature. Furthermore, we hope that the ideas and experiences in the examined articles inspire both academics and practitioners to explore further thepotentialofProjectMethodologyandsimilarmethods.

Poster Session / 101

LEARNING BY PROJECTS: theory and practice in Brazilian teachers education

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In this article, we share some of our experiences and lessons learned from a practical implementation of Carl Roger's approach of Project Based Learning, as well as, we discuss the Ausubel's principles of "meaningful learning", which underlies this theory, in a situation involving future High School maths teachers. Our declared goal was to train and encourage these students, who often worked full-time and arrived to the evening classes, to apply Project Based Learning effectively in their own future teaching practice. In our research, which was conducted during the second semester of 2013 in the Federal Institute of Alagoas, we analysed the progress of these students based on their productions (presentations, reports, peer- and self-assessment, etc.) and on the data collected in a questionnaire and semi-structured interviews. The preliminary results indicated that the students took more responsibility for their own learning, showed an increase in self-efficacy and procedural knowledge and developed a positive attitude towards applying Project Based Learning in class. However, we also observed deficiencies in the gain of conceptual knowledge that required to be addressedinthecoursedesignbeforeembeddingthisapproachinthecurriculum.

Parallel Session 2 / 102

Practical preparation videos on a zero Rand budget

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Due to limited equipment and laboratory space for practicals, students only have a relatively short time to complete their weekly practical. In this time they need to familiarise themselves with the apparatus that they are going to be using, carry out the experimental procedure, and obtain and interpret all the expected results. Their practical manual is comprehensive enough for them to prepare adequately for a practical session. But with the addition of a preparation video to supplement the practical guidebook, the hope was that students would arrive at a practical already familiar with the apparatus and with a clearer idea of what they are going to have to do. A video would also help cater for students with different types of learning methods, in line with universal design for learning. The project was undertaken to produce videos for half of our first semester second year practicals at The University of the Free State. No money was spent buying equipment or software, nor to pay professionals for their services. The assigned demonstrators for each practical were given the task to write the script for and present the video for their own practical. Evaluation of the effect of the videos were done by comparing the students' experience and marks with two other groups. These are the practicals from the previous year, where all the practicals were presented in the same way, but not of them had introductory videos, and also to half of the current year's practicals which did not have videos. The demonstrators also gave feedback on their experience, each of them were responsible for two practicals this year, one of them we made an introductory video for and the other we did not.

Poster Session / 103

The use of data triangulation as a resource to find a better strategy to teach concepts of physics applied to medicine

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Potentially meaningful materials were developed to promote meaningful learning of concepts of physics applied to medicine. They were used in implementations with four different groups of students, and the implementations were modified according to the needs and wants of each situation. The didactic proposal involved experimental activities, simulation and computational modeling, recreational/playful activities, concept mapping, and V diagramming. This paper focuses on data triangulation as a resource to find strategies that are more adequate for teaching concepts of physics applied to medicine and, at the same time, to help finding evidences of the occurrence of meaningful learning of physics concepts, which might stem from the implementations themselves. It is not the aim of this paper to investigate the proposal per se. Hence, reliable and validated pre-test and post-test has been used in these implementations and is presented in this paper. Data gathered by these tests underwent non-parametric statistical analyses. It can be observed that the last two groups presented relevant improvements in the results of the post-test whereas the very last one showed even more relevant results in comparison to the other groups. This finding might be due to the use of recursiveness, which did not occur in the three previous implementations.

Parallel Session 2 / 104

Google it: why, what, and how should instructors teach if students can find everything online?

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The aim of this presentation is to rethink the role of the instructor in the teaching and learning process. It is directed at instructors and staff members involved in the course design process. Learners browse the internet for most of their knowledge acquisition. From Google, YouTube, Wikipedia, and even social media sites – the internet has become its own "new age" instructor. Online resources relevant to Physics Education is vast and accessible. Some leading institutions, such as Harvard, MIT, and Khan Academy have developed meaningful content and have already shared their courses to the public free-of-charge. These institutions may offer insight into the variability amongst learners and their motivation to learn. But have the "official" instructors accepted that they are no longer the only doorway to knowledge? Do instructors intentionally design courses and learning activities to include these additional sources of expertise? A learning designer at the University of the Free State has designed blended courses that leverage the new age instructor and its resources – offering an alternative approach to curriculum development and delivery. These course designs have roots in several teaching and learning methods, amongst others: open educational resources, blended learning, flipped classroom, and personalised learning. Samples of re-designed blended courses will be showcased along with lessons learned from revisiting the role of both the official and new age instructor.

Poster Session / 105

Development of methodologies for reducing dropout in courses in the Exact Sciences

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This paper seeks to present new methodologies aimed at maintaining the number of students in the undergraduate programs in areas related to the exact sciences, with the intention of gradually increasing the quantity of qualified professionals who work in the areas encompassed by these courses. This line of research demonstrates its importance at a moment in which the dropout rate from undergraduate courses in these areas has been increasing at an alarming pace. This leads to a situation in which a lack of professionals has the effect on the labor market of making it necessary for unqualified candidates to take on positions in an area for which they have not been trained. We conducted data analysis based on questionnaires that included problems of basic mathematics and basic physics, given to students seeking degrees in the exact sciences. With the objective of identifying the greatest difficulties faced by students who took the tests, this analysis pointed to reasons that might explain the high dropout rate in these courses. By identifying some of these reasons, it is possible to develop tools and methodologies for reducing student dropout in these courses. The results of these questionnaires, which were analyzed with statistical software called IBM SPSS, provided data showing that, for example, 57% of participating students chose the course because they liked the area of study, which directly influences the posterior decision to abandon the course.

Parallel Session 3 / 106

ALTERNATIVES TO CLASSICAL LABORATORY ACTIVITIES

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Physical experiments are necessary for learning and practicing concepts: theoretical models are compared to actual experiences. In this work we analyze different experimental alternatives: tradicional laboratory experiments, mobile phone labs and “home made” experiences.

For classworks, we notice that students feel that experiments are not priority activities and in case they would choice, not do them. Classworks are performed after introduced the subject in the classroom, while making an evaluation and then, if passed, they go to the lab. A small group, shows interest, while the rest only want the work and leaving, yet without fully understanding the key concept behind the experiment. This turns evident when reporting the experiences.

In those labs using mobile phones as measuring devices, we were able to appreciate a major involvement of the students, although of course, outcomes tend to be less accurate. In calculating inaccuracies, specific sensors for each measurement (proximity, light intensity, etc), are much more precise than mobile sensors, as spected. Finally, in a volunteer “experimental challenge” proposal, we realize that the achievement of bonding physical theory with measuring effects are enhanced by the degree of participation and the quality in the answers.

The scope in which this work was done is in the physics chairs I, II and III of the engineering faculty of the UNLP, city of La Plata, Buenos Aires, Argentina. The university is public and students do not pay tuition. The first and second year classes, to which these subjects belong, have between 50 and 100 students.

Parallel Session 3 / 107

RESEARCH ABOUT THE ADAPTATION PROCESS OF ASTRONOMY DIDACTIC MATERIAL - THE DIARY OF SKY - FROM THE CONTEXT OF THE NORTHERN HEMISPHERE TO THE SOUTHERN HEMISPHERE

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This paper describes one of the phases of a broader research carried out by the Science Education Research Group (SERG) from State of São Paulo (UNESP, Brazil), which has evidenced the distance between the academic production of the area of Astronomy Education and the knowledges and practices of students and teachers in Basic Education. In this text, we seek to investigate the singularities found during the stages of translation and adaptation of a specific didactic material, in the form of a school diary – "Il Diario del Cielo" (Diário do Céu / Diary of Sky) -, originally created and idealized to the reality of the Northern Hemisphere (Rome, Italy) and adapted to the reality of the tropical belt of the Southern Hemisphere (Bauru, São Paulo, Brazil), as well as discuss the potential of this material, to work with concepts of phenomena related to Astronomy, in a training program of continuing training for in-service teachers in Secondary and High School in the area of sciences. Topics such as: the visible horizon, the time of birth, climax and sunset and the Moon, the duration of the day according to the time of year and the latitude of the place of observation, equinoxes, solstices, seasons, phases of the Moon, among others, are approached from a sequence of didactic activities developed with students, in regular schools, according to the bases of Position Astronomy. Among the results found, it is important to note that the need to record daily data from the active and systematic observation of the sky and the environment in a diary, besides revealing an interdisciplinary character, involving different areas of knowledge, also points to the need to diagnose, discuss and reflect on the teacher's difficulties in managing the contrast between the times of astronomical phenomena (day / night cycle, lunar cycle, seasons, eclipses, ...) and those of the school, between open spaces for the sky and the confinement of classrooms in schools, making the task of teaching about astronomical content more difficult. It also points out the reduced expectation of teachers in relation to teaching about the relations of similarities and spatio-temporal differences between the realities of the contexts of the North and South Hemispheres, compromised by the way and the quality - or even by the inexistence - of the initial formation of the teachers, which leads to the incipient domain of disciplinary and pedagogical knowledges focused on astronomy and sometimes the feeling of incapacity and insecurity, when working with the subject in schools.

Poster Session / 108

SCIENCE IN 4D: A SUMMER SCHOOL FOR PROMOTING ACTIVE LEARNING IN AN INTERDISCIPLINARY APPROACH

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How to prepare and implement effective in-service teacher training program to promote teachers' professional development? Despite many actions promoted by national and local administrators in order to enhance the quality of science education in the secondary school, the most effective experiences inspired by science educational research remain isolated and find it hard to spread into the classroom practice. Starting from good results obtained in pre-service teachers training by using active learning focused on activities in laboratory, we designed a national summer school in order to answer to the teachers' request of a professional development in disciplinary topics and educational methodologies. Since in our experience the most powerful and interesting teaching/learning processes often involve an interdisciplinary approach, we decide to propose a school whose participants could be any science teacher (i. e. mathematics or physics, chemistry or science teacher in a secondary school). Each edition is focused on a relevant topic in science and can be declined in different and significant ways for every scientific discipline. The unifying theme proposed is broadly speaking a fourth dimension where scientific description of nature is realized. Hence the title of these summer schools became Science in 4D. In first editions the transversal themes were the time, sustainability and the color in nature.

Professional development can provide the opportunities for teachers to learn what they need to know and be able to do as they assist students in the learning process (Bybee & Loucks-Horsley, 2000). Active learning, problem-based learning, collaborative learning and inquiry-based teaching strategies could have a significant impact on science education (Bybee, 2006; Barron, & Darling-Hammond, 2008; Savery, 2006) if teachers used them diffusely. Moreover, in-service teachers have few opportunities of trying and fully acquiring these educational tools in a laboratory environment.

The summer school was designed in such a way that participants were involved in laboratory where they could experience firsthand the effectiveness of these methods in a disciplinary or interdisciplinary context. Since motivation has been recognized as an important factor in the construction of knowledge and the process of conceptual change (Palmer, 2000), an interdisciplinary approach was pursued in Science in 4D summer school. All editions are reported with some examples of disciplinary and interdisciplinary laboratory developed by participants.

