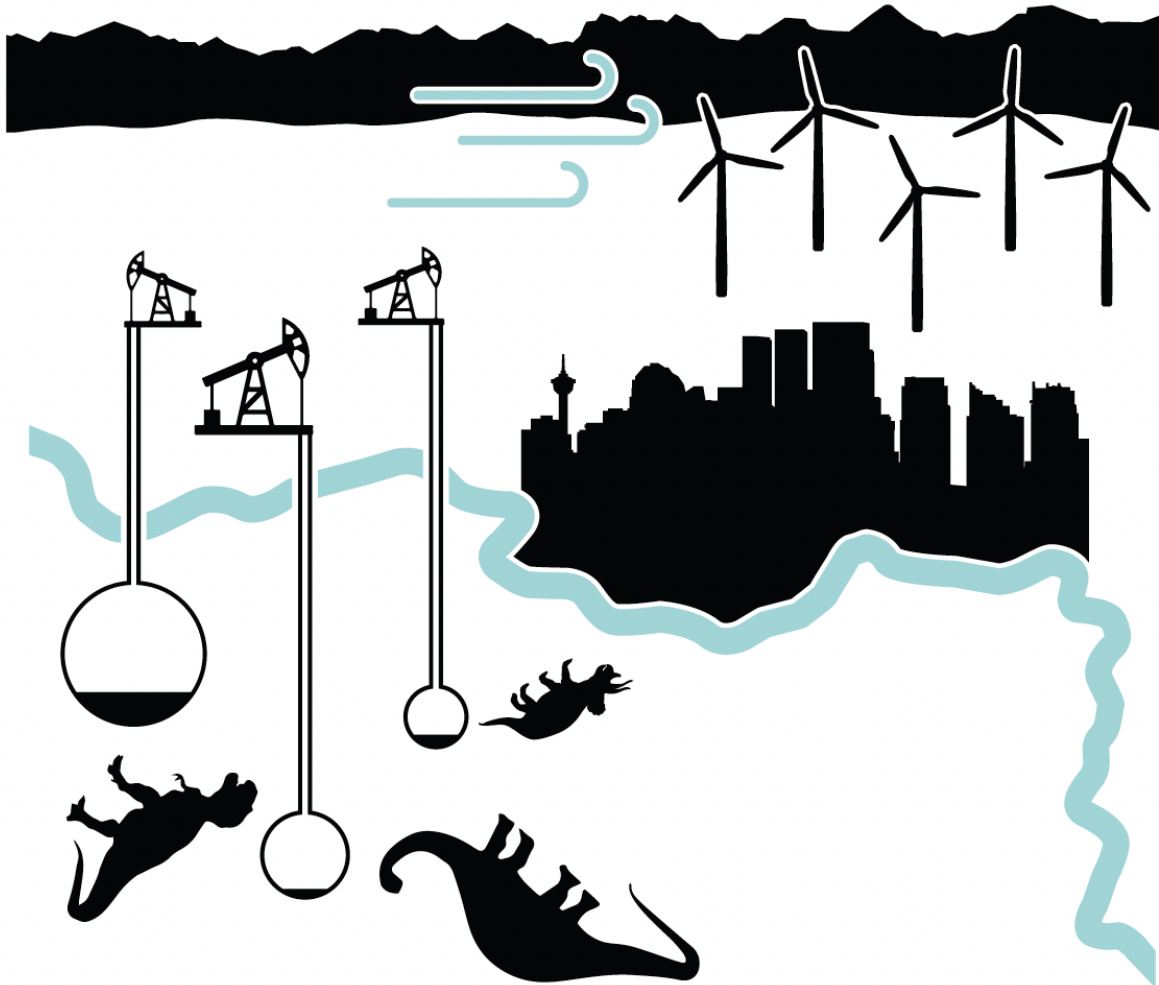
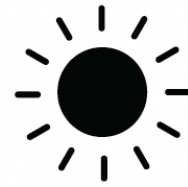


16TH BIENNIAL IHPST CONFERENCE

**UNIVERSITY OF CALGARY
CALGARY, ALBERTA, CANADA
JULY 3-7, 2022**



ENERGIZING* *EDUCATION

WITH THE HISTORY, PHILOSOPHY & SOCIOLOGY OF SCIENCE

IHIST

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The University of Calgary campus community appreciates the opportunity to live, study and work on the traditional territories of the people of the Treaty 7 region in Southern Alberta, which includes the Blackfoot Confederacy (comprising the Siksika, Piikani, and Kainai First Nations), the Tsuut'ina First Nation and the Stoney Nakoda (including the Chiniki, Bearspaw, and Wesley First Nations).



Taylor Institute for Teaching and Learning (TI)
434 Collegiate Blvd NW, Calgary, AB, T2N 4V8

May 31, 2022

Re: 16th Biennial IHPST Conference
University of Calgary

Dear Conference Delegates:

It is a great honour to welcome you to the Taylor Institute for Teaching and Learning, at the University of Calgary, for the 16th Biennial IHPST Conference. In my role as Senior Director of the Taylor Institute for Teaching and Learning (TI), I lead nearly 50 faculty, staff and students as we work to strengthen teaching and learning cultures, communities and practices. It's been a challenging time for higher education. The global pandemic has dramatically disrupted how we experience teaching and learning. It has brought continued uncertainty, complexity, and fatigue, and has also inspired us to think differently about how we meaningfully connect with students, colleagues, and the communities which surround us. It is an important time to step back and explore the theme of "Energizing Education."

Inspired by the work of Roxå & Martensson (2009) we recognize that the small, but significant conversations we have with trusted colleagues can have a transformative impact on our learning and growth as educators. Through our physical spaces, programs, and communities, we create meaningful opportunities to link networks and to encourage knowledge exchange, collaboration, and relationship-building. The spaces that surround you are inspired by the foundational principles of collaboration, flexibility, and transparency. These principles encourage us to connect meaningfully with colleagues, to explore and adapt to new possibilities and experiences, and to share and make visible our work and learning. We hope your time here brings many opportunities for significant conversations about teaching and learning that continue to energize your discussions and work together.

Sincerely,

A handwritten signature in black ink, appearing to read 'Natasha Kenny'.

Dr. Natasha Kenny, PhD
Senior Director, Taylor Institute for Teaching and Learning
nakenny@ucalgary.ca

Roxå, T., & Mårtensson, K. (2009). Significant conversations and significant networks—exploring the backstage of the teaching arena. *Studies in Higher Education*, 34(5), 547-559.



FACULTY OF SCIENCE

Department of Geoscience
2500 University Drive NW
Calgary, AB, Canada T2N 1N4
geoscience.ucalgary.ca

20 June 2022

I am pleased to extend my warmest greetings to everyone attending the 16th Biennial IHPST (International History, Philosophy, and Science Teaching) Conference. This event provides an important interdisciplinary platform for researchers, historians, sociologists, philosophers, educators, and students to collaborate, share insights, and find answers to issues facing science education today.

The timely and incredibly important theme of this year's conference is, "Energizing Education with the History, Philosophy, and Sociology of Science." At the Faculty of Science and the University of Calgary, we have taken a leadership role in developing the ground-breaking energy innovations the world so urgently needs. From problem-driven research to tech transfer and commercialization, our scientists and grads are focused on creating solutions for a sustainable future in Calgary and the world.

The IHPST Conference is a perfect gateway for transdisciplinary scholarship that continues to break down siloes in the pursuit of new ideas and knowledge. All my best wishes for meaningful discussions with your peers and a very successful 2022 event!

Sincerely,

Dr. Kristin Baetz
Dean, Faculty of Science
University of Calgary

General Schedule

All Times are in Mountain Daylight Time (MDT)

	Sunday 3 July		Monday 4 July	Tuesday 5 July	Wednesday 6 July	Thursday 7 July
8:30			Concurrent Sessions	Concurrent Sessions	Concurrent Sessions	Concurrent Sessions
9:00	Executive Board Meeting	Graduate Summer School				
9:30						
10:00						
10:30						
	Room for 12	Room for up to 20	coffee	coffee	coffee	coffee
11:00			Plenary	Business Meeting	Plenary	Concurrent session
11:30			Dr. Pablo Kreimer Entire group	Entire group	Dr. Carol Cleland Entire group	
12:00			Lunch	Lunch	Lunch	Final Session
12:30	Regis- tration		On your own	Adjacent food court		Entire group
1:00			Concurrent Sessions	Concurrent Sessions	Poster Session 5 min	Science & Education Editorial Board Meeting
1:30			4 rooms	5 rooms		
2:00			coffee	Heritage Park and conference dinner.	coffee	
2:30			Concurrent Sessions		Editor's session	
3:00			4 rooms		Full group	
3:30			coffee		coffee	
4:00			Concurrent Sessions		<i>Formations</i> Original Dramatization	
4:30					University Theater	
5:00	Opening Session (Entire group)					
5:30						
6:00						
6:30	Reception Entire group					
7:00						
7:30						
8:00						