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Poster Session / 109

A New Trial of Physics/Science Short Lab Class for Non-Science Cources Students in Kagawa University

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We have demonstrated a new use of technology which is based on a conventional thermography to show the heat transfer of water. Our main purpose of the research was focused to the development of science class lob in primary school. After then we could expand some teaching materials and ideas to some national and public primary schools.
Nowadays we found that our students subject to non-scientific area had only tiny knowledge of natural science just like primary school children, even though they passed difficult entrance examinations. More seriously, this trend is becoming conspicuous. We physics and science teachers have made a project team in the university four years ago against this situation, and planned new science lab class for such the students. We employed a teaching material (ex. thermography) which is intuitively understand but based on new technology facing to cutting edge for a single class, and we provided such the materials continuously through one semester.
We are going to start from a short survey of educational situation in Japan, and show our project in the university and explain our materials.

Parallel Session 1 / 110

From the recovery of mathematical inadequacies to the development of transversal skills for physics students

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Reducing the drop-out rate between the first and second year during university studies through the innovation of teaching tools and methodologies has been the new action promoted by a national project in recent years. As part of the interdisciplinary coordination of the project's areas of Siena, we conducted a survey among the students of the scientific degree courses to identify the shortcomings and difficulties encountered in the first years of the course and the perception that the students had of the usefulness of scientific skills in (mathematical, physical and chemical tools) in the disciplines characterizing the course of study. The outcome of this survey, which began with sample interviews and ended with online questionnaires, revealed the need to develop an innovative action to fill in the entry shortcomings and to immediately promote the development of transversal skills such as problem posing, problem solving and the ability to model and argue in an interesting context for students.
The concept of the contextualized laboratory stems from a close collaboration between Physics and Mathematics teachers gained in interdisciplinary activities with the aim of designing and testing with the students materials that promote the active learning both in recovering incoming mathematical skills and in developing new skills needed in scientific training. The activity is configured as an educational research in order to identify the most effective tools which can be used in the training of graduate tutors who can use it correctly and permanently in support activities for students.
Since last year the survey on student needs ended well beyond the end of the first semester, it was decided to start a contextualized laboratory for the students of the degree course in physics in the second semester. The experimentation with the students was unsuccessful but allowed us to identify the critical issues to be overcome. This year the workshop took place in the first half of the year and achieved results well beyond the most optimistic expectations. The trial confirmed the validity of the educational materials developed and it will allow the next year to move on to the active training of the tutors.

Parallel Session 2 / 111

RETOOLING PHYSICS INSTRUCTION THROUGH CONTEXT-BASED STRATEGY

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Physics is a science subject that has attracted the attention of researchers over the years due to low enrolment and poor achievement of students in the subject. One of the major focuses of Government reform in science education is amending the curriculum from teacher-centred to student-centred curriculum and life-long learning. This is done for students to be able to relate what is learnt in the classroom to real life situation in order to make science most especially physics more relevant to students' lives. This will enable students to develop thinking skills by connecting physics concept to real life situation in the society. This paper examined the perception of students in learning physics concepts through related encounters with real life situations, living styles and day to day activities. The population of the study comprised of students and community members of Ifelodun Local Government Area in Kwara State. Data were collected both in the classroom setting and among community members where students are living using questionnaire and oral interview. Findings from the study showed that students were not able to connect what they learnt from the classroom to their day to day activities and real life situation. Also, it was discovered that physics concepts were used everyday in their activities but little could they explain the concepts. It was recommended that synergy should exist between the curriculum in schools and the culture of the society for better understanding of physics and for technological development of thesociety.

Parallel Session 1 / 112

Gender Differences in Performance in Physics Practicals

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An analysis of Physics practicals data is presented. In particular, we study the association between gender of students and their overall mark and their Physics practicals marks (Mechanics, Thermodynamics, Optics, and Electricity). Together with gender, all variables are binarized. To visualize performance of students, the qualitative method of plotting a two-dimensional orbit is used to represent binary multivariate longitudinal data of each student. Analysis of orbits reveals information of patterns in the data. This study gives a good indication of which fields of Physics females perform well in and which fields the male students are stronger in (equivalently where gender struggled in various practicals). Details of the analysis of past exam papers will also be discussed . A comparison to the GEE statistical model tells us that visual results present initial insights to help and complement statistical data analysis.

Poster Session / 115

An evaluation of student's understanding of DC circuit concepts through students' written explanations

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One of the topics that is regarded as challenging to learn for conceptual understanding by students from secondary to tertiary levels is simple electric circuits. The topic is said to be challenging to learn for qualitative understanding due to the presence of misconceptions brought by or derived from every day prior experiences about the topic. In literature, the word "misconception" is mostly interchanged with alternative conceptions, naïve conceptions etc. The results of various studies from different countries showed that students have the same pattern of learning difficulties in understanding electric circuits and ultimately pass their grade with vague or inconsistent understanding of the topic.The use of multiple-choice concepts tests is common in probing students' understanding of physics concepts but less has been done in probing students' understanding of the concepts by using students' responses to explanation-type questions. However, the study that dealt with the analysis of explanation-type question to physics grade 12 examination scripts concluded that the analysis of the explanations written by students in exams "does offer researchers and teachers a reliable and efficient way by which written student explanations can be probed for conceptions". Departing from the norm of using multiple-choice concept tests to probe students' understanding of some concepts in DC circuits the current study used the scientific explanations to achievethefollowingtwoaims:

(a) To explore pre-service students' understanding basic DC concepts through their responses to written explanations.

(b) The impact of using the explanation-type questions on diagnosing students' misconceptions of DC circuits prior to formal instruction.

Parallel Session 2 / 117

NATIONAL HIGH SCHOOL EXAM (ENEM) LIKE A FORMATIVE ASSESSMENT OF PHYSICS EDUCATION IN BRAZIL

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Brazil has some large-scale assessments, for instance, state or national exams to evaluate basic education, higher education admission process, and the national high school exam (ENEM) which is for sure the most important. It is possible to do ENEM as many times as Brazilian students want, but it is only possible to access higher education if one has finished high school. ENEM consists of two-days test, there are 180 multiple-choice issues plus an essay, divided 4 academic discipline: math, languages (Portuguese and Spanish or English), natural sciences, and humanities. For the admission process, the score for each area is treated based on the Item Response Theory (IRT), which tries to minimize the effect of random guesses. We use the researches on problem-solving strategies, because they provide a number of difficulties associated with the resolution of questions of physics. As seen, know the difficulties presented in their solution strategies of a problem can suggest ways to understand what are the reasons signal a wrong alternative. We believe these possibilities can be returned to schools as a way to assist teachers in improving the teaching quality, especially publics, approximate this exam to a formative assessment (TARAS, 2010). We analyze the physics issues in 2015. These were classified and compared independently by two physics experts, totalizing 15 issues. For the year analyzed, around 1.4 million of candidates realized ENEM of public school. Statistical analysis, to rating alternatives, was conducted using SAS 9.4 software. Wrong alternatives with higher rate, could be used to identify the strategies to solve the proposed questions. All of issues where solved by the authors, carefully searching possible alternative tracks to the issues solutions. Alternative tracks, were compared with the rates item, searching to explain the students' physics knowledge used in the issues solutions. The issues represented a large spectrum of physics knowledge. We can seem a low value in the issues correct (0.30), this reflect a hard difficult of the students in physics. The best performances in issues were when the context is closer to everyday life and the worst performance are in issues when necessary a mathematician approach. The strategies analyze results in the following inferences: a not correct use of units of measurement, the presence of symbolic forms, intuitive reasoning in solving problems and not scientific concepts. With the results we can construction of a reference matrix indicating which the mistakes made by students and the possible reasons that led to commit such errors. At the time that this array was returned to school and interested owed would be considered as a feedback element that essential to the development of a formative assessment (TARAS, 2010). If the results returned for the schools teaches can be used to promote learning, and we expected that physics teachers, use that information to improve the students' knowledge, in physic area on public schools.

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Poster Session / 118

QUANTUM TUNNELING INDUCING AC AND DC EFFECT IN A MODIFIED JOSEPHSON JUNCTION

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We study a novel model of Josephson junction and investigate the appearance of tunnelling current. Using quantization technique, we prove the junction to be modelled as a two-level system where the tunnelling current is induced by the Landau - Zener transition. We prove that, the current passing through the junction is caused by LZ tunnelling with the nature of that probability current changing significantly with charging energy. In the case of sinusoidal energy, the system mimics a Landau-Zener-Stckelberg interferometer with the resulting current exhibiting AC behaviour.

Parallel Session 2 / 119

Studio Teaching Model for an Introductory Engineering Physics Course on Classical Mechanics

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Studio teaching approach is increasingly adopted as an alternative to the standard teaching methodology. It allows a better active learning setting for students to increase their participation inside the classroom while lecturing time by teachers is substantially reduced. This new methodology has been tested in many universities around the world and has proved its effectiveness. In this paper we present our design, experimentation and evaluation of using studio teaching for the introductory engineering physics course on classical mechanics over two consecutive academic years. Our studio teaching model led to an overall relative improvement in class performances and a substantial decrease in students' absenteeism rate. Students' satisfaction surveys show an overall acceptance of the new methodology despite few complaints about the duration length of the studio sessions and the workload in class.

Parallel Session 2 / 120

AN ANALYSIS OF THE INFLUENCE OF THE INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS ON THE SELF-EFFICACY BELIEFS OF PHYSICS TEACHERS

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The insertion of Modern and Contemporary Physics (MCP) topics in the high school physics curriculum has been discussed for approximately two decades in Brazil and it is already possible to observe the inclusion of some of these topics in the curricula adopted by some schools. In accordance with the guidelines contained in the National Curricular Parameters for High School (PCNEM) and the complement to this document (PCN+), the official curriculum of the state of São Paulo includes the study of elementary particles and other MCP topics among the subjects to be taught in Physics classes. However, researches shows that most physics teachers are still not addressing these topics in their classes. Teachers argue that, among other obstacles, they lack the knowledge to do so and, even those with some knowledge about these topics say they do not feel confident to teach them. In this study, we consider that one of the variables that may influence teachers' decision to accept or not the challenge of promoting innovations in teaching is their self-efficacy beliefs, that is, the subjects' beliefs about their ability to perform a given action in a satisfactory way, regardless of the outcome of that action. These beliefs gain importance as subjects try to avoid situations that cause them frustrations, and therefore, unless they believe they can perform a task satisfactorily, they have little or no incentive to invest time and energy on it. In this sense, this study aimed to analyze the influence of the participation of Physics teachers in a scientific outreach event – the International Masterclasses Hands on Particle Physics, or simply Masterclass – and in a workshop on particle physics – a related event – on their self-efficacy beliefs, aiming at the teaching of elementary particle physics in high school. To accomplish this objective, we conducted semi-structured interviews with two teachers who had already attended the Masterclass and the workshop, both organized by the São Paulo Research and Analysis Center (SPRACE). Based on these interviews, we elaborated narratives about these teachers' histories and conducted an analysis to characterize their self-efficacy beliefs and the meanings attributed by them to the participation in both events. The analysis revealed that both teachers had high levels of self-efficacy beliefs and attributed educational, instrumental and motivational meanings to the participation in these events. Given that several aspects of teacher education (such as content learning and the theoretical assumptions in which this education relies) and the availability of pedagogical resources (like learning activities, experiments and examples to contextualize the content) can influence teachers' self-efficacy beliefs, this analysis has led us to conclude that attending such events has the potential to affect teachers' self-efficacy beliefs, influencing their decisions about whether accept or not the challenge of promoting curricular innovations

Parallel Session 2 / 122

Multiple choice question responses: beyond just right or wrong

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Multiple choice questions (MCQs) are a tempting alternative to constructed response questions, especially when large numbers of students are being examined, because of their potential to save labour during marking [1]. However, one major criticism of the MCQ is that it lacks a mechanism to award 'partial marks'. Moreover, it is limited in its ability to assess understanding, or the candidate's abilitytoproduceanything.