Orientation to Session Presentations

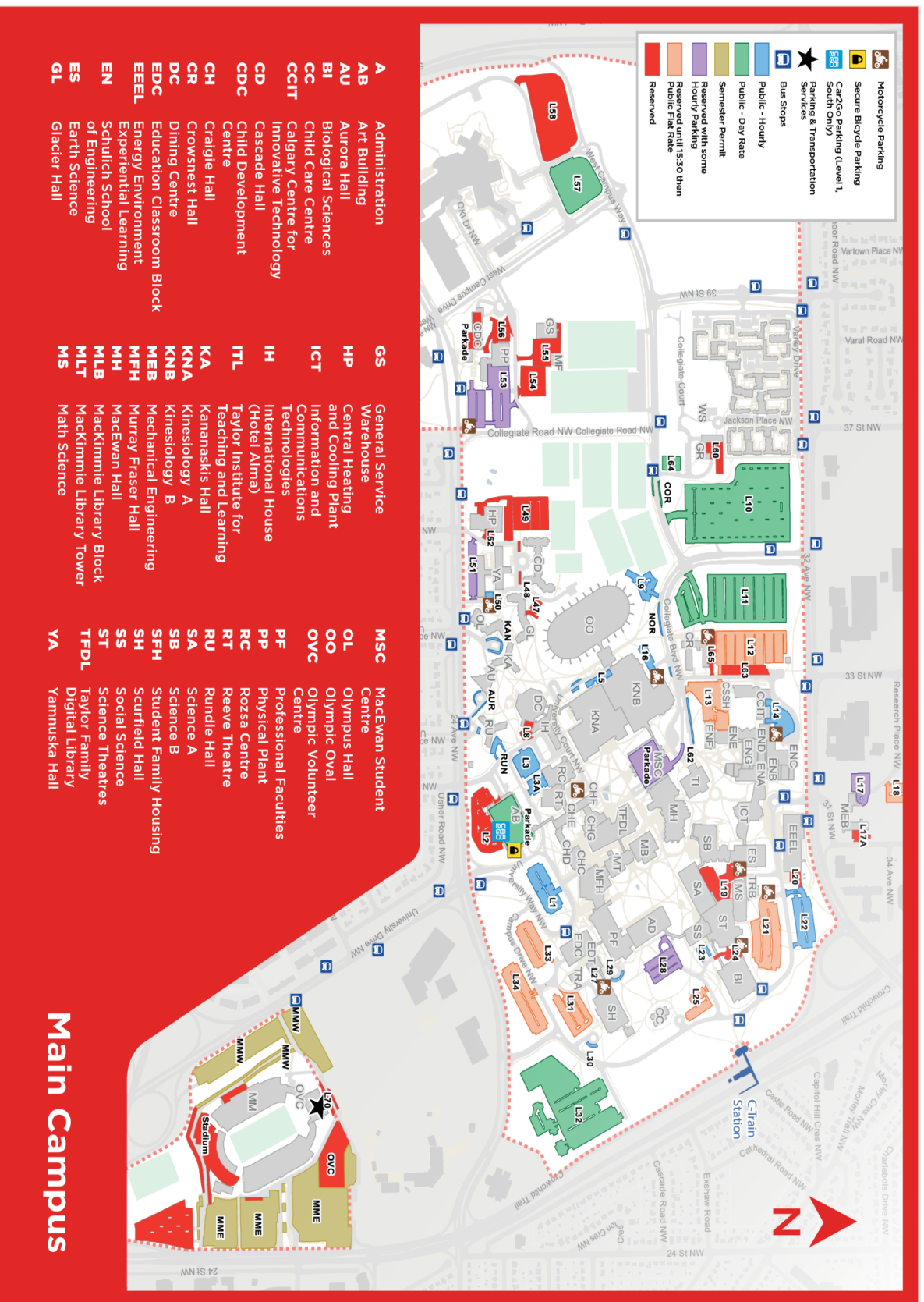
- All in-person presentations must be uploaded to the university computer in the room where the session is taking place, at least 10 minutes prior to the beginning of the session.
- The last presenter of each session will be the session chair. They will introduce speakers, keep time, and manage question periods.
- Regular paper presentation sessions (3 papers per session) will follow the structure:
 - 20 minute presentation
 - 10 minute questions/discussion
- If a speaker does not show up at the appropriate time to present, they forfeit that time slot. It is important to leave that space open. Discussion of the previous paper can continue or the group may take a break, but the intended schedule must be adhered to out of fairness to those who may wish to view a particular presentation that is scheduled at a particular time.
- The Zoom call will be started by a conference volunteer. The volunteer will make sure that the “screen share” function is activated so that remote participants will be able to view each presentation.
- Presenter **MUST** use a microphone during their presentation for remote participants to hear.
- Remote presentations will already be uploaded to the computer desktop. The session chair will make sure to organize the presentations (both PowerPoint presentations for in-person participants and pre-recorded videos for remote presentations).

Healthy Conference Management

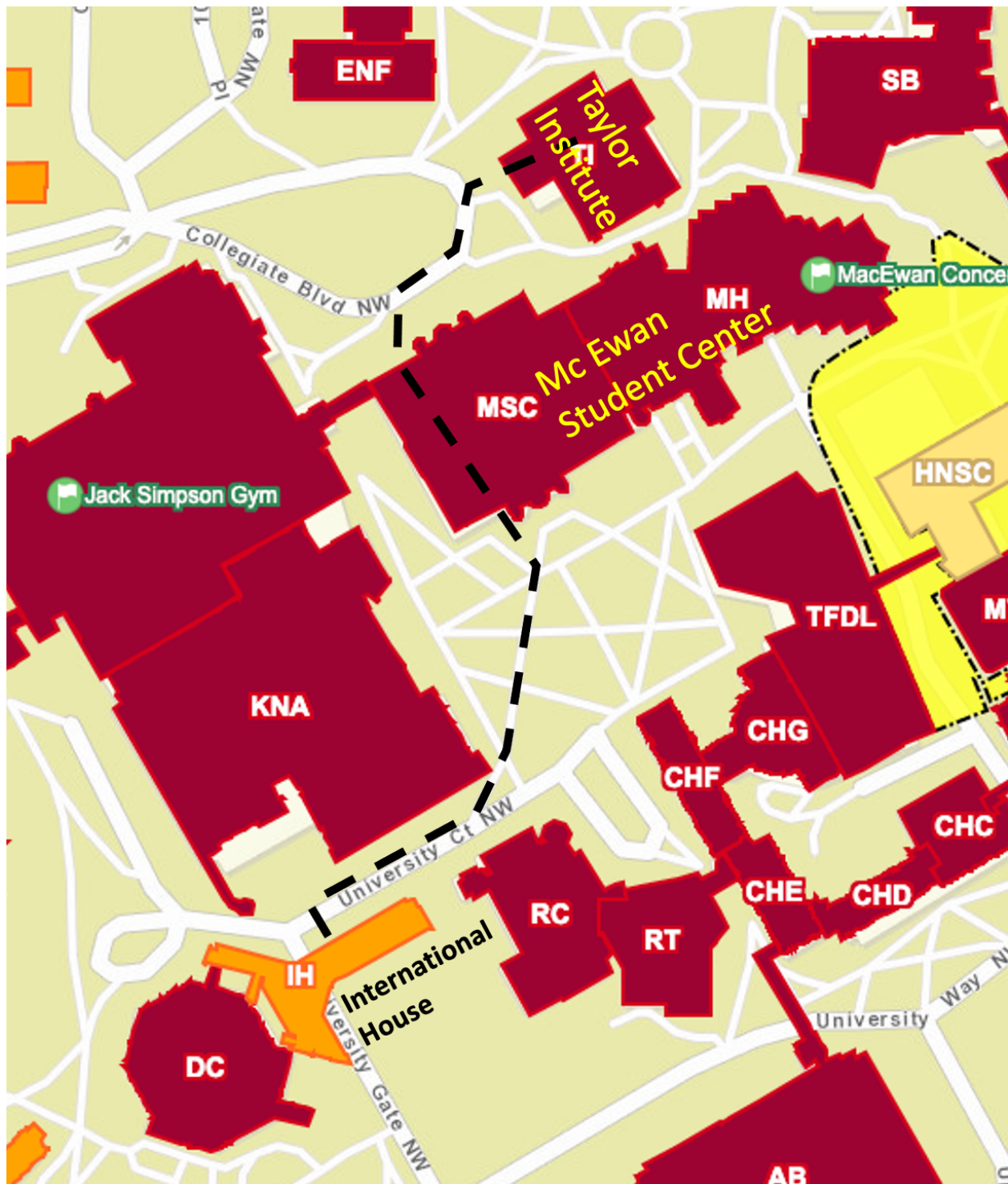
We are all very happy that you could come to Calgary to enjoy the weather, the hospitality, and the intellectual stimulation. However, we need to keep mindful that there is still a dangerous virus causing sickness and death globally. It is the intent of the conference organizers that everyone maintains their good health while participating in the conference. To maximize this for everyone we will ask that you abide by the following protocols:

1. Masks are no longer required on University of Calgary campuses, as of May 1 2022. Masks are still strongly recommended for use on campus, and everyone should feel comfortable continuing to wear a mask. For more information see: [Masking on campus](#). You will receive multiple individually wrapped masks for your own use.
2. If you or anyone in your household has a fever, cough, sore throat, runny nose or shortness of breath or have tested positive for COVID-19 recently, please do not attend the event. If you are an employee or student, please refer to the [COVID-19 Isolation Guidance for Employees and Students](#). Registered participants who are unable to attend the conference, can attend virtually. If you would like to attend virtually, please contact: Glenn Dolphin (glenn.dolphin@ucalgary.ca)
3. You will also receive a box of 5 rapid antigen COVID tests. This is for your convenience and you are not required to test during the conference, but if you are feeling symptoms, this is one more tool for understanding your health conditions.
4. For those who will need a COVID test prior to travel back to your home country, we have arranged with a pharmacy on campus to perform a rapid antigen test and give documentation of results to be presented to airlines as necessary. Please check to see what the requirements are for your specific country. There is also a [lab at the Calgary airport](#) that will conduct testing for passengers (including PCRs). You must contact them to make arrangements.