The candidate who chooses a partly correct answer is indistinguishable from an entirely incorrect choice, yet these are usually awarded the same marks in most MCQ-based examinations – i.e. zero. There exists a way to award different marks to each option in an MCQ, depending on the seriousness of the error resulting from the choice. Alternative options are distractors intentionally designed to follow logically from an anticipated error, which makes it possible to award a different mark to each distractor according to the magnitude and/or importance of the error concerned. The magnitude and/or importance of error is linked to the question of whether the mistake is one of principle, procedure, execution or communication.

The feasibility of doing this depends on the practicalities of marking – it is possible to do it manually, although the extra labour almost defeats the purpose of using MCQ as an assessment method. Computer-based systems need to be more sophisticated than the norm if they are to cope with the demand presented here.

In the School of Physics at Wits, the assessment of MCQ responses is being evaluated using a marking programme developed by one of our co-authors, which allows the execution of MCQ examinations as described above. A number of examples will be demonstrated and discussed.

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Parallel Session 1 / 123

Making Physics Relevant: Getting teachers to look beyond the Physics that they teach

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Amid the information and technology revolution (aka 4th industrial revolution) many researchers have bemoaned the apparent decline in interest in the natural sciences (especially Physics) exhibited by high school students in many developed and developing countries. Researchers have attributed this decline to the growing alienation between Physics and everyday living. In developing countries Physics is seen as the preserve of the intellectually elite, and many "average" students shun it because of its perceived complexity as well as its irrelevance to meeting the needs of daily living. In developed countries many researchers similarly report a marked decline in the popularity of Physics despite the fact that these communities are awash with Physics-driven technological innovations. This study seeks to rekindle public understanding and interest in Physics by highlighting the relevance of Physics applications in everyday living. The study focuses on how Physical Sciences teachers could be exposed to the real life applications of the Physics that they teach, and how these physics principles influence their physical and psychological experiences. If teachers can be inspired, motivated and convinced of the relevance of Physics in everyday living, they can in turn motivate their learners to enjoy Physics and this could stem the tide of dis-interest in the natural sciences. For developing countries, increased interest in science could result in a wider human resource base available to spearhead the country into the 4th industrial revolution.
The presentation discusses the strategies used to garner interest among physical sciences student teachers and the reflections of these teachers after the intervention.

Parallel Session 2 / 125

An investigation of the effectiveness of using analogies to develop a robust understanding of direct current (DC) electric circuits in first-year university students

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The effectiveness of using a teaching strategy, based on analogies for direct current electric circuits, to attempt to address first-year underprepared university students was investigated. The study consisted of 53 participants drawn from the faculty of health sciences at Nelson Mandela University. A quantitative research design was adopted using the "Determining and Interpreting Resistive Electric Circuits Concepts Test" (DIRECT) version 1.2 as a research instrument. The DIRECT is a 29-item multiple-choice test with only one correct answer in each question. The DIRECT was modified to further probe students' confidence levels in their answers. The instrument served as a pre-test prior to the start of the formal lessons on direct current electric circuits. At the end of a five-week treatment period, the same instrument was administered to all participants as a post-test. The statistical analysis and interpretation of the pre-and posttest data were conducted using Software Package for Social Sciences (SPSS) version 23 and STATISTICA version 12. In answering the main research question (Can a misconception-based module, using analogies, positively influence academically underprepared first-year physics students' conceptual understanding of direct current (DC) electrical circuits?) and sub-questions thereof, the students' mean scores between the pre-and posttest were calculate and compared using t-test at a significant level of 0.05. The results revealed a statistically significant difference between the pre-and posttest mean scores. The pre-test mean score was 22.24 with a standard deviation of 8.07. The posttest mean score was 38.68 with a standard deviation of 13.93. The mean score difference between the posttest and pretest was 16.44 with a standard deviation of 13.82 at p-value less than 0.05. The results from the pre-test suggest that students held very strong alternative conceptions on direct current electric circuits. The post-test results also revealed that some alternative conceptions were still held onto after the intervention. There were no statistical significant difference found between the students' correct answers and their confidence levels. The quantitative analysis of the results suggested that there is a positive change between the post-test mean score and pre-test mean score and this change is statistically significant ($p < 0.05$). The results showed efficient evidence to conclude that analogies-based teaching strategy was an effective means of reducing the number of alternative conceptions the students held about direct current electric circuits. The study recommended the need to ascertain out what the students felt about the improvement of their understanding of direct current electric circuits concepts. The study suggested qualitative research methodology as an area for future research.

Keywords: Analogies, Alternative conceptions, Direct Current Electric Circuits.

Parallel Session 1 / 126

APPRAISAL OF SENIOR SECONDARY SCHOOL PHYSICS TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE

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ABSTRACT

The study was designed to appraise the senior secondary school physics teachers' pedagogical content knowledge (PCK). It also determined the relationships between the level of the teachers' PCK and their students' understanding of physics; and the students' perception of their teachers and their understanding of physics. The study employed a survey and classroom observation for data collection, using students' perception of teachers questionnaire; Physics Teaching Observation Scale (PTOS) and Physics Achievement Test (PAT). Descriptive statistics i.e. mean and standard deviation, was used to analyze the level of possession of physics teachers' PCK. Pearson Product Moment Correlation Coefficient was used to measure the relationship between teachers' level of PCK and students' understanding of physics, and students' Perception of their teachers and their understanding of physical . Emphasis was placed on two levels of PCK: Knowledge of the subject matter and knowledge of instructional strategies for teaching physics. A sample of sixty students and three teachers were involved in the study. Findings revealed that the teachers possessed low level of PCK of physics, and there is a significant relationship between the teachers' level of PCK and students' understanding of physics, and students' perception of their teachers and their understanding of physics. Among others it was recommended that opportunities should be provided for both pre service and in service teachers to enhance their PCK through courses and other professional development programs that specifically improve a teacher's content knowledge as well as pedagogical knowledge of physics.

Poster Session / 127

SCHOOL CONTEXT AND ITS RELATIONS TO HIGH SCHOOL STUDENTS' DISCOURSE ABOUT PHYSICS CLASS

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This research aimed to investigate high school students' discourse about Physics class and its relations to the school context. To achieve our purpose, we invited students from a public state high school of the countryside of São Paulo state, Brazil, to participate of debate groups on the theme "Physics class". We organized three meetings with different groups, one with freshmen students and two with seniors. The meetings took place in a special room in the facilities of a public university of the same town. We recorded the meetings in audio and then transcribed them for the process of analysis for which we used the referential of French Discourse Analysis initiated by Michel Pêcheux. We interpreted that the meanings about physics classes in the students' discourses are greatly influenced by some factors of the school context: (a) low quantity of weekly Physics classes provided to the students, which are only two per week, and this number is even lower when school events or holidays happen on the days on which the classes were supposed to happen; (b) heavy workload for teachers; (c) insufficiency of number of teachers; (d) lack of teachers graduated in Physics; (e) many open classes or classes with substitutes whom do not have sufficient knowledge and practice to provide a Physics classes with quality; (f) the obligation on teachers to comply with requirements from superiors, such as the obligation to use certain text-books in class, to apply specific types of tests and to cover an amount of subjects with students in a short period of time; (g) among other reasons, problems in the educational and cultural Brazilian system do not afford good work conditions and salaries to the teachers, whom end up been unhappy about their jobs or even changing to other occupations. As a matter of fact, many students go through the entire high school process with meanings of Physics class that are negatively affected by these conditions. As we noted in the literature and in our research, the majority of students graduates from high school believing that Physics class is the same thing as Math class, that Physics class only requires memorization of formulas and equations and do not afford meaningful discussions in class. We also consider that teachers cannot take all the blame as they are as victims of the educational system as much as the students are. Thus, in an optimistic way, not only we expect that this paper can contribute to reflections about the quality of physics classes that are being offered to young people, but also, that our discussions may draw attention from researchers and politicians to think about the quality of the educational system of their countries.

Parallel Session 3 / 128

PHYSICS LITERACY THE MISSING LINK TO SUSTAINABLE DEVELOPMENT IN KENYA

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ABSTRACT

Physics research is known to unlock mysteries of the Universe and the world we live in. Many innovations and discoveries are enabled by understanding concepts in physics. The great achievements of world physists have not inspired many youths to enrolling for physics at secondary level or at courses requiring physics as core in tertiary institutions. A very big working and adult population is not literate in physics and this leads to under achievement of the many challenges of our times e.g. sustainable sources of future energy, understanding our changing climate and global food security, managing technologies used daily e.g. computers, smartphones, and GPS devices and sustaining quality lives for example in healthcare and treatment of diseases like cancer. A population that is not physics literate may not cope with demands and sustainability of space industry, liquid-crystal displays, optic fibers, cancer treatment, energy efficiency, data storage and detecting of explosives and pollutants among the many challenges of our time. Many reasons ranging from the quality of teachers to low motivation among the learners as well as poor teaching methods have been identified for apathy shown in the enrolment of physics at all levels. This paper aim at bringing out what needs to be done to produce a literate society in physics for sustainability of critical development in Kenya.

Key Words: Physics Literacy, Sustainable Development

Parallel Session 2 / 129

PROBING INTRODUCTORY ASTRONOMY STUDENTS' NOTIONS OF RELATIVE SIZE AND DISTANCE OF CELESTIAL OBJECTS. PART I

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As part of ongoing efforts to improve teaching in astronomy an instrument, the Introductory Astronomy Questionnaire (IAQ) was developed at the University of Town (Rajpaul et al. 2014). The IAQ covered a wide range of topics that are usually covered in an introductory astronomy course and was first administered to a cohort of students who had enrolled for such a course as a pre- and post-test. The IAQ was subsequently translated into Norwegian, (NIAQ), which investigated pre-service science teachers and middle school students (Lindstrøm et al. 2015, 2016). Despite the differences between the cultural contexts of the two studies, both studies yielded similar results in terms of students' views of astronomy. What stood out most was the fact that understanding of distances and sizes were equally poor across contexts. The present study, focuses on these two aspects which are key to students' being able to engage meaningfully with astronomy as a discipline.

To this end we modified the IAQ (hitherto IAQ_R) with regard to the questions that involves ranking 1) celestial objects (galaxy, planet, star, universe, solar system, and sun) by size and 2) similar objects (centre of the Milky Way, edge of the observable universe, edge of the Solar System, the Moon, the Sun, Alpha Centauri, the ozone layer, centre of the Earth, Neptune) by distance from the Earth. The modifications include the omission of the asteroid belt in the distance ranking, the swapping of Polaris for 'the nearest star to the sun (Alpha Centauri)' and the addition of 'star' in the size ranking. Most importantly we added in the facility for respondents to set objects equal (=) to each other in the size ranking. The original IAQ only allows for '<' and '>' comparisons. Allowing students to set size of objects equal to each other permits many more response combinations. (The same responses could in principle be elicited as per the NIAQ, but the extra possibility and additional object potentially prime different cognitive resources). This present study seeks to accomplish two things: 1) to see to what extent the present study can replicate the results from the previous studies and 2) to set the ground-work for future qualitative analysis and intervention methods focusing on size and distance visualization in astronomy education.

The modified IAQ (IAQ_R) only focuses on questions pertaining to size and distance of celestial bodies. The IAQ_R was administered to a comparable cohort of students at the University of Cape Town who were taking the Introductory Astronomy course. The IAQ_R was administered during the first lecture, in order to probe students' pre-instruction understanding of the ranking tasks. The accompanying paper, Part II (Sivitilli et al.,) details the analysis, results and a possible interpretive framework.

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Probing introductory astronomy students' notions of relative size and distance of celestial objects. Part II

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How is the present collective view of our place in the cosmos reflected in the mind of an individual? This is an important question to consider when teaching astronomy, as the descriptions involve the seemingly familiar, like space and time, yet on scales that are not easilycomprehensiblewithinsimplemental models.

As outlined in Part I of the present work, we explore how students in an introductory astronomy course conceive cosmic-scale sizes and distances. We present our analysis of student responses from the IAQ_R, the modified version of the IAQ [Rajpaul et al. 2014. Phys Rev] described in Part I.

Our preliminary findings confirm previous findings with regard to the notions held by both cohorts of these students (South African and Norwegian) not only in terms of the presence of these notions but also insofar as the proportions of students is concerned [Lindstrøm et al. 2016. 2015 PERC Proc.]. Amongst these notions are perceptions that stars are smaller than planets, the overestimation of earth's atmosphere extent into space, and the presence of other stars "within" our solar system. As noted in the previous work, we also explore the correlation between students' quality of knowledge of celestial objects and their ranking in size and then consider what limitations such a correlation (or lack thereof) may have in revealing the importance of spatial awareness in astronomical knowledge.

As extensions to the previous IAQ analysis, we discuss in detail (a) how the extra level of freedom (including
=) in the size ranking task plays itself out in the results obtained and (b) how size ranking correlates with distance ranking. With regard to the latter we show that a higher proportion of the respondents who underestimate star size in the ranking task also appear to underestimate the relative distance of the nearest star to the sun.

We suggest that the results of the present and previous studies are clear indications that learning about cosmic scales is challenging from a fundamental cognitive perspective. Eriksson has used a social semiotic framework to show clearly that Disciplinary Discernment is key to learning astronomy [Eriksson et al. 2017. EJSME]. We suggest there may be an even more fundamental aspect that underpins the cognitive structure on which Disciplinary Discernment may depend. An embodied cognition perspective places spatial engagement as a central component of much abstract thinking as evidenced in the cognitive linguistic literature on conceptual metaphor [Lakoff 2000]. Thus, we theorize that the key challenge arises from the difficulties of "compressing" the cosmic scales to within human comprehension. Furthermore we suggest that the embodied cognition standpoint allows us insight into developing intervention methods that tap into the same neural mechanisms that allow people to spatially map their immediate surroundings, thus aiding students in building spatial mental models of the cosmos. Such interventions would potentially be done with planetarium and virtual reality technologies, projects currently being explored by the authors as doctoral research.

Parallel Session 1 / 131

Gaps in Teacher Competencies Linked to Inquiry-Based Practical Work in Certain Resource-Constrained South African Physical Sciences Classrooms

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Scientific research and economic development are being threatened by the dwindling interest of learners in science. The incorporation of inquiry in science education can contribute to addressing this threat while fostering scientific literacy. However, in relation to the implementation of inquiry-based science education, serious gaps in the competencies of science teachers have been noted. In order to better address these gaps, professional development efforts need to be context-specific and linked to the specific needs of the participating teachers. In order to inform such professional development, we focussed in this research on the case of teachers in certain resource-constrained South African physical sciences (physics and chemistry) classrooms. The purpose was to identify gaps in teacher competencies associated with the routine implementation of inquiry-based practical work. Based on a framework of teacher competencies including the TPACK framework, we used a multi-method case study involving two resource-constrained High Schools. The data collection methods consisted of interviews, classroom observation, artefacts (document analysis), and field notes. We analysed the resulting data using the data-driven inductive approach in thematic analysis. The results show that in relation to the implementation of inquiry-based practical work in the classroom, participants have multiple gaps in their content knowledge, pedagogical knowledge, technological knowledge, pedagogical content knowledge, technological pedagogical knowledge, in addition to certain professional values. We have discussed the research- and practice-based implications of these results in relation to teacher professional development in South Africa and internationally.

Parallel Session 2 / 132

General Physics for Earth Sciences, an undergraduate introductory physics course for first-year students majoring in the earth sciences at the University of Johannesburg

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Curriculum development for higher education science degrees becomes particularly important with regards to service courses, i.e. those courses designed to cater for students majoring in scientific disciplines different from that of the service course. Not only do service courses provide general scientific literacy to future scientists, but (if properly designed) they also address preconceptions around the relevance of a particular science discipline within the broader scientific context. Physics service courses are not exempted from the above considerations.

A first-year physics course for Earth Sciences majors recently developed at the University of Johannesburg is described. The need for such a course to be developed came from the necessity to address 1) the poor performance of the students in the old "content-neutral" general physics service course, and 2) the lack of engagement of these students with the content.

The design of this fourteen-week course spans from vector algebra and two-dimensional mechanics to properties of solids and fluids. Particular care has been put into enriching each section with relevant examples within the geosciences context, and making linkages between physics principles and laws to more advanced geoscience subjects. Examples of these are: mass wasting as an application of the inclined plane problem; relevance of vector addition for the triple junction stability in plate tectonics; Archimedes' principle and buoyancy at subduction zones; the importance of friction in rock deformation, and many others. The pedagogical approaches adopted in the teaching of the course are described, bringing evidence that these, together with the relevance of the course content to students, have contributed to tremendously increasing the student performance and holistic experience of the course.

Finally, arguments are proposed to support the claim that the emphasis on relevance of the content is the appropriate answer to address the issues around decolonization of the curriculum within the (South African) higher education landscape.

Parallel Session 2 / 133

Exploring how students in Physics Education can bring awareness on the importance of accessing solar energy in Namibian's rural areas (Case Study)

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The sun is the principal source of energy for all living things, without its presence all life on earth would come to an end. Solar energy is radiant energy from the sun caused by nuclear fusion in the sun's core. For many years solar energy has been looked at as a fundamental source of energy due to vast amounts of energy that are made freely available. Solar energy is harnessed, stored and converted into heat, light and electrical energy for various applications such as cooking, refrigeration and lighting.

Access to modern energy services is a requirement for sustainable development, to equip the nation to accomplish their daily tasks, to excel in business opportunities and economic growth, so as to uplift the whole community particularly the population in the rural areas. Although Namibia has made significant progress in electrification, rural electrification is still limited due to a lack of knowledge and skills on how to harness the freely available solar energy. Financial constraints are also a contributing factor to acquiring modern technology. The possible solutions to solar energy concerns are widely debated at different plat forms by stakeholders, politicians and the public at large. Therefore this study focused on raising awareness and sensitise the communities especially the rural and informal settlements in urban areas on how to make use of the freely available solar energy. The study involved 20 informants: 10 from each region. For data collection, semi – structured interviews, document analysis and focus group discussions were used for cross fertilisation of ideas. The results of the study will benefit the communities in both rural areas and informal settlements in urban areas in Namibia.

Poster Session / 134

Solar system at your fingertips: an interdisciplinary learning path

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An active learning path was carried out directly by students in a vocational school by following a cooperative-learning approach. At the beginning of the school, some students showed relationship problems and formed small groups that, in some cases, led to the exclusion of pupils with special educational needs. These problems, coming from a quite diversified socio-cultural context, were linked to a lack of interest and a mnemonic few reflective approach to Science.

The path was designed with the aim of creating a learning environment as much involving as possible and with the purpose of fostering aggregation, i.e. form a more cohesive and collaborative class group in which students could appreciate the advantages of cooperative work, help and mutual support. The laboratory path was organized in a sequence of activities carried out during the first part of the year. To encourage research and planning, various phases were designed: firstly an initial brainstorming to stimulate curiosity and allowing to evaluate the prerequisites and misconceptions; secondly the design and the active construction of models on the Solar System and on Kepler's Laws.

Since reasoning with ratios and proportions is widely regarded as a critical bridge between the numerical, concrete mathematics of arithmetic, useful in day life practice, and the abstraction that follows in algebra and higher mathematics, the science teacher in collaboration with the mathematics teacher, realized a further laboratory on the proportionality in celestial bodies, astronomical distances and scale ratios.

All phases were conceived according to a group work and the continuous sharing of the products realized by using the Google Suite and Google Classroom platforms. Collective discussion allowed the comparison of ideas and a problem solving approach to various difficulties that emerged. A relevant activity was the final exhibition in the school: each group presented their products. This led the subsequent self-evaluation and peer review phase.

A closer analysis of laboratories shows that all requests for achieving a cooperative learning are satisfied (Curseo 1992, Johnson 1999), such as positive interdependence, individual accountability, face-to-face promotive interaction, social skills and group processing.

The designing and the planning of the learning-teaching path (Friend 1999) was discussed with special education teachers in order to favoring the active participation of students with special educational needs in cooperative groups. In these cases, the focus was centered on pupil's learning and mainly at the maturation of attitudes (observational, descriptive and cooperative in the classroom) rather than at the contents. The path has guaranteed training success for everyone, none excluded. The interdisciplinary learning path was an effective realization of an inclusive classroom, where also borderline students were involved and gained a successful learning experience.