Help us support a healthy campus by following public health measures, practicing good hygiene, and continuing to act responsibly. Thank you for your cooperation and we are happy to see you at the 2022 IHPST conference.



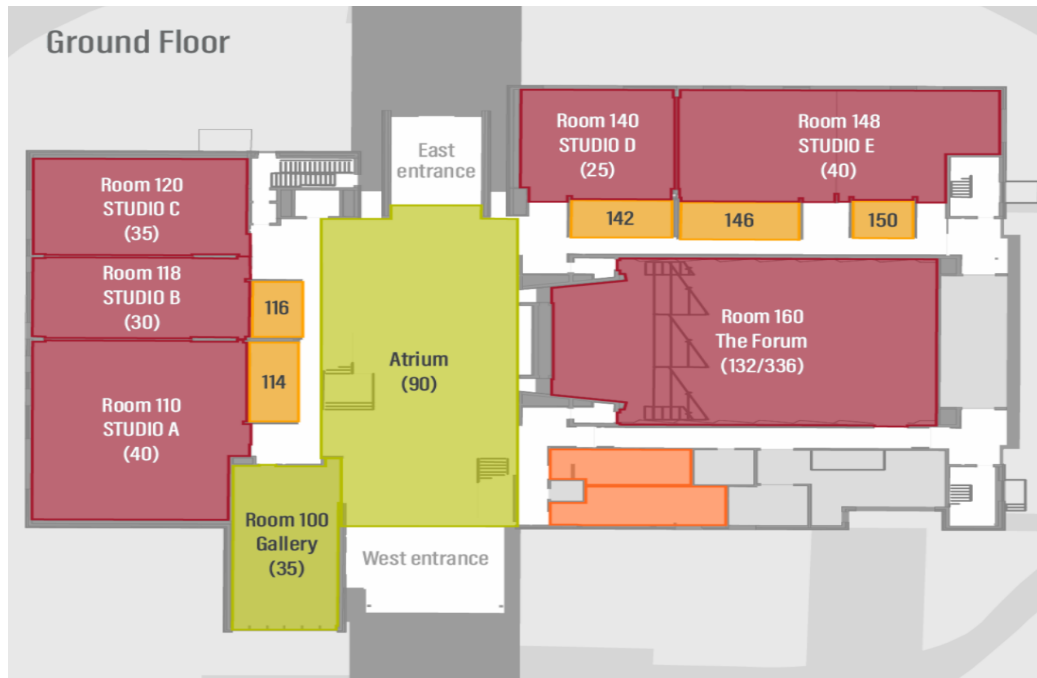
The Taylor Institute for Teaching and Learning is the venue for the entire conference



Getting to and from the Taylor Institute from the International House.

Use this link to find an interactive room finding map

<https://www.ucalgary.ca/about/our-campuses/campus-maps-and-room-finder>



Taylor Institute Floor Plan

Virtual social gathering space

Dear IHPST 2022 Participants,

We have created two virtual online coffee/social rooms using Gather.Town for the conference.

Gather.Town is a web-conferencing software platform like Zoom but with the added functionality of seeing the virtual “room” you and others are occupying and the ability to move around and interact with other participants based on your locations in the room, just like real life.

You have an icon representing you that you can move around the “room” using the “WASD” keys or the “arrow” keys on your keyboard. You will be able to speak to anyone else in the room who is close to you.

Here is a 4-minute YouTube video explaining how to get started with the basics in Gather.Town:
<https://www.youtube.com/watch?v=89at5EvCEvk>

The links for the two rooms are below:

<https://app.gather.town/app/cDdMMQdU5yJXETN3/IHPST%20Social%201>

<https://app.gather.town/app/WYvx7iVsd6leSbVr/IHPST%20Social%202>

Password Calgary

The rooms will always be open, and so you might arrange to talk with people whenever, but the official coffee hours, reception, and lunch times in the schedule will be the official times to come

and meet other people. Each room holds up to 25 people at a time. Start by trying to join the first room, and if it is full try joining the second room.

We look forward to seeing you at the conference online or off!

Sincerely,

IHPST 2022

Ps. There are also some games you can play with others in the room if you interact with the tables by moving close and clicking your X key (for Pictionary you will create a game in Skribbl.io and share the code with other players).

PPs. Here is a link to the Gather website with more details about what you can do in Gather and how to do it. You don't need to read it though to get started. Just watch the 4-minute YouTube video and jump right in!

Sponsors

The conference committee acknowledges the tremendous generosity of the following entities for their financial support of this conference.

Tamaratt Teaching Professorship in Geoscience

Calgary Institute for the Humanities

Department of History, Faculty of Arts

Department of Philosophy, Faculty of Arts

Department of Classics and Religion, Faculty of Arts

Department of Community Health Sciences, Cumming School of Medicine

Calgary Science, Technology, Environment, and Medicine Studies Lab

AMF/Hannah Professorship in the History of Medicine and Health Care

Department of Geosciences, Faculty of Science

Werklund School of Education

School of Creative and Performing Arts

Program with Abstracts

All Times are in MDT

Sunday, 3 July 2022

Graduate Student Summer School

1:00 PM–4:30 PM

Room: Earth Sciences Building: ES 121

Sunday, 3 July 2022

Registration 12:00 PM–5:00 PM

Room: International House Lobby

Sunday, 3 July 2022

Opening Session, 5:30 PM–7:00 PM

Taylor Institute for Teaching and Learning (Forum)

Sunday, 3 July 2022

Opening Reception, 7:00 PM–9:00 PM

Taylor Institute for Teaching and Learning (Atrium)

Monday, 4 July 2022

Session 1, 8:30am–10:00 am All Times are in MDT

Studio B

Panel session

**The International Handbook of Physics Education Research (IHPER)
PART 9: THE HISTORY AND PHILOSOPHY OF PHYSICS IN PHYSICS
TEACHING**

Don Metz, University of Winnipeg

The IHPER handbook will be published through the American Association of Physics Teachers (AAPT) and the American Institute of Physics (AIP). The senior editors of the project are Drs. M. Fatih TAŞAR and Paula HERON. The handbook currently will be comprised of 3 volumes, 13 sections and 82 chapters. Of particular interest to the IHPST conference is Section 9: THE HISTORY AND PHILOSOPHY OF PHYSICS IN PHYSICS TEACHING edited by Drs. Don Metz, Peter Heering, and Cibelle Celestino Silva. In this hybrid panel discussion, we will present the nature of the IHPER project and an introduction to the Section 9 chapters. Each chapter will be outlined in a five-minute presentation and a discussion will follow.

The goal of the handbook is to provide a resource that addresses central questions in the area of Physics Education Research. These questions include:

- What has PER contributed to our current knowledge of teaching and learning of physics?
- What would we be lacking today without decades of continued PER?
- How has PER evolved over the decades (in terms of research questions tackled, instruments employed, methodologies used, etc.)?
- What were the major turning points in PER history?
- How has physics teaching and learning changed (improved) over the decades due to the direct impact of PER?
- How has PER benefited from other disciplines (e.g. cognitive psychology, educational psychology, pedagogical research, instructional design research, etc.) and vice versa ?

Monday, 4 July 2022
Session 1, 8:30am–10:am
Studio C

Title: Understanding diversity of scientific methods: The impact of an online intervention on teachers and students

Sibel Erduran, Olga Ioannidou
University of Oxford, United Kingdom

Abstract Epistemic practices have often been characterized as important components of science education (e.g. Chinn & Maltotra, 2002). Despite their pedagogical affordances, strategies of teaching and learning the epistemic aspects of science continue to be an issue of concern among researchers, as well as practitioners. The types of activities that students are engaged in school science often do not provide the opportunities for development of students' epistemic thinking. This paper presents an empirical study investigating how teachers' and students' understanding of scientific methods can be improved. Capitalizing on a theoretical framework on the diversity of scientific methods called Brandon's Matrix (BM) (Brandon, 1994)- a series of online lessons were designed and distributed to 969 secondary students in England. Subsequently, 12 early years education teachers from the United Arab Emirates (UAE) were trained in the context of SciKids Project using resources based on what was learned about the implementation of BM in England. Findings based on statistical analysis of students' responses and teachers' qualitative as well as quantitative data suggest improvements in the cohorts' understanding of scientific methods. These findings demonstrate that teaching approaches that are oriented towards epistemic practices, even in the form of short interventions, can effectively facilitate students' understanding of scientific methods. The findings of the study are particularly important given that students' opportunities to engage in epistemic practices are often limited. Furthermore, this study advocates the use of theoretical frameworks originating from philosophy of science, such as Brandon's Matrix, as effective tools for teaching higher order skills, including epistemic thinking.

Thomas Young: an 'anti-Newtonian' in the 'age of Newton'?

Michelle Mercier
Europa-Universitaet Flensburg

Today, the description of an experiment under the heading *Young's double-slit experiment* can be found in almost every textbook on physical optics, frequently combined with remarks on Thomas Young (1773-1829) and the historical experiment (1807). In the historicized description as usually transported by textbooks, Young is characterized as an 'opponent' of Isaac Newton (1642/43-1726/27).