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Parallel Session 3 / 135

CHANGES IN STUDENTS' PROBLEM-SOLVING SKILLS: THE ROLE OF A FOCUSED TEACHING INTERVENTION BASED ON SEQUENTIAL MULTIPLE REPRESENTATIONS

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This study was set to investigate the role of Sequential Multiple Representations in Enhancing Senior Secondary School Physics Students' Problem-Solving Skills in the context of a tightly focused teaching intervention. The intervention involved a sequence of four lessons conducted over a period of 6 weeks, with the first and last week used for pre and post-test. The intervention was set deliberately to push students to use multiple representations in a particular sequence (starting from word to symbols, diagram, and then generating equations) to solve electric circuit problems. The population of the study comprised of all students offering physics in the fifteen public senior secondary schools in Bauchi state, Nigeria. Simple random sampling technique was used to select two schools and 80 students constituted the sample size. Forty (40) students were assigned to the intervention (experimental) group and 40 students to the non-intervention (control) group. The instrument used for data collection was a Physics Problem-Solving Task on Electric Circuit (PPSTEC) with a reliability coefficient of 0.76. An assessment rubric was developed by the researcher with four (4) levels of attainment of problem-solving skills (No attempt, Problematic, emergent and exemplary). The rubric was used as an analytical tool that characterized, assessed and ascertained the changes in students' problem-solving skills before and after the teaching intervention. The result shows that the intervention group made substantial improvement from about 89.75% at the level of no attempt and problematic response in the pre-test to 74.50% moved to the higher levels of emergent and exemplary. Based on the finding, it was concluded that the use of sequential multiple representations as a teaching strategy is an effective tool for enhancing students' problem-solving skills in the context of electric circuit problems. We therefore recommend for further research with different sets of students, and in different context across Nigeria to provide more empirical evidence on the role of sequential multiple representations as a means of developing students' problem solving skills in electric circuit problems.

Parallel Session 1 / 136

DC CIRCUITS: CONTEXT AND SENSE-MAKING

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The present papers report on a programme that aims to probe, at a fine-grained level, how students engage with simple DC circuits, in particular with regard to context and sense-making. We discuss the results from an instrument, the Aspects of Circuits Questionnaire (ACQ), in which non-substantive variations of a simple circuit were presented to students. This talk discusses ACQ itself and then highlights the findings that pertain to context sensitivity.

An important part of the first year physics curriculum is electricity. However, it has become apparent worldwide that teaching even the very basic concepts has not been successful in helping students gain a proper understanding thereof. One criticism of the way in which circuits is often taught is that it is too theoretical and that involving students in practical work and simulations should improve the situation. Thus many innovative curricula have been developed in which students are taken through a structured sequence of laboratory exercises in order to clarify the concepts. One very popular approach for example has been to use circuits in which the brightness of a light bulb is used as a visual proxy for current. However, despite many such attempts the results have not shown dramatic improvements in student understanding.

An eight questions probe, Aspects of Circuit Questionnaire (ACQ) was developed for this broad fine-grained investigation. All circuits were open circuits, consisting of a single battery connected to a resistive element with a single wire. Each question was presented as a situation in which a posited group of students discuss a particular situation, and take a particular stand. Respondents are then presented with four choices, from which they have to choose one, Forced Choice Responses (FCR). The respondents are then requested to explain in detail their reasons for the particular choice. The FCR data were analyzed by tallying the choices and presenting them as histograms for visual comparison while the Free Written Responses (FWR) data were analyzed using a grounded approach.

The analysis of the FCRs showed that majority of student's responses were highly sensitive to context [3]. A key finding that emerged from the coding of the FWR was that only one "foothold idea" was productive across the entire spectrum of micro-contexts: "loop continuity / completeness" [4].

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Parallel Session 2 / 137

Probing the nature of student explanations of visual phenomena: a pilot study

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Explanations of what we perceive visually may not depend solely on invoking an appropriate model for light but can also involve aspect of visual cognition. With regard to light, three incompatible models are used to describe its complex behaviour: straight lines, waves and particles. Each of these models describes aspects of light under different contextual conditions. For example, geometrical optics can be used to describe reflection, but this model cannot account for the bending of light when it passes through a slit i.e. the model of light travelling in straight lines does not offer the affordances for describing diffraction. However, optical phenomena are not always adequately explained by such a "bottom-up" (reductionist) approach. For example, the explanation as to why the moon is perceived to be larger on the horizon but smaller when directly above our heads requires a "top-down" explanatory component which draws on various cognitive aspects of visual perception.

The present, broad programme of work aims to map out the nature of student explanations of visual phenomena in terms of (1) choosing the appropriate model of light and (2) recognizing the extent to which a top-down component is necessary. To this end, an instrument Models and Perceptions in Optics Questionnaire (MPOQ), is being constructed and piloted as part of the first phase of the broader programme.

The present talk reports on some of the preliminary work that has been carried out in terms of question construction and piloting the questions to students both in South Africa and Nigeria. Specifically, we report on three questions: the first question involves the directionality of light travel with respect to the eye, the second question centres around refraction while the third question involves the observed size of the moon. Each question is is framed as a debate among a group of posited students, each of whom offers a different explanation. Respondents must choose the explanatory option "with which they most closely agree" (Forced Choice Responses), and more importantly, are then asked to explain the reasons for the choice (Free Writing Responses). The FCR's are analysed by simple tallying while the FWR data are analysed using a grounded approach.

The first version of the three-question instrument was piloted in South Africa with a group of 140 first year medical students, while a second version of the MPOQ was administered to a (mixed) group of 180 first year medical, physics and physics education students in Nigeria. The questions will be discussed in more detail and preliminary results and observations from the analysis will be presented.

Parallel Session 2 / 138

Student ideas on vector direction in kinematics graphs

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Understanding graphs is a primary skill in any discipline, physics in particular. Students frequently do not know whether to extract the desired information from the slope or height of a graph. This is a pilot study to understand the interpretation of direction of a vector in a kinematics graph. We used a questionnaire consisting of three graphs to study the understanding of kinematics graphs of first-year university students in various contexts. The study was conducted on Extended Curriculum Students (ECP) and main stream students who were registered for various courses in a UoT. The students were asked to determine the direction of movement of the objects in various graphs within different contexts. The result from the study shows that the students are engaging with the shape of the graphs rather than the variables in each axis. This paper presents the outcome from three different graphs and their reasoning for their responses, and the comparison between the two groups.

Poster Session / 139

Effect of Problem Posing Teaching Strategy on Prospective Physics Teachers' Conceptual understanding and Problem Solving Behaviour in Some Selected Concepts of Physics

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It is pertinent to consider appropriate alternatives means of imparting knowledge so as to defend quality science teaching and learning from going into extinction when the need arises. Among these alternative is the use of problem-solving strategies that involve different problem-solving activities like learning through open ended such as problem posing. Problem posing improves students' problem-posing activities, reinforce and enrich basic concepts, foster more diverse flexible thinking and preconceptions. Based on this, the study determines the effect of problem posing teaching strategy on prospective physics teachers' conceptual understanding and problem solving behaviour in some selected concepts of physics. The objective of the study is to find the effect of problem posing teaching strategy on different categories of problem solvers (experts and novices) conceptual understanding and problem solving behavior in some selected physics concepts. The design adopted for the study was mixed method and the sampling techniques was multistage sampling techniques. This sampling technique enables the categorization of the prospective physics teachers into experts and novices problem solvers. The area of the study was Bauchi State. Instruments used for data collection are Physics test for conceptual understanding (PTCU) and physics test for problem solving behavior (PTPSB), developed by the researcher based on the concepts work and energy. The data was analysed using descriptive statistics and qualitative approach. The findings indicate that experts' prospective physics teachers' conceptual understanding is logically organized according to schema with systematic problem solving behaviour, while novices' prospective physics teachers' conceptual understanding is hierarchically organised with random mode of problem solving behavior. It was recommended among others that teacher educators should adopt problem posing teaching strategy in teacher training programme for flexible and systematic thinking that enhance skills acquisition.

Poster Session / 140

Poster presentations as an approach to implementing a 'flipped learning' pedagogy in introductory physics

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'Flipped learning' or 'flipped classroom' pedagogies are gaining prominence in undergraduate science learning [1]. With the growing access to information through the internet, the traditional model of the teacher as the only facilitator of knowledge has become inadequate [2]. Lage et al [3] considers the key purpose of the flipped classroom to be to shift the focus from rote learning to the students' application of conceptual understanding.

This presentation reports on a class group activity using poster presentations as a flipped classroom teaching medium. Poster presentations, a popular technique of displaying research at conferences, are being used increasingly as a teaching method [4]. In their teaching of mathematics, Denson [5] suggests that poster sessions are beneficial in that the preparation thereof promotes learning, it is an excellent alternative medium for developing communication skills, it encourages students to investigate a topic thoroughly, it provide opportunities for peer-learning and promotes a positive attitude in students.

In this work, prior to making the posters each student would submit a chapter summary before the topic was discussed in class. For the execution of the poster presentations students were placed in smaller groups of three to four students to make a group posters. When they presented their poster it was in a smaller venue with another group of three to four students who would serve as their audience and a facilitator who would record the presentation. Hereafter the audience would presents their poster and the previous group who had presented would become the audience. The video recordings of the presentations were then placed onto the University online learning facility with the restriction that only those six to eight students were allowed to view, and review for peer assessment. Nichols et al [6] in their paper on using video in nursing education says that, depending upon the use intended by the instructor, a video may be able to tap all three domains of learning: cognitive, affective, and psychomotor. Barry et al [7] looked at how to develop a protocol for video recording student group oral presentations, for later viewing and self-assessment by student group members. Their investigations revealed that watching the video of their group presentation was an effective method of feedback and could improve both group and individual performance in the future [7]. The purpose of the video recording of the presentation in this work is to provide the students opportunity to reflect on their presentation skills and to possibly use the video recording as a useful study aid.

This presentation will discuss the extent to which this poster presentation intervention served as a means to assist students in improving their presentation skills, understanding the course content and to become better, skilled communicators of course-related material/physics concepts.

Parallel Session 2 / 141

Perceived self-efficacy as a factor to realize choice-satisfaction towards post-compulsory Physical Sciences

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Perceived self-efficacy is known to affect the choices that people make. This construct is taken from Social Cognitive Theory. The effect of choice on a person's well-being can be understood in terms of Capability Approach, according to which people may exert agency on these opportunities available to them. Once people seize available opportunities the likelihood for these opportunities to be realized, so that they can live the life they value most, become possible. In this study Capability Approach is used to frame the extent to which perceived self-efficacy, from Social Cognitive Theory, can be seen as a factor learners can use to realize choice-satisfaction. The context in which we apply this is that of learners' choice whether to take Physical Sciences at the post-compulsory level or not. If perceived self-efficacy can be conceptualized as a factor which determines the extent of learners' choice-satisfaction it would be expected that high perceived self-efficacy would improve the likelihood of Grade 10's being satisfied with the choice they made in Grade 9 to take Physical Sciences in Grade 10 or not. This is because learners with a high perceived self-efficacy will judge themselves more validly and be more likely to make choices contributing to better their quality of life. I surveyed 541 Grade 10 learners on their perceived self-efficacy, satisfaction with choice regarding Physical Sciences, and some opportunities identified in education. Biographical data was also collected. A simple linear regression was done to determine the relationship between perceived self-efficacy and satisfaction with choice. Multiple regression was done to adjust for biographical factors and basic opportunities identified in education. The findings show a statistically significant positive relationship between perceived self-efficacy and choice-satisfaction towards Physical Sciences. A relationship independent of biographical factors and mediated by opportunities in education was found.

Poster Session / 142

What is your favourite particle and why?

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When introducing the Standard Model of particle physics at secondary level, high-school teachers and students are faced with various abstract concepts and lots of novel terms. Among the many challenging terms is the infamous "particle zoo", which stems from the early days of particle physics, when every newly discovered hadron was believed to be a distinct elementary particle. Since then, the Standard Model of particle physics has been colloquially compared with the variety of species in a zoo on a regular basis.
Here, it is assumed that such a representation of the Standard Model of particle physics can have a negative impact on students' understanding of the fundamental concepts underpinning particle physics. Indeed, a careful educational reconstruction of the subject matter is key when introducing particle physics in the classroom. Specifically, within the framework of constructivism it is indispensable to take students' conceptions into account and to focus instructional strategies on already existing conceptions.
Therefore, we have conducted a large-scale international study with high-school teachers (n=532) and high-school students (n=1003) from all around the world to investigate and document what they consider as their favourite particles. We will present the findings and discuss potential implications for teachers, educational researchers, and policy makers.

Parallel Session 1 / 143

PHYSICS AND HUMANITY

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The physics community of practice has been active at all levels in promoting the advancement of women. However, the percentages of women in university departments remain generally lower in physics than in the life sciences. Arguments relating to teaching and research loads and work-life balance are comparable in these disciplines.

TheGlobalSurveyofPhysicistscarriedoutin2010byIUPAP(R.IvieandC.Tesafaye(2012)*PhysicsToday* **65** 47) showed both similarities and contrasts in the work experiences of women and men, in less developed countries and more highly developed countries. The Survey was carried out in 8 languages, across 130 countries, and had 14932 respondents. It reported that women had significantly less access to most resources for career advancement.

This paper will address these questions: why is the advancement of women relatively slow in physics? What concepts are useful to physicists in understanding gender in science? When a successful initiative is concluded, why do numbers and workplace practices snap back towards the status quo before the intervention? It will be argued that these questions are closely linked. Different dominant factors in the choice of physics have been suggested, including perceived gender bias in the field (C.M. Ganley et al (2018) *Am. Ed. Res. J.* **55** 453), and the belief that innate talent is a prerequisite, combined with the stereotype that women do not possess this talent (S.J. Leslie et al (2015) *Science* **47** 262).

Much has changed in the environment for women since 2010. Observable trends include factors such as the many initiatives to attract and retain women, and vocal anti-harassment campaigns. Geopolitical factors include a rise in the "abandonment of the liberal order", reductions in science funding, and changing threats of conflict affecting even the university environment. In this altering context, it is vital to obtain data on trends and on disciplinarycontrasts.

The International Science Council has funded the project "A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences: How to Measure It, How to Reduce It?". This project is led by the International Mathematical Union, partnered by 10 scientific Unions and organisations. The project includes a survey in which two of the aims are to provide contrasts across disciplines, and to identify trends based on data from the 2010 Survey. A Joint Data-backed Study on Publication Patterns builds on the study by the International Mathematical Union (Mihaljević-Brandt et al (2016) *PLoS ONE* **11** e0165367). A Database of Good Practices is being designed, with reference to the structure suggested through the UNESCO SAGA project. These works will contribute evidence to support decisions on the best deployment of our resources in initiatives aimed, in part, at improving the university environment for women, noting that knowledge of science is universal, but is shaped by local culture (M.T. Lin (2017) Int. Conf. on Women in Physics).

Poster Session / 144

Overview of Modern Physics Learning Objects in Brazilian Government Repositories

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From the potential of the virtual education to a powerful ally in the teaching-learning process: digital technologies, which despite its potential brings with it great challenges, due to the plurality of resources and innovations provided by it. Students and teachers are surrounded by technologies that cause interest and, consequently, the use of these novelties begins to intensify, then emerges the need for a favorable use of these technologies to education. At the same time, it is consensual among physicists, at an international level, the need to introduce contents of Modern and Contemporary Physics in the curricula of Physics of High School. For many, the absence of the subject is unacceptable, since it was the century in which revolutionary ideas totally changed science and can arouse students' curiosity and help them recognize physics as a human endeavor, to make contact with the exciting world of science, current research in physics and still help to understand the world and the current digital culture. Many researches have been based on the understanding and the proportion of use of Digital Technologies of Information and Communication as resources for the teaching-learning. Among the difficulties it's to the plurality of resources found in the Internet and the time spent to find quality resources. Therefore, it was sought to identify which resources of modern physics are available in the repositories subordinated to the Brazilian federal government that can actually assist teachers in the teaching-learning process. Among the research questions that this paper seeks to answer are: what modern physics resources were developed and publicized? What are the main themes? What were developed in Brazil? Have they been funded in what way? Developed by whom? In this sense, we resorted to the repositories of educational resources linked to the Brazilian government, they are: Teacher Portal (Portal do Professor), International Bank of Learning Objects (Banco Internacional de Objetos de Aprendizagem - BIOE) e National Infrastructure of Learning Object Repositories (Infraestrutura Nacional de Repositórios de Objetos de Aprendizagem - INROA). Among the results, it is possible to point to the great amount of Brazilian resources that have auxiliary didactic guide to the teacher, elaborated from an edital financed by the Brazilian government and that the majority of the foreign resources are simulations, elaborated by the groups of the Phet Colorado and Wolfram.

Poster Session / 146

A comparative analysis of school physics curriculum content in selected countries

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Meaningful curriculum reform is central to the provision and acquisition of globally relevant scientific skills. A globally competitive curriculum fosters the cultivation of skills required for sustainable economic growth and development. In addition, it is imperative to harness the affordances associated with the provision of intellectually stimulating school physics curriculum content in order to foster the development of cognitive and reflective skills. In response to this key imperative, a comparative analysis of school physics curriculum content in selected countries was carried out with a view to identify levels of commonalities and the depth up to which each curriculum extends. Comparative analysis of school physics curriculum content in selected countries revealed striking inherent characteristic features that serve to provide the structural differentiation between these curricula. The level of economic growth and development in selected countries appeared to be a function of the quality and depth of the school physics curriculum content. Theoretical implications for meaningful curriculum reform are discussed.

Parallel Session 3 / 147

THE INSTRUMENTATION FOR TEACHING PHYSICS AT INITIAL TEACHER TRAINING: ASSUMING AUTHORITY IN THE PHYSICS TEACHING-LEARNING PROCESS

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This work investigates a didactic sequence developed in the discipline of Instrumentation for Teaching Physics (B), the didactic-methodological strategies adopted and its innovative character towards critical and reflexive formation. The context of the research focuses on the Licentiate course in Physics, Nighttime, in the ofter of the discipline during the second semester of 2016, at the Federal University of Santa Maria(UFSM). The discipline's main objective is to understand the importance of the laboratory for the development of Physics and for the teaching of Physics, as well as to elaborate and defend in class, teaching structured and unstructured scripts for high school that integrate theory and practice in Mechanics and Thermodynamics. From this point, it was thought of in a dynamics job that allowed a study spoken about the physical contents involved, selection and construction of the experimental activity and socialization during two meetings a week. Features such as MOODLE, WhatsApp, and shared documents in Google Drive were used in the course of activities. Based on the results obtained, it is accepted that the didactic sequence adopted in the discipline promoted the understanding of academics about the importance of planning and use of the experimentation in their future activities as teachers.

Parallel Session 2 / 148

The meeting place: Physics for development (C13) and Physics education (C14)

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IUPAP is the host of two related commissions in physics, all working towards making physics possible in developing world while teaching it better everywhere else. These commissions, C13 and C14, are expected to continually interact with each other so that physics remains the centre of all sciences. In this presentation, C13 commission will present their activities in the past three to five years, to highlight the actions taken to move the development of physics in poor countries of the world, some of which are not even members of IUPAP. In addition, we will discuss the plans in the IUPAP centenary celebrations in 2022, where these twins are expected to lead together and make physics fun afresh

Poster Session / 149

Physics teaching and learning: A case for Indigenous Knowledge in Physics

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mThe goal of this conceptualization is to explore how physics educators can integrate indigenous knowledge into their teaching of physics concepts in the science classroom whether at the secondary or tertiary level of education. The facts remains that African history has constantly affirmed the existence of the knowledge of physical sciences among indigenous people of African origin wherever they found themselves. This knowledge, indigenous knowledge, has sustained African indigenous people for centuries, even before the adventure of Europeans on the African soil. Evident in history of recent past are the use of physics concepts by indigenous people of Africa; such concepts as the use of levers to move heavy object, the smelting of ores, the understanding of the cosmos, the stars, the phases of the moon, the sun, the solstices and the seasons and the interconnectedness of the heavenly bodies and natural phenomena and the concept of time. The question is why has Eurocentric science ignored and continue to ignore the roles of indigenous knowledge in the field of physics and its education? Why has indigenous physics and physics concepts not been part of the physics curriculum, especially, in Africa schools? Why have physics teachers continually neglect to include indigenous knowledge in their teaching of physics? In this conference, physics teachers and academic staff members will be challenged and engaged in articulating how indigenous knowledge can be used in the teaching and learning of physics concepts in the science classroom. The post-apartheid school curriculum (NCS, 2005 and CAPS, 2011) have mandated that in teaching the science, (including physics), teachers must incorporate indigenous knowledge so that the 300 years of such knowledge existing within the indigenous community, in South Africa, and by extension, Africa be not lost, despite the marginalization of indigenous knowledge by westernized science. Also, in the wake of the clarion calls to decolonize the university curriculum including the teaching and learning of sciences, physics included, in the midst of the often hostile culture of science, it is imperative that the teaching of the sciences, including physics must as of necessity must be transformed. Without that, the success/pass rates of learners will continue to be low. It has been established in the literature that students' cultural beliefs affect the ways they learn.

Parallel Session 1 / 150

Active learning, student numbers, and formal session attendance in Statistical Physics III at the University of the Witwatersrand

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Active learning techniques have been employed in teaching the Statistical Physics III module (final year undergraduate level) at the University of the Witwatersrand since 2009, and have proved very effective. This is evidenced by the excellent pass rates, increased class averages, and obvious retention of the core knowledge presented in the course. More recently (since 2015), enrolment for the module has doubled from approximately 25 students to approximately 50 students, leading to a statistically significant drop in the class average for the module. A re-examination of some of the active learning strategies employed has been ongoing following the increase in student numbers. It has become evident is that the percentage attendance at formal lectures has decreased visibly. This can be seen in both 2nd Year and 3rd Year modules in the Physics major stream, and the literature indicates that this is by no means limited to Physics, or to South African Universities. This paper will report on the core active teaching strategies employed in the module, the changes that have been made to the implementation of these strategies to accommodate the increased numbers, and the measures introduced to combat the tendency to for students to miss formal teaching sessions.