In 18th century Britain, Newton's works (and possibly his social status) had an immense impact on the development of physical optics. During this period, many scientists mentioned Newton's

works in their publications on physical optics and adopted his ideas or claimed to have extended his work. Certainly, Newton's works were also of considerable importance for Young in the beginning of the 19th century, when he developed a wave theory of light, formulated a principle of interference and carried out extensive experimental work in this regard. However, the connection between Newton and Young is far more complex than the characterization of Young as an 'opponent' of Newton transports. Moreover, it remains completely unclear what role can be ascribed to Newton's writings for the development of Young's (experimental) works on physical optics.

As part of my PhD project, Young's experiments on diffraction and interference were analyzed by using the replication method. Some of experiences (experimentally) made will be described in this talk and argued, that even if Young had rejected Newton's hypotheses on the nature and properties of light, his experimental practice can only be described as in the tradition of Newton.

Key Words: Thomas Young, Isaac Newton, Replication method

**DIDACTIC KALEIDOSCOPE FOR PHYSICS TEACHER EDUCATORS WITH ROOTS
IN THE HISTORY OF SCIENCE AND TECHNOLOGY**
Alvarado-Guzmán, L¹; Malaquias, I²; Nardi, R¹.

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lisbeth.alvarado@unesp.br, r.nardi@unesp.br

²Departamento de Física, CIDTFF, Universidade de Aveiro, 3810-193 Aveiro – Portugal
imalaquias@ua.pt

Abstract The objective of this communication is to bring some elements for the construction and/or strengthening of criteria for the selection and implementation of alternative topics in the teaching of Optics, linking elements of Astronomy, through three exemplary cases of the nineteenth and twentieth centuries, which are: (a) Fraunhofer's experimental work that puts in situation the purposes of experimental practice, the role of manual skills in obtaining experimental results, the relationships between craft and scientific knowledge; b) the problem addressed by Garavito concerning the analysis of light aberration as an argument in favor of the motion of the Earth and the issues on the nature of science associated with communication between researchers, access to publications and possible impacts on scientific and university programs that time in Colombia and c) the work of Antonia Maury on stellar classification and the difficulties faced for her recognition. It is proposed as a model a didactic kaleidoscope that is framed in these three historical cases and their different contexts, generating a multiplicity of images of science and technology, which can bring relevant and current discussions with science teacher educators.

Key Words: Physics teacher educators, History of optics, Didactic kaleidoscope.

Monday, 4 July 2022
Session 1, 8:30am–10:am

Analysis of a didactic activity involving scientific reasoning at the beginning of cosmic rays research

João Pedro Ghidini, Marcelo Gameiro Munhoz, Ivã Gurgel
Instituto de Física/Universidade de São Paulo, joao.ghidini.silva@usp.br

Abstract One of the challenges of curriculum innovation is how to connect the teaching of a new topic considering the contemporary concerns of science education. In this work, we will analyze a didactic activity developed and implemented in the context of a Teaching-Learning Sequence (TLS) on cosmic rays, involving a muon detector, which explores some aspects of the Nature of Science. The TLS was applied in two classes during extracurricular hours with approximately 12 students each, in a Brazilian peripheral public school. Through secondary sources and the works of the philosopher Ronald Giere (1988,1991), we carried out the didactic transposition of the beginnings of cosmic ray research, so that two models were in dispute to explain the electroscope discharge (excluding air humidity): is ionizing radiation terrestrial or extraterrestrial? The activity is centered on scientific reasoning (Osborne, 2013). In this activity, seven cards with descriptions of experimental observations, facts and hypotheses are given to students. Each pair received three sheets where, after reading the cards, they wrote what the cards' contributions are to defending that ionizing radiation is terrestrial or extraterrestrial, comparing at the end the two models. Two weeks after their implementation, we carried out semi-structured individual interviews with approximately 50% of the students and applied a final questionnaire to all. We conclude that in the TLS redesign we will keep the activity, previously seeking to enrich the students' vocabulary, adding more examples of how to take notes and giving greater emphasis to the post-activity discussion.

Key words: scientific reasoning, scientific models, cosmic ray research

Application of Mystery Tube activity to help pre-service science teachers understand models of theory change

Sangwoo Ha, Kyungpook National University (South Korea)

Abstract The value of philosophy of science in science education has long been advocated by science educators. Understanding how scientific knowledge is generated is one key area of philosophy of science that is relevant to science teaching. Research on the nature of scientific knowledge in science education has mainly focused on how it is constructed rather than how it is revised through discussion. In this study, we expanded the classic “mystery tube” activity by including additional steps where initial hypotheses are discussed and revised in groups, to help preservice science teachers understand the models of theory change proposed by Karl Popper, Thomas Kuhn and Imre Lakatos. Participants were 41 undergraduate preservice science teachers in a South Korean university. Activity worksheets, end-of term reports, and recordings of group discussion were analyzed qualitatively to understand how the participants related the Popperian, Kuhnian and Lakatosian models of theory change to their own experiences of theory construction and revision. The results indicated that the participants identified both the strengths and weaknesses of each model in explaining different aspects of the activity. It was also suggested that the participants found the activity helpful for understanding different models of theory change in philosophy of science. We discuss implications for using hands-on activities to teach topics in the philosophy of science to preservice teachers.

Key words: Pre-service science teachers, mystery tube activity, models of theory change

Justifying the quantum of action: A case study of Planck’s Nobel Lecture

Soares, R. G.

Cordeiro, M. D.

Federal University of Santa Catarina - Brazil

Abstract A case study on Max Planck’s Nobel Lecture shows some aspects of Larry Laudan’s view of science. Faced with an empirical problem, that of the blackbody radiation, Planck, a specialist in the second law of thermodynamics, solves the empirical problem that would later be known as the ultraviolet catastrophe, by using his knowledge of the meaning of the second derivative of entropy in relation to energy. For him, a theoretical problem emerged from that solution, as to the meaning of his successful interpolation. Adjusting his methods and values, he turns to statistical mechanics, considering the total energy as a composition of finite elementary energies, which framed energy in probabilistic nature. The quantum of action, a constant that emerges from his theoretical study, was to him symbolic of the quantization of interactions between matter (the oscillators in the cavity as a model for a blackbody) and the energy inside the cavity. Between 1901 and 1920, the year of his Lecture, much was done by the community to corroborate the precision of Planck’s works, including Einstein’s quanta of light, to which Planck was resistant for many years. Those two decades made Planck go a long way, making peace with statistical accounts of matter and ultimately with the quantization of energy implicit in Einstein’s

work. It is not without reason that Planck paraphrases Goethe, saying Man errs as long as he strives, a quote perfectly fitted with Laundan's account of science's rationality.

Keywords: Nobel Lecture; quantum of action; rationality

Monday, 4 July 2022

Session 1, 8:30am–10:am

Studio E (Teacher session I)

Students' functional understanding of nature of science: Report of a film-based teaching activity

Monique Aline Ribeiro dos Santos, Colégio Técnico, Universidade Federal de Minas Gerais
Rosaria da Silva Justi, ICEx, Universidade Federal de Minas Gerais

Abstract A possible approach to promote an emancipatory science education involves including issues like feminism, racism, etc. in our teaching aims. In this work, we report an experience carried out by the chemistry teacher in a class of 29 15-17 years old students, 13 males (4 blacks), and 16 females (5 blacks), divided into five groups. It was based on the film Hidden Figures, and it was proposed to evaluate the students' functional learning of Nature of Science (NOS). It consisted of watching the film at home; choosing scenes that show aspects of NOS; present them to the class; and relate each scene to aspects of NOS. Data – the transcripts of the presentations of one scene selected by four groups – was analyzed qualitatively. In it, the request of Mary Jackson, one of the protagonists, to be part of NASA's engineers' training program was denied because there were no women in such a program. The students established the following relationships with the scene: motivational influence, cultural influence, socio-political influence, and historical influence. Such results show the amplitude of the context portrayed in the film since from a single scene, students were able to establish many relations with different aspects of NOS, which shows a functional understanding of NOS. In our view, if we believe that the finish lines should not continue to be moved to minority groups (such as women and black people), there is an urgent need to include aspects as those identified in this experience in our teaching aims.

Teaching nature of science to elementary children: Successes, challenges, and possibilities.

Elyse Webb, Heritage Elementary, Dallas-Center Grimes School District, Grimes, Iowa
Jordan Holub, King Elementary, Des Moines Public Schools, Des Moines, Iowa
Jesse Wilcox, University of Northern Iowa, Cedar Falls, Iowa

Abstract Although nature of science (NOS) has been investigated extensively in secondary grades (e.g. Bell et al., 2016; Herman & Clough, 2016; Ward & Haigh, 2017), much less work has been done in the elementary (Akerson & Donnelly, 2010). Yet recent research indicates that if NOS were taught in earlier grades, children may develop a robust understanding

of how science works and what scientists do (Authors, 2021). As a result, many of the naïve conceptions of science and scientists K-12 students often have may not take hold if NOS is taught throughout the K-12 system. Additionally, finding developmentally appropriate NOS activities for elementary children is a significant challenge.

This presentation seeks to elucidate what NOS concepts are appropriate for elementary children and how to teach those concepts in an elementary setting. We plan to start the presentation by highlighting NOS ideas generated by various scholars. We will engage participants in a discuss regarding which of those ideas might be appropriate for elementary. We will then discuss various common NOS pedagogical approaches and how those can be applied to elementary children. Next, we will engage participants with some activities and materials we have used with elementary children and share some of our stories and insights about how this impacting elementary students' learning. Finally, we will discuss with the IHPST participants how we might move forward in developing NOS instructional practices and materials for elementary children.

Key words: elementary science, nature of science

Nature of Science as a tool for inclusive science education

Anders Jönsson, Önnestads Adult Education College

Abstract The aim of this presentation is to present some experiences of using selected aspects of Nature of Science as guidelines for a more inclusive science education. As an example, during the teaching sequence students performed a number of inquiry tasks, which simulated authentic scientific methods (e.g., collecting data for estimating Simpson's diversity index and using data from gel electrophoresis for DNA fingerprinting). The students were also presented with research designs and data from authentic investigations, along with information about the researchers, so that they could draw their own conclusions based on this data, but also get a broader picture of people involved in science. The teaching sequence has been performed in biology at the upper-secondary level in the Swedish school system with a small class of young adults (n = 11; 64% females; mean age 22.4 years) during an academic year. Data on students' perceptions of science (more generally) will be collected with a questionnaire on epistemological beliefs (Conley et al., 2004) that has been translated and adapted to the Swedish context, while perceptions of the specific teaching will be investigated through focus-group interviews. Students will answer the questionnaire at three occasions, in order to identify potential changes in perceptions over time. Focus-group interviews will be performed during April 2022. Only preliminary findings will be presented at the conference.

Key words: Biology, Inclusive education, Nature of science

Monday, 4 July 2022
Session 2, 10:30am–12:00pm
Plenary: Springer Lecture
Forum

Techno-scientific promises and disciplinary fields in peripheral contexts: An approach from Latin America

Dr. Pablo Kreimer, University of Quilmes, Argentina.

While scientific development has always worked along with promises of future development, the ways in which such promises are formulated, modulated, the characteristics of the actors involved, and the conditions of the promises production and compliance, have changed over time. In particular, they have very different consequences across different contexts. Indeed, the formulation of scientific promises in peripheral scientific contexts have different structures and consequences, compared to hegemonic sites.

By “bringing the future to the present”, promises are intended to provide solutions to important public problems. Yet in doing so, a disciplinary space of knowledge production is positioned as “the most legitimate” to solve these problems, displacing competing visions, questioning diverse actors, and building the epistemic bases to think about these issues. However, in globalized dynamics, peripheral scientific elites hardly have the capacity to formulate solutions based on local knowledge, since they face structural barriers to the industrialization of knowledge. This result is subordinate integration to large international consortia, which can address key scientific problems, or even industrialize knowledge, and can market the products of these endeavours globally.

Monday, 4 July 2022
Session 3, 1:00pm–2:30pm
Studio A
Symposium: Why Trust Science? I. Understanding the Naysayers

Why Trust Science? I. Understanding the Naysayers

Session Organizers:
Douglas Allchin, University of Minnesota
Sibel Erduran, University of Oxford

Naomi Oreskes’ book *Why Trust Science?* has sparked considerable discussion. This session, based on papers from a special themed issue of *Science & Education*, focuses on understanding the perspectives of the science naysayers — those who reject climate change or the safety of COVID vaccines, or endorse a flat Earth, for example. Based on research on their beliefs and analysis of their “arguments,” educational remedies are proposed.

Socioscientific Issues Thinking and Action in the Midst of Science-in-the-Making

Benjamin C. Herman,* Michael P. Clough, & Asha Rao

*Texas A&M University

Abstract Like all socioscientific issues, the COVID-19 pandemic requires decisions that are contentious, involve scientific thinking, and vary across social groups. We investigated perceptions of COVID-19 among 557 university biology students. Hierarchical moderated multiple regression analyses demonstrate that students' *personal* COVID-19 mitigating actions after stay-at-home orders were significantly and positively associated with, in order of importance: (1) higher levels of COVID-19 spread prevention knowledge; (2) more liberal, as opposed to conservative, political orientations; (3) being female; and (4) increased disbelief of false COVID-19 information. Furthermore, the students' political orientation moderated the relationship between their trust in scientific models to guide COVID-19 decisions and their personal COVID-19 actions. Trust in scientific models was a significant positive predictor of moderate, conservative, and very conservative student groups' actions. Conversely, no such association was found among very liberal and liberal students. Similar regression analyses revealed that students' support for *societal* COVID-19 mitigating measures is positively associated with, in order of importance: (1) more liberal political orientations; (2) increased knowledge of COVID-19 spread prevention; (3) increased disbelief of COVID-19 false information; (4) trust in scientific models of COVID-19; and (5) beliefs that extra-scientific factors are needed to resolve the pandemic. These findings imply that educators need to help students analyze how political outlook/identity and personal biases interact with trust in science and influence socioscientific decision-making. In addition, science communicators should acknowledge sociocultural variance in order to optimize trust in science and reasoned and responsible action.

The Public Discussion on Flat Earth Movement: An Analysis Based on the Esperantist-Epideictic Discourse

Cristiano Mattos*, Felipe Sanches Lopez, José Luis Ortega, & André Rodrigues

*University of Sao Paulo

Abstract In this presentation we reflect on public discourses about science and pseudoscience, proposing the same discursive structure for both: the Esperantist-Epideictic genre. This genre of discourse might bring together characteristics that we understand as constituents of the public discourse on science. It also enables us to depict the process by which to maintain cohesion on a group's values. The discursive activity points to science as neutral, free, and independent of social influences, reflecting those already in this discursive sphere. Discursive hermeticity appears in the Esperantist content and the Epideictic form by avoiding the dialogical situations where there is no epistemological and axiological dispute. We thus show that the Esperantist-Epideictic genre helps to understand the process of maintaining a cohesive group whose beliefs about the Flat Earth appear in social media. We use data from three sources:

transcriptions from seminars held at the 1st FlatCon Brazil, most-viewed videos on YouTube where advocates talk about Flat Earth, and semi-structured exploratory interviews conducted at FlatCon. Our findings indicate that some conceptions of validation of knowledge, scientific method, science bias, reality, and truth compound a distinct part in the current conversations about the Flat Earth movement. Moreover, the Esperantist-Epideictic genre of discourse can be an analytical tool for framing the echo chamber in social media while defending or attacking the Flat Earth movement. We conclude that in a time where there is a growing consensus that science is under attack, the ways in which its defenders are trying to stand up to it may be causing some harm.

Who Speaks for Science?

Douglas Allchin, University of Minnesota

Abstract Ironically, flat-Earthers, anti-vaxxers, and climate change naysayers trust in science. Unfortunately, they trust the wrong science. That conundrum lies at the heart of scientific literacy

in an age of well-funded commercial and ideological interests and overwhelming digital information. The core question for the citizen-consumer is not philosophically “why trust science?” but sociologically “who speaks for science?” Teachers can help students learn how to navigate the treacherous territory of inevitably mediated communication and the vulnerabilities of epistemic dependence. Students need to understand the role of science communication practices (media literacy) and the roles of credibility, expertise and honesty and the deceptive strategies used by imitators of science to seem like credible voices for science.

Monday, 4 July 2022

Session 3, 1:00pm–2:30pm

Studio D

What were Schrödinger’s hypothesis to obtain his so-called Schrödinger’s Equation? A proposal on how to integrate epistemic and social aspects of Science in Science Education.

Nathan Lima, Leonardo Heideman

Programa de Pós-Graduação em Ensino de Física, Departamento de Física, Universidade Federal do Rio Grande do Sul - Brazil

Abstract There is a consensus that it is important not only to teach science but about science, highlighting the different aspects that compose what we call Nature of Science. There are many attempts to provide a theoretical framework for such an approach, for instance, the consensual list, the whole science approach, and the family resemblance approach. In this work, we propose a different approach to deal with epistemic and social features of science in an integrative

perspective. We propose to discuss historical episodes, evaluating the different sorts of hypothesis (statements that exceed the empirical existing content) that were provided during the scientific proposal. In order to perform such analysis, we propose a theoretical categorization of the different sorts of hypotheses. First, we may classify hypotheses according to the epistemic level that they occupy in the scientific work. They can be (i) *a priori*, (ii) non *a priori* and not demonstrated; (iii) demonstrations. Also, *a priori* hypothesis may be classified according to their nature. They may be of three kinds: philosophical hypothesis, essentialist hypothesis and representative hypothesis. In order to highlight the pedagogic potential of this theoretical categorization, we discuss Schrödinger's own derivation of his Wave Equation, as he presented in 1928 in a series of lectures. We identify the hypotheses assumed along his derivation and show their difference in terms of their epistemological level and nature. Specially, through making Schrödinger's essentialist and philosophical hypothesis explicit, we connect the epistemic factor of the scientific practice with the social context in which it takes place.

Intuitive epistemologies on the nature of science in university professors teaching psychology

Zuraya Monroy-Nasr*

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Asunción López-Manjón**

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DGAPA-PAPIIT IN401222

Abstract The research on the role of intuitive or personal epistemologies has provided substantial evidence about the mediating role of teachers' epistemology in the way they conceive of teaching and how they perform in it. Our research was carried out with a non-probabilistic, intentional sample of 81 university professors teaching psychology that responded to an online questionnaire. It included a section about intuitive epistemologies with 22 items adapted from questionnaires used in other investigations (Pecharromán & Pozo, 2008; Zhou & Tan, 2020), as well as with original items. These were elaborated under distinct conceptions of epistemological positions about the nature of science: naive realism, critical realism/rationalism and constructivism. It also included another section with 16 items, adapted from the Literature Epistemic Cognition Scale (LECS) developed by Yukhymenko-Lescroart *et al.* (2016), to investigate the epistemic cognition of philosophy, comparing the epistemological positions in two different domains (science and philosophy). A six point Likert-like scale was used. According to the results, participants mainly chose constructivist options. Even those with more years of teaching experience tend to favor constructivism as a response. A strong relation between a constructivist intuitive epistemology and multiple meanings (LECS) was found. The relevance of inquiring about teachers' intuitive epistemologies comes from their effect on learning. It is an essential step to propose and achieve changes in the way educators interpret what scientific knowledge is, in order to overcome difficulties in teaching psychology.

Key words: epistemology, psychology teaching, constructivism

Sonja Ashauer: A Brazilian woman in theoretical physics in the mid-1940s

Barbra Miguele, Universidade de São Paulo (USP) - São Paulo, Brazil

Abstract The question of gender in science has taken place in the history of science, contributing to the construction of new perspectives about the scientific practices. At the same time, researchers in science education have argue that it is important to develop the identity of students in relation to science and historical case studies can improve the science teaching as examples of women participation in science. In this presentation we discuss the scientific path of Sonja Ashauer (1923-1948), a Brazilian theoretical physicist who, during the mid-1940s, was at Cambridge University working on her PhD thesis around the problem of modifying the classical theories of electrodynamics. At the beginning of her scientific life, Ashauer studied Physics at the University of São Paulo (USP) in Brazil, where she took part in the research group led by Gleb Wataghin, a group that made their researchers' foreign travels a systematic part of their way of doing physics. In this proposal we discuss the role played by Ashauer within the set of practices and relationships that characterized the research in physics at Wataghin's group, and we argue that her attitudes as a researcher in Cambridge were beneficial to insert that group into the international community of physics. Finally, we highlight that the story of Sonja Ashauer's scientific path can contribute to approach the problem of Gender in Science and in its history in Brazilian scientific education.

Key-words: Sonja Ashauer; Brazilian science; Brazilian Physics; Gender and Science

Monday, 4 July 2022

Session 3, 1:00pm–2:30pm

Studio E (Teacher Session II)

The study of the human body in elementary school and the Cultural History of Science: discussing practices and social actors.

Priscila do Amaral, Federal Center for Technological Education - CEFET/RJ

Abstract In this work, we report the development of a research that has as its theme the study of the human body, in the 16th and 17th centuries, adopting the Cultural History of Sciences as a historiographic aspect. The motivation for the research arose from the fact that students did not recognize the human body studied in science classes as their own body. We carried out a historical study of the practices and social actors involved in the study of the human body in the Birth of Modern Science, generating subsidies for the empirical part of the research, carried out for two consecutive years (8th and 9th year) with elementary school students in a Brazilian public school. Most of the participating students were of African descent. The methodology used was action research. We seek to bring to the teaching of the Human Body a historical-cultural approach, focusing on practices such as public dissections, use of lenses, production of anatomy treatises, and to discuss which people participated in these studies and whose bodies were studied. The discussion brought reflections on the invisible bodies and actors and how the body

model studied in that period is still present in the teaching of the human body. In addition, it brought discussions related to the context of students.

Key words: historical-cultural approach, human body, primary education

Teaching Evolution and Geologic Time: Strategies and Resources

Kean Roberts, Ames High School, Ames, Iowa

Billy Lange, Ames High School, Ames, Iowa

Jesse Wilcox, University of Northern Iowa, Cedar Falls, Iowa

Abstract Although evolution and geologic time are fundamental concepts in biology and geology, a significant portion of the American population dismisses them. For example, in a recent Gallup poll, 46% of Americans believe evolution is inconsistent with their beliefs (Gallup, 2019). Similarly, four out of ten Americans believe Earth is 10,000 years old (Ghose, 2014). While scholars have pointed out issues with these polls (McCain & Kampourkai, 2016), a significant resistance to evolution and geologic time appears to be impacting science teachers. For example, Berkman & Plutzer (2011) found that only 28% of biology teachers actively advocate to teach evolution in their classes, 60% of biology teachers are cautious and concerned about teaching evolution, and 13% actively teach creationist ideas. Contributing to the problem is a lack of history and nature of science (NOS) instruction to support instruction of fundamental scientific concepts that many in the public don't support. The purpose of this presentation is to discuss resources and strategies we have used to engage students in learning about evolution and geologic time and to reduce resistance from stakeholders regarding this instruction. Specifically, we will discuss how historical short stories can help students understand how science ideas were developed. Furthermore, teaching ideas such as what a theory means, methodological naturalism, and non-overlapping magisteria (Gould, 2011) can reduce resistance to evolution and geologic time.

The Encounter of Two Cultures: The Practice of Science in Interdisciplinary Aesthetic Education in High Schools

Hsien-Jang Wang, the teacher of National Yuli Senior High School, Taiwan

Huei Lee, Department of Education and Human Potentials Development, National Dong Hwa University, Taiwan

Abstract Is it possible for the interdisciplinary learning of art and science complement each other? In 2018, the Ministry of Education in Taiwan has issued the outline of natural science to emphasize on the interdisciplinary integration in senior high schools. Science educators advocate through the exploration of socio-scientific issues (SSI) instruction can develop students' interest and motivation in science, understandings of nature of science (NOS), and reasoning skills.

Therefore, this course, with a focus from the perspective of arts, will integrate the concept of science in arts to guide students to learn by an interdisciplinary approach. The course is designed for the 11th graders in senior high schools. It will include 24 classes over a period of 12 weeks, adopting a local-based SSI design, to combine life situations, and integrate chemistry and other sciences into art conceptualization. In addition to the practical art learning, the course will help students to learn the significance of scientific knowledge and promote students' awareness of local humanistic care. In terms of student response, the course will motivate them and arouse their interests to further engage in learning of interdisciplinary knowledge, which will not only enhance their aesthetic experiences, but also positively guide their attitude toward sciences.

Key words: aesthetic education, aesthetic creativity, interdisciplinary scientific learning

Monday, 4 July 2022

Session 4, 3:00pm–4:30pm

Studio A

Symposium: Why Trust Science? II. The Political Context

Why Trust Science? II. The Political Context

Session Organizers:

Douglas Allchin, University of Minnesota

Sibel Erduran, University of Oxford

Naomi Oreskes' book *Why Trust Science?* has sparked considerable discussion. This session, based on papers from a special themed issue of *Science & Education*, addresses how educators should conceive the nature of that trust in a political context, especially with respect to its ontological concerns.

Key words: trust, post-truth, ontological turn

Not Only *Why* but Also *How* to Trust Science: Reshaping Science Education Based on Science Studies for a Better Post-Pandemic World

Nathan Willig Lima* & Matheus Monteiro Nascimento

*Universidade Federal Do Rio Grande Do Sul

Abstract Many authors blame postmodernism and studies on Sociology and Anthropology of Science (Science Studies) for the rise of relativism and anti-science movements. Despite such criticism, Science Studies have always been concerned with the construction of the *common world* (a shared reality), while the anti-science movement goes in the opposite direction, denying science to defend economic and political interests of specific groups. In this sense, the *post-truth*

movement is part of a political agenda and therefore science education will not be able to face the dilemmas of such a scenario unless it takes a clear political stance. Thus, our objective is to articulate why we should trust science as well as what it means to trust science based on the so-called *ontological turn* of Science Studies. We argue that, based on this sociological framework, it is possible to recognize the value of science as a community capable of producing networks and actors that mobilize the world and that respond to day-to-day problems. Next, we discuss the fact that trusting in science does not mean blind trust in specialists. It is necessary to increase the participation of different actors in the construction of the *common world*, especially by calling into debate those who were made invisible in the process of colonialism. Finally, we argue that recovering confidence in science is a political process. Namely, public opinion can only be changed by politically organizing the field of science and science education.

The Committed Objectivity of Science and the Importance of Scientific Knowledge in Ethical and Political Education

Newton Duarte, Luciana Massi*, & Lucas André Teixeira

*University of São Paulo State (UNESP), Araraquara

Abstract Despite advances in discussions about the nature of science, there is still a paucity of discussion on the ontological dimension of science in science education research that makes it difficult to defend its content and teaching. In this presentation, the reasons for trusting science and science education are analyzed through three arguments. First, both the belligerent obscurantism and fake news of the ultra-right and the postmodern relativism of sections of the left wing are connected to objective movements from the capitalist socioeconomic reality. The reestablishment of trust in science and its teaching requires an effort to understand the contemporary social contradictions, problems, and challenges. Second, scientific knowledge does not need to abdicate objectivity in order to ground ethical and political positions. Third, the socialization of scientific knowledge through school education is a necessary, albeit insufficient, condition for the ethical-political education of younger generations. In concluding our arguments, we claim that it is necessary to overcome the choice between an education that is *either* ostensibly neutral *or* fully socialized. We can conceptualize education that acknowledges the virtues of avoiding political and ideological bias, while not rejecting the contextualization of scientific knowledge and respect for the multiple voices of different oppressed groups within a culture.

Monday, 4 July 2022
Session 4, 3:00pm–4:30pm
Studio D

Zombies in the classroom: Teaching versions of historical experiments in educational settings

Peter Heering, Europa-Universität Flensburg

Abstract Even though this analysis mainly refers to the German-speaking area, the results probably apply more general: When physics lessons at secondary level or the beginners' practical course of university physics programs are analysed, then a (partly implicit) historical reference can be found in teaching experiments. Educational devices serve as material representations in case of several experiments from the history of physics, and they are frequently standard in education. For example, Millikan's oil drop experiment is just as canonical as the Franck-Hertz experiment, and the measurement of the speed of light with the rotating mirror according to Foucault (or Michelson in the North American context). Although the naming refers to a historical context, this context is usually not discussed in more detail.

On the one hand, the question arises as to what relation the corresponding experimental set-ups have to the historical apparatuses and, on the other hand, what the practice with these set-ups actually has to do with experimentation. I will discuss these issues using two concrete examples. First, I will analyse historical teaching versions of Joule's experiments to determine the mechanical heat equivalent (essentially connected to the establishment of the energy concept). This case serves as an illustration of different teaching approaches related to the historical experiment. Subsequently, the Millikan oil drop experiment will be discussed to show where problems can be created by such experiments, especially with regard to the development of an appropriate understanding in Nature of Science, and how the experiments can be used more appropriately.

Key words: experiment, energy, charged particles

Picturing Benjamin Franklin's kite experiment: an analysis of three nineteenth-century illustrations

Breno Arsioli Moura, Federal University of ABC, Brazil
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Abstract In this communication, I will present an ongoing study on three illustrations published in the nineteenth century that portrays Benjamin Franklin (1706-1790) and his famous kite experiment. First, from a recollection of this historical episode, I will analyze the accuracy of these pictures in relation to the available descriptions of the experiment, viz., Franklin's letter to Peter Collinson (1694-1768) published in Royal Society's *Philosophical Transactions* in 1752 and Joseph Priestley's (1733-1804) report in his *The History and Present State of Electricity*

(1767). This analysis will show that the illustrations had some common elements, such as the inclusion of a boy next to Franklin and the amateurish facet of the experiment. One of them shows explicit scientific errors. The descriptions accompanying two of the illustrations indicates the wide influence of Priestley's report on the drawings. I will indicate how the results of this iconographical study can lead to the discussion on the importance of an accurate representation of historical episodes in order to foment an adequate notion of the nature and production of scientific knowledge. In my view, a critical analysis of the illustrations allows us to challenge common-sense ideas on the kite experiment, as well as to comprehend the range of Franklin's contribution to the studies on electricity in the eighteenth century.

Key words: Ben Franklin, kite experiment, history of electricity

Student teachers' approach in studying and disseminating a university collection of historical scientific instruments in the context of informal science education

Constantina Stefanidou
Panagiotis (Takis) Lazos
Kostas Skordoulis

Department of Primary Education, National and Kapodistrian University of Athens

Abstract This paper explores how students of the Department of Primary Education (student teachers) of the University of Athens approach the history of laboratory training of pioneer teachers of the Maraslean Teaching Center during the 19th and 20th century. Student teachers, with the scientific guidance of the authors after studying the history of the Maraslean Teaching Center and the collection of historical scientific instruments, designed and implemented educational material to highlight and disseminate this history to the public. The first findings show that student teachers consider that they have an increased role in highlighting the history of the Maraslean Teaching Center and in particular the collection of historical scientific instruments. The educational material produced by the first group was presented to students and public during the Athens Science Festival 2021 and is freely available on the internet while the material produced by the second group has not been applied and presented yet.

Monday, 4 July 2022
Session 4, 3:00pm–4:30pm
Studio E (Teacher Session III)

Using Technology to Glimpse into Students' Conceptions of NOS: The Delicate Balance Between Knowing My Students and Knowing What They Know

Dr. Ami J Friedman, Walled Lake Western High School, Walled Lake, MI USA

Abstract This interactive presentation is intended for working k-12 teachers and university professors. Like much of the world, March 2019 became a challenge both personally and professionally as I found myself needing to pivot from finely-honed and cultivated teaching methods developed over 23+ years of teaching to being able to connect with and teach my high school students in a meaningful way via a computer screen in the middle of a global pandemic. In this session, participants will engage with technology tools that can be used to elicit students' understanding of science content and practices. While participants will be experiencing these tools as a "student", I'll share my "teacher" view into the applications highlighting how I utilized them to learn about students' NOS conceptions. Embedded throughout the presentation participants will see actual students' examples from the 2020-2021 school year. Challenges, pitfalls, and successes will also be shared, as well as which tools I'm still using now that we're back in person. Lastly, the evaluation of these tools using the Triple E Framework ([Kolb, 2017](#)) for their appropriate use in the curriculum will be shown.

Key words: technology, NOS, teaching

Energy Party in Rural Leadership Schools: The Practice of Inquiry-Based Interdisciplinary Concepts Teaching

Hui-Chuan Chang, Teacher of Sciences, Experimental Primary School of National Dong Hwa University, Taiwan

Huei Lee, Department of Education and Human Potentials Development, National Dong Hwa University, Taiwan

Abstract Our school, the Experimental Primary School of National Dong Hwa University, is the leading school in the remote areas in eastern Taiwan that focuses on the development and design of energy course. The group of teachers responsible for the course in question have developed jointly an energy course module for teaching energy, an interdisciplinary concept, with the 7th Sustainable Development Goals, i.e. Affordable and Clean Energy, incorporated into the design, and further initiated SSI discussions as well as connected with local characteristics and life situations to guide students to know what energy is, to explore energy-related issues, and to establish the civic awareness of making good use of the Earth's resources and the sustainable development of energy. The complete interdisciplinary module contains 24 lessons, includes 12 science lessons, delivered to 4th-grade students required to study and learn through inquiry and

discussions. The students did engage in energy-saving actions both at school and at home as soon as the course started, and such outcome not only indicated both the construction and the practicability of interdisciplinary concepts, but also won the Gold Award of the 2021 Representing Primary and Secondary Schools for Promoting Energy Education.

Keywords: energy education, socio-scientific issues (SSI), inquiry-based practice, interdisciplinary concepts

Reflections on past, present and future of relationships between school teachers and IHPST: A conversation

Ami Friedman, Cristiano Moura and Hermann Schiffer

Abstract In this open conversation, a former, the current and elected teacher representatives will engage the public in discussing perspectives on the participation of schoolteachers in the IHPST community and summarize the presentations in teachers' sessions at the 16th IHPST Biennial Conference.

Monday, 4 July 2022

Session 5, 5:00pm–6:00pm

Studio A

The Changing of Students' Image of Scientists Through A Dialogue Transcending Space, Time and Gender

Chiang, Chia-Ling and Lee, Huei

Department of Education and Human Potentials Development, National Dong-Hwa University, Taiwan.

Abstract Students' image of scientists has a profound impact on not only their involvement in science learning in the class, but also their willingness to devote themselves to science and technology-related fields in the future. People's image of scientists is mostly white, male, unsociable, or even a little crazy. In order to encourage students to have a diverse image of scientists, and to understand that scientists in different eras in different regions have worked hard to explore and explain the scientific problem. This study designed a curriculum which was called 'A Dialogue Transcending Space, Time and Gender'. This curriculum is aimed at elementary schools for three weeks. The curriculum, designed for the sixth-grade students, is focused on the themes related to the regular motion of the sun and solar observation. It introduces the stories of three astronomer, as well as astronomical instruments. Three interactive historical vignettes (IHVs) were developed and applied during the instruction. Qualitative methods were used to data collection and analysis. The data includes the students' writings about their image of scientists at the beginning and after the instruction, as well as student worksheets and the letters they wrote to

the three scientists. The results of the study show that the students' images of scientists have indeed become more diverse and freer from gender and ethnicity stereotype. They can also understand that scientists in different regions and eras have the efforts and contributions to science, which could be independent or interactive.

Keywords: gender stereotype, image of scientists, interactive historical vignettes.

Have you ever seen a “scientist”? – Discussing “invisibilities” in the Sciences with contributions from the Cultural History of Science and from Ethnoecology

Hermann Schiffer, CEFET/RJ; Brazil

Abstract Authors from the Cultural History of Science (CHS) literature have been revealing the role of different social actors in the History of Science who were “made invisible” from the lack of recognition and registry. Also, studies in Ethnoecology call attention to the cultural, social, environmental, and also epistemological value of traditional ecological knowledge (TEK). Developing discussions about the invisibilities in the Sciences with students could help dealing with some challenges in Science Education, such as the lack of recognition of the contributions to Science from social actors, such as women, black people, and from local people, but also from ancient communities, such as indigenous people. Inspired by these areas and by researches done in Brazil, this theoretical research aims to discuss strategies in which the CHS can inspire activities in science classes to question the invisibilities in the Sciences and to show how the TEK can be an example to potentialize these strategies. Some reasons supported in the literature will be highlighted for science educators to discuss invisibilities in classes. Also, it is proposed that these discussions be somehow organized and presented in different “dimensions”, such as an *epistemic* and a *social* one. Activities should compare TEK and WMS in different aspects with the intent to not depreciate the first, and they should also explicitly discuss and help students develop values such as *empathy*, *sympathy* and *social justice*, not commonly evoked during science classes.

Key words: cultural history science, ethnoecology, EDI/social justice

Monday, 4 July 2022

Session 5, 5:00pm–6:00pm

Studio D

How citizen science is revolutionizing the sciences: Implications for school science

Abstract This theoretical analysis focuses on how citizen science, in which large numbers of non-professionals contribute to the data collection and analysis, is affecting traditional notions of scientific practice and how knowledge is produced and validated. The crowdsourcing of data has triggered new epistemic questions and ethical issues about the knowledge, how it is produced, and who does science. Evidently, this shift is impacting perceived notions about the very nature of science (NOS). The infusion of CS projects in informal and formal science education programs, will require addressing some of the emerging NOS issues to help learners make better sense of their experiences. This presentation discusses the implications of CS engagement to supporting meaningful discussions about the trustworthiness of scientific knowledge, methods, and practices.

Keywords: Citizen Science; Nature of Science; Science Curriculum

Developing Students Understanding of the Nature of Science via Citizen-Science Educational Projects

Dina Tsybulsky, Technion
Yuval Perez Halachmi,

Abstract Citizen Science (CS) is a developing field in science and science education, bringing forth the collaboration of research institutes, organizations, and citizens. There are currently hundreds of research studies originating from various scientific institutes and universities from around the world that are being conducted in cooperation with citizen scientists. Students' participation in CS allows students to integrate their school learning about science with authentic experience in scientific research and thus can help them develop the habit of scientific practices and thought. The present study seeks to examine the impact of K-12 school students' (n=400) participation in CS projects on their understanding of the nature of science (NOS). The study examines students' understanding before and after their participation in the projects and compares different projects to understand their effectiveness in promoting students' understanding. The research tools used were pre- and post-questionnaires. The data analysis was performed using statistical tests (e.g., Wilcoxon Two-Sample analysis, Kruskal Wallis test). The results indicate a significant improvement in students' NOS understanding, which shifted from naïve conceptions to a more informed understanding in most of the examined NOS aspects. In addition, our analysis revealed three variables that may impact the differences in the change of understanding among students: type of NOS teaching (explicit/implicit), type of CS project (contributory/collaborative/co-created), and type of inquiry (structured/guided/open). The study contributes to our knowledge regarding students' understanding of NOS during their participation in CS, which will pave a pathway to further research in this field.

Keywords: nature of science, citizen science, K-12 biology students

Monday, 4 July 2022
Session 5, 5:00pm–6:00pm
Studio E

The evolutionary perspective in the work of João Baptista de Lacerda (1846-1915): social Darwinism and evolutionary theories in Brazil from the turn of 19th to the 20th century

Anderson Ricardo Carlos, University of Sao Paulo

Maria Elice Brzezinski Prestes, University of Sao Paulo

Abstract This presentation addresses preliminary research on the origins of the evolutionary ideas of a Brazilian physician and researcher from the turn of the 19th to the 20th century, João Baptista de Lacerda (1846-1915). Working on different subjects of physiology, anthropology, and microbiology, Lacerda developed his entire career at the National Museum of Rio de Janeiro, where he came to occupy the position of director. He publicly presented himself as an adept of evolutionary theory. In addition, the Brazilian history of science later named him a “social Darwinist”. Considering that before the Modern Synthesis of the years 1940, there was no consent about what the evolutionary theory was, we intended to identify what ideas were incorporated in Lacerda's published works, tracing them to possible sources. Over the decades, nonetheless, Lacerda shifted his perspective and adopted the defense of the theory of Darwin. But what were the evolutionary ideas Lacerda first defended? From which author or authors? When did occur that shift, and for which reasons (epistemic or other)? We intend to answer the questions showing what Darwin's book and exactly what facts and arguments Lacerda presented justifying his shift. In further stages of the research, we aim to contextualize his ideas and scientific practice in the socio-political scenario of the period, looking for a better comprehension of the social-Darwinist label he received. The ultimate goal of the research is to gather its results as a curriculum contribution to science teacher training in Brazil.

Keywords: History of evolution, History of Sciences in Brazil, Nature of science

Teaching the Nature of Science from the history of cell theory: An application of the IM-NOSBIO model

Tiago Guimarães Inêz, University of Sao Paulo
Breno L. Lacerda Brito and Charbel N. El-Hani

Institute of Biology, Federal University of Bahia. National Institute of Science and Technology in Interdisciplinary and Transdisciplinary Studies in Ecology and Evolution, Brazil

Abstract Learning about the Nature of Science (NOS) can help students of diverse educational levels to grasp the main characteristics of scientific work. Assuming the importance of NOS for science education, Inêz, Brito and El-Hani (2021) put forward a model aiming to promote instruction and learning about NOS according to the context of biology teaching, named “Integrative Model for Teaching NOS in Biological Education” (IM-NOSBIO). The present study aims to describe a pedagogical application of the IM-NOSBIO from the history of cell theory. We take the development of this theory as a point of departure to show that this model can help biology teachers to foster the understanding about five NOS categories that characterize how scientific knowledge works in the specific domain of the biological sciences. The first is the importance of making observations in science and its role for the development of biological researches. The second refers to the functions and main characteristics of biological theories and models in scientific work, (*e.g.*, cell theory and the fluid mosaic model, respectively), as well as their similarities and differences. The third is the development of new research instruments (*e.g.*, optical microscope) and the publication and dissemination of books, letters and papers related to the study of cell. The fourth involves the social mechanisms by which scientific community scrutinizes and validates the results achieved by scientists. The fifth refers to the differences among many social contexts in which scientific work is carried out generally, and in the specific domain of biology.

Keywords: Science education, Nature of Science, Cell theory.

Tuesday, 5 July 2022

Session 6, 8:30am–10:00am

Studio A

Roundtable: Continuing the Discussions on Nature of Science for Social Justice: Exploring Possibilities for Future Research and Collaborations

Organisers:

Lena Hansson, Kristianstad University, Sweden
Hagop A. Yacoubian, Lebanese American University, Lebanon

The participants in this roundtable did all contribute to the volume “Nature of Science for Social Justice” (Yacoubian & Hansson, 2020). The roundtable focuses on the research that has evolved in this area during the past two years and highlights the research projects that the participants

engaged in which contributed to further refining the construct of *nature of science for social justice* (NOS for SJ). Our volume focused on the goal of SJ and explored what NOS content should be taught, as well as why and how it should be taught. In the volume, the organisers of this roundtable, together with 18 other science education scholars, initiated a research-based dialogue on what NOS for SJ can mean and what should characterise NOS teaching contributing to the educational aim of SJ. The authors of the different chapters had different perspectives and frameworks as their starting point as they contributed to answering the following questions: *Why should school science aimed at SJ address NOS? What NOS-related content, skills and attitudes form the basis when aiming at SJ?, and How can school science address NOS for SJ?*. This roundtable takes the volume as its point of departure and engages the panellists and the audience in discussing the development of this line of research, as well as exploring possibilities of future research and collaborations.

Tuesday, 5 July 2022

Session 6, 8:30am–10:00am

Studio B

Reflection of decisions in socio-scientific issues

Johanna Ratzeke and Dietmar Höttecke (University of Hamburg, Germany)

Abstract Complex societal and scientific challenges require rational and well-founded decision-making in socioscientific issues (SSI) that takes reliable scientific knowledge and self-reflections into account. Accordingly, standards for science education demand the promotion of decision-making competence. Research in science education suggests that teaching scientific knowledge and structural knowledge about complex decision-making strategies might not be sufficient to meet the challenge of teaching decision-making in science. Usually – as findings in psychology indicate – decision-making is based on intuition, feelings, and simple heuristics instead of rational considerations. Therefore, we see self-reflection as a means for students to become aware of initially chosen heuristics and how they might have been influenced by preliminary knowledge, feelings, expectations, social norms, and values. Furthermore, decisions are influenced by the perspective on an SSI, either as an individual or collective perspective. In our study, we integrate teaching explicit reflection in physics classes and investigate in a 2x2-experimental design the effects of two independent variables on two dependent variables. Independent variables are: (1) *method of reflection* and (2) *perspective of a decision-making problem*; dependent variables are *students' ability to*: (A) *self-reflect decision-making* and (B) *use decision-making strategies*. We will present results regarding students' ability to self-reflect their decision-making depending on the fact if they were explicitly taught to do so. Students' ability was evaluated by application of a coding frame based on Qualitative Content Analysis. The application of inductive-deductive formed categories to students' decisions revealed

differences in the dependent variable (A) depending on the characteristic of the dependent variable (1).

Keywords: decision-making, reflection

Influence of COVID-19 Science Perspectives and Sociocultural Factors on University Biology Students' Pandemic Response

Benjamin Herman^{1,2}, Michael Clough¹, Alex Sobotka¹, Asha Rao²
Department of Teaching, Learning, and Culture¹
Department of Biology²
Texas A&M University

Abstract Science education research must continue to explore how perceptions about science and its nature and sociocultural membership influences socioscientific engagement. This session will address research and pedagogical recommendations based on how 415 university biology students' perceptions about COVID-19 science (e.g., prevention knowledge and NOS) and scientists, and sociocultural group membership associated with their: 1) COVID-19 behaviors; and 2) feelings that enacted COVID-19 mandates are justified. Higher levels of students' actions and mandate support significantly associated with increased COVID-19 knowledge (e.g., spread prevention and health impact awareness). However, being increasingly politically conservative significantly associated with lower levels of COVID-19 mitigating actions and mandate support. Confidence in the CDC and cognizance of science as an amendatory/revisionary process positively predicted COVID-19 mandate support. Furthermore, political orientation moderated the relationship between students' views about COVID-19 science, and their COVID-19 actions and mandate support. More specifically, confidence in the CDC positively associated only with very conservative students' COVID-19 mitigating actions. Furthermore, among more politically conservative students, as opposed to very liberal students, increasing confidence in the CDC and cognizance of the amendatory/revisionary nature of science was a strong positive predictor of beliefs that COVID-19 mandates are justified. These findings demonstrate that beliefs about COVID-19 science and their impact on SSI decisions become increasingly complex when accounting for people's sociocultural group membership. We will report how the university biology students made COVID-19 decisions because of sociocultural