Poster Session / 151

An assessment of students' understanding of Newtonian Mechanics

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The Force Concept Inventory (FCI) pretest [1] comprising of 30 multiple choice questions was administered at the commencement of the academic year to ~950 First-Year Engineering students registered for a full-year Mechanics course. The purpose of the diagnostic assessment was to acquire information on students' prior knowledge of their understanding of basics concepts of Newtonian Mechanics. In addition, this instrument has been utilized to ascertain areas of weakness in students' understanding which could be targeted during the academic year and to evaluate the possibility of applying the test to assess the effectiveness of instruction. The class attained a weak average mark of 33% which is similar to results reported in [2]. The collective responses for individual questions have been evaluated and will be discussed in terms of students' misconceptions.

In order to ascertain whether the FCI data gives evidence of any correlation to interactive classroom activities, the results of the first class test based on dimensional analysis, force vectors and vector operations in vector geometry and vector algebra formulation were compared with the FCI responses. We found a roughly linear correspondence with R2~0.16. The classroom activities included the use of "clickers" in the majority of lectures coupled with more focused co-operative group work in tutorial sessions. The class average was for the test was ~53% and the pass rate in the region of 56%. Although the test coverage was limited to a very small basic component of Mechanics, a refined analysis shows that students who performed well in the FCI test also produced good class test results – amongst students who got 60% or more for the FCI, the pass rate for the class test was ~88% and of the students who failed the class test, only ~3% attained 60% or more for the FCI. Conversely, competence in the class test was not strongly correlated with the FCI test – of the students who passed the class test, only ~16% achieved 60% or more for the FCI while the class test pass rate amongst students who obtained less than 60% for the FCI was 52%. It should be noted that students in general performed much better in the class test. In order to validate these preliminary findings, upcoming class tests and examinations scores will be compared with the FCI test results. The impact of teaching and learning will be re-evaluated by conducting a FCI post-test after the completion of the syllabus on statics and dynamics.

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Poster Session / 152

South African science students' perceptions of physics as a fundamental discipline

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Meaningful development of scientific literacy is underpinned by coherent acquisition of scientific skills. The development of physics knowledge in particular hinges to a large degree on cognitive and affective factors. In light of this key imperative, students' perceptions of physics as a fundamental discipline were established through the administration of Physics Anxiety Questionnaire with first year science students at a South African university. The questionnaire provided a meaningful platform to identify students' perceptions in relation to various aspects such as physics experimental work, mathematical knowledge required to navigate physics studies, physics problem-solving, application of physics general knowledge in daily life as well as the concomitant integrated assessment of physics skills and knowledge in various instructional settings. Key findings of the study strongly suggest that the acquisition of physics skills is crucially dependent on a conflation of cognitive and affective factors forming an integral part of the learning process. Theoretical implications for meaningful development of scientific literacy are discussed.

Parallel Session 1 / 153

Teaching and Learning Approach - Concepts and Quantitative Tools

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Over a number of decades, different versions of the textbook: Fundamentals of Physics by Halliday and Resnick with built-in concepts was utilised for the Physics I Major introductory calculus course. Since 2016, a new textbook: Principles and Practise of Physics by Eric Mazur [1] centred on conceptual understanding and quantitative skills was implemented as a new teaching and learning approach for lecturers and also to students whom have been exposed to conventional methods and structured curricula in particular at first year level. The organization of the contents in the text-book by Mazur uses a range of research-based instructional techniques different from other textbooks. The supplementary features include Mastering Physics and an Interactive eText with an integrated, conceptual understanding of physics with problem solving activities ranging from on-line tutorial exercises with hints and feedback, assignments and quizzes.

In order to probe the effectiveness of the textbook, the teaching approach and students experiences, and a course evaluation was administered to ~200 students comprising of the following survey questions:

- The course was extensive in its coverage of subject matter.
- The course is well structured.
- The course was pitched at the correct level.
- Problem solving exercises reinforce the material presented.
- The textbook is easy to read and understand.
- I found that the pace of the work is appropriate.
- Student participation during lectures should be increased.

The data obtained from this survey will be presented and discussed to provide insights into the new approach of teaching and learning adopted for the above mentioned course. In addition, selected examples of concepts and quantitative tools will be highlighted.

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Plenary / 155

Adapting RealTime Physics for Distance Learning with IOLab - A Final Report

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The IOLab is a versatile, relatively inexpensive data acquisition device developed by Mats Selen and his colleagues at University of Illinois (1). It is self-contained in a cart that can roll on its own wheels, and it includes an optical encoder that measures motion quantities and a force sensor. It also contains sensors to measure a variety of other physical quantities. With a current cost of around $100, students can purchase their own individual device (like a clicker) and can-in theory-use it to do hands-on laboratory, pre-lecture (flipped classroom) and homework activities at home. We report on the results of a project (2) to develop distance-learning (DL) laboratories using the IOLab. We have adapted RealTime Physics Mechanics (3,4) labs for use with the IOLab and tested them in supervised laboratory environments and in distance learning mode at Portland State University and Chemeketa Community College. We will describe the labs and lab environments, and the significant FMCE (5) conceptual learning gains.

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Plenary / 156

If Physics Education for Development is the Question, Black women are the answer!

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Drawing from the conference theme, Physics Education for Development: a focus on context, I propose for this talk that we look at the role of women, particularly women of color, for the sustainable development of communities. There are several experiences of socioeconomic development programs around the world that focus on women for the programs' success. Similarly, businesses companies have found that profits increase when they invest in an inclusive and diverse workforce. Thus, scientific endeavor, and physics education, in particular, should consider the role of women and historically underserved or underrepresented populations when the goal is development. I will argue Physics lacks diversity and this could be hindering our progress. In general, we teach a physics that is usually disconnected from people's experiences, lacking role models that look like our students, and that is made somewhere far away - either geographically or in time. Increasing diversity in physics through women and underrepresented groups can be one way to help us creating and promoting a new and more inclusive Physics. I hope to share some ideas that support us to get there!

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Educational technology for physics: what's useful? And how do we generate it?

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My theoretical physics research is in ultracold gases, where the phenomena are predominantly quantum mechanical. My novel results have been discovered and analysed via computer algebra. This understanding of the power of computer algebra has transferred to my education practice - where it enables my team and I to design mathematically based questions that can be automatically marked. These questions better probe the depth of understanding than normal multiple choice, by enabling free form mathematics to be entered as the answer. But which questions? The choice and implementation is undertaken by summer student interns, and I will discuss how one harnesses their imagination and understanding of their peers' needs
whilst ensuring that materials they generate are properly quality assured to be released to whole classes.

And finally, how about equality? If the questions are to be inclusive and relevant to all we need to ensure we have an inclusive team writing them. Hence, I will discuss the importance of the student recruitment process.

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Co-Creating Inclusion in Physics: Learning from What Helps Women of Color Thrive

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Centering marginalized voices has long been a tool for critiquing mainstream institutions and individual practices by feminist theorists and critical race scholars. In this paper, I will present findings from Centering Women of Color in STEM: Identifying and Scaling Up What Helps Women of Color Thrive (CWCS). The project studies predominantly white physics departments in which women of color thrive. Our ultimate goal is to provide insights into how physics spaces that were not created for women of color can become more welcoming of them, and thereby increase the success of all students.
In doing this work, our team considers broader notions of race and gender intersectionality via explicit engagement with ideas of family and identity beyond those traditionally considered. We use the Athena SWAN and Race Charter criteria to address inclusion in higher education through a robust engagement with the broad spectrum of gender and race expression. We apply Patricia Hill Collins' Domains of Power to situate our findings, and point to opportunities for intervention (Collins, 2009; Johnson, 2018). Findings from CWCS challenge us to co-create learning environments where excellence and inclusion work together, evidence of what inclusive environments look like. I invite audience members to consider how they can contribute to increased inclusion in their home institutions based on what they learn here.

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Physics education for 21 st century graduates

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The century in which today's students are growing up is different in a number of important ways from last century. This includes ubiquitous and increasingly sophisticated technology, climate change, globalisation, and the concentration of the bulk of the world's wealth in the hands of an ever-decreasing percentage of its population. And then there was the great recession of 2008. Taken together, these things impact on students' thinking patterns, behaviours, expectations, constraints and opportunities. Broad global developments, such as the fourth industrial revolution, the United Nations Sustainable Development Goals, as well as the recent rise of so-called fake news and popular rejection of evidence-based thinking, frame the context for what we can and must do in educating our students.

So what are the implications for Physics and Physics teaching? Physicists have always taken pride in the fact that we acquire ways of thinking and solving problems that have broad applicability. While that may be true, no human endeavour can ever be divorced from context. How is the teaching of Physics being affected by the global context, and how can Physics teaching contribute to addressing global challenges? In this presentation, I will make some suggestions, in broad terms, of what we ought to be teaching, what the key characteristics are of who we are teaching, and how we should teach
in order to equip our students to be successful 21 st graduates. That means being able to navigate the complexities and uncertainties of a turbulent world, today and tomorrow, and, we hope, contribute to making it a better place for all of its inhabitants.

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Blurring the classical-quantum divide

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Interference, the quintessential property of wave optics, is a venerable topic that spans centuries of study, influencing how we understand both the classical and quantum worlds. Infact, little has changed since the seminal work of Young with his double slit experiment, performed even to this day in much the same way as he did it. In this talk we will revisit the central paradigms in classical and quantum interference and show how they can be bent, in some cases broken, and how this influences the way we teach such topics. We will outline through simple demonstrations that interference may be observed in places one may not think to look, that quantum entanglement may be demonstrated with purely classical light, and that much of quantum mechanics can be taught in a practical manner without the need for complicated single photon experiments. In the process we will provide a complete resource for DIY experiments that incorporates modern digital tools with 3D printed components to bring the concepts alive in the laboratory.

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Developing representational competence in first year physics: Implications for curriculum and classroom practices

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Physics educators recognise that successful introductory physics learning depends on understanding and using the various 'representational modes' (i.e. semiotic systems) (see Airey and Linder 2017) which are characteristic of the communication practices in physics (for example, specialised language, symbols, graphs, sketches, diagrams, mathematics, and gestures). Physics Education Research has demonstrated that the explicit use of multiple representations in undergraduate physics teaching is important for helping students learn the 'disciplinary discourse' (Airey and Linder 2009; Lemke
1990, 2004) of physics, and thus explicitly shift the physics education focus to
learning to 'think like a physicist' (van Heuvelen, 1991). It has been argued that this can be achieved through creating a 'representation-rich learning environment' (for example, see Rosengrant et al., 2009: 010108-2), which focuses on helping students learn and understand how to appropriately use physics representations; to appreciate why certain representations are useful, and to see the epistemological underpinnings of these representations, thus developing students' 'meta-representational competence' (for example, see Kohl and Finkelstein, 2008: 010111-11).

In this presentation, I discuss two different pedagogical approaches used in introductory physics courses; one more traditionally oriented and the other oriented towards developing students' 'representational competence' (see, Linder, Airey, Mayaba and Webb, 2014). The theoretical framing for this study draws on a particular Semantics perspective that was developed by Karl Maton at the University of Sydney, as part of his Legitimation Code Theory (Maton, 2014). The study examined how pedagogical approaches have an impact on the way that students approach physics problem tasks. The results illustrate how the adoption of a pedagogical approach that is based on an explicit unpacking of content through pedagogically designed 'moves' (Conana, 2016) between representations that includes making their underlying 'epistemological commitments' (Hewson, 1985) transparent, led to more sophisticated approaches being adopted by students when tackling physics tasks.

Finally, I will discuss what I see being the usefulness of the methodology used in the study for providing rich educational insight into ways that curriculum and classroom practices that I argue can make a meaningful difference when seeking to generate optimal ways of supporting student learning in the challenges that they meet in undergraduate physics courses.

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Embracing the interconnectivity of people beneath the night sky: Where physics and culture meet

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In Canada, like many other countries around the world, there has been an increased call for incorporating Indigenous knowledges within physics, and physics teacher, education. Coupled with this are dedicated efforts to foster learning environments where students grow to become problem solvers not only for physics-based problems, but for societal problems as well. Physics education, at all levels, and within formal and informal settings, is being reconstructed to increase the relevance and resonance of physics content matter for students on personal, community, and global levels. It is from this launch point that physics is now being taught and learned through lenses of multiple perspectives, modalities, cultures, and social justiceand awareness. As such, a focused effort to introduce andragogical and philosophical approaches beyond the traditional methods of physics education is underway.

Through the contextual sharing of global and Indigenous star-lore and sky-lore legends and lessons, this talk will weave stories of ethnoastronomy of the aurora and constellations as an exemplar of assist learning about the globally shared night sky. It is through this vision that the hope of sharing and learning these stories in physics with our current and future students can create a better world.

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WHAT DOES EMOTIONAL ENGAGEMENT OF UNDERGRADUATE STUDENTS WITH EXPERIMENTS DEPEND ON?

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Introduction

Students' emotional engagement is one of the important factors to be considered in Physics Education Research. Our study aims to investigate the role of colour, and the inclusion of a history of science context in generating students' emotional engagement (Stinner, 1993). We have tried to engage students emotionally with thermal physics through anexperiment.

Research question

Do students emotionally engage in the experiment if colours and a history of science context are included in the experiment notes?

Methodology

We constructed an 'intervention' experiment on thermal physics. This was a guided inquiry experiment with clear instructions. Students were explicitly asked to discuss, analyze and interpret. We included a colourful story on the 'History of Heat' in the introduction of the experiment. The 'control' experiment on 'ultrasound waves' was written in a standard manner and was not modified. We designed a survey of 19 items based on Peixoto et al. (2015) and four open-ended questions. The surveys were given to the students of both the 'intervention' and 'control'groups.

Data Collection

This study was done over three weeks of laboratories for 1st year 1st semester regular undergraduate students at the University of Sydney. The data collected were 1) observational field notes 2) surveys 3) logbooks. Surveys were collected from 339 students, 190 forthe 'intervention' and 149 forthe 'control'.

Results

Our preliminary results indicate that students were more emotionally engaged in the 'intervention' compared to the 'control'. Some quotes were:
"fantastic! It affected me in a very positive way, enlightening not only me but my fellow peers in the field of thermal physics"
"excellent with description and picture"
"very easy to follow, fun and much clearer instruction" Comprehensive
data analysis will be presented at the conference.

Conclusion

Our study shows that a simple change in the way experiments are presented to the students results in improved emotional engagement; students reported that the experiment was easier to understand and more enjoyable.

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Using spreadsheets to improve student engagement in the laboratory

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This paper explores whether the integration of digital technologies in the form of a spreadsheet can be used to improve students' engagement with experimental work. In addition, the experiment was presented as an open inquiry investigation. The experiment, investigation was about electricity and power consumption, Vampire Power. Using Design-Based Research methodology, in Trial 1 we ran an open inquiry investigation with 41 teachers and 58 students in 4 workshops. In Trial 2, digital technology, an Excel spreadsheet, was integrated into the investigation and deployed with 25 teachers and 38 students in 2 workshops. In Trial 3 the same investigation as in Trial 2 was deployed with 29 teachers and 85 students in 3 workshops. Measures of 'mental effort' and 'attitudes' indicated that, in Trial 1, teachers invested mental effort and showed positive attitudes, but students did not. In Trial 2, both teachers and students invested mental effort and had positive attitudes. Trial 3 results were similar to Trial 2. We conclude that harnessing digital technologies, spreadsheets specifically into an open inquiry investigation improved student engagement.

Parallel Session 2 / 165

AssessING laboratory SKILLS: SHARING something WE TRIED THIS YEAR

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PROBLEM

The teaching of experimental physics in laboratories is central to any physics course. Through the teaching of experimental skills, students learn to produce scientific knowledge following scientific methods, by developing expertise in identifying and designing experiments, critical thinking and problem solving skills, the capability to analyze scientific findings and to communicate them effectively to the scientificcommunity.

However, in articulating the big picture, we must not lose sight of the basics of experimental work: students taking actual measurements and using equipment, analyzing data, and interpreting and connecting with knowledge. This was articulated by Kirkup (2009) who says `Experimentation is at the heart of science... Many of the skills required to convert theory into reality and to explain measurements are learned through... a methodical and systematic approach to solving experimental problems and analyzing experimental data.' Richardson, Sharma and Khachan (2008) capture the development of these basics of experimentation as 'levels of sophistication'.

In our work, we have gone back to the basics and are incorporating these fundamental skills into our lab program, strategically utilising these to teach the broader skills such as critical thinking. Together with teaching the basics, we have developed and implemented tools to test whether students are actually acquiring them.

ACTION

We have introduced a new model for assessing student laboratory learning. Three learning outcomes are identified for each lab: an experimental approach, an analysis of the data acquired, and interpretation of the results in the light of theory. Over the semester, students practice this threefold approach to experimental work in each of eight separate experiments.

These skills are then assessed in three separate assessment tasks: an individual practical test, which tests the students' ability to perform an experimental investigation; a paper-based test which tests student's understanding of analysis and uncertainties, and a short lab report, which tests students' ability to interpret experimental data to address an experimental aim. The novelty of this approach is that we are assessingthe process of experimental work, instead of the outcomes.

OUTCOMES

We introduced this model during semester 1 2018 in Junior Physics at the University of Sydney. We involved our lab tutors as partners in the development and implementation phases. This presentation will discuss our experience with the introduction of this new assessment model for experimental lab. Our initial results suggest that students are mastering the skills they need, and that this mastery is noticeably better once explicit assessment of the skills is introduced. We will discuss feedback from students and tutors, as well as how we can improve the schemes in future semesters.

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Parallel Session 2 / 166

Riddles in VERITASIUM: Making sense of how students reflect

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Reflection

"Reflection enables us to correct distortions in our beliefs and errors in problem-solving" (Mezirow, 1990). The importance of reflection in education has been noted as far back as 1910 in John Dewey's book "How we think". According to Dewey, there are 6 phases of reflection.1. an experience;

2. spontaneous interpretation of the experience; 3. naming the problem or the question that arises out of the experience; 4. generating possible explanations for the problem or question posed; 5. ramifying the explanations into full-blown hypotheses; 6. experimenting or testing the selected hypothesis. (Rogers, 2002) Reflection is also an integral part of metacognition including self-regulation in learners (Ertmer and Newby, 1996, Bewes and Sharma 2011).

Intervention

Derek Muller of the physics education channel "Veritasium" uploaded two videos, the first of which asked four physics riddles, and the second answered these riddles. These video mirror the stages of reflection outlined by Dewey. These two videos were shown to first year physic students at the University School of Physics. The students watched the first video, and were prompted to write down their answers, and the confidences in their answers. Then they watched the second video, and answered if they did/or did not change their mind, and why. The total sample size was 548 first year physics students.

Categories

The answers were coded qualitatively, and fell into distinct categories, which match Mezirow's (1998)taxonomy of critical reflection.

The categories were "Almost", "Alternative Solution", "Issues", and "Self". "Almost" "Alternative" and "Fault" all match Narrative Critical Reflection On Assumptions (CRA), outlined by Mezirow, and "Self" matches Narrative Critical Self Reflection on Assumptions (CRSA). The question had a profound impact on the types of reflection triggered. The detailed analysis will be presented at the conference.

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ICPE-SAIP-WITS 2018 Conference Proceedings: Author guidelines, submission and review procedures

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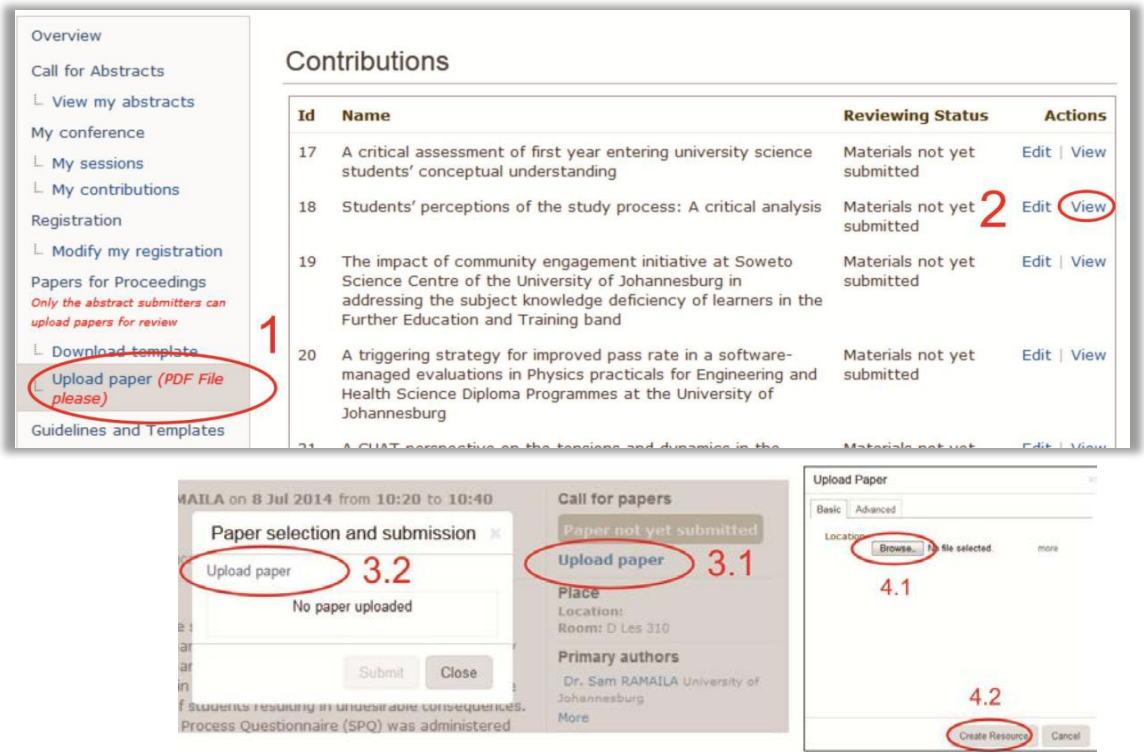

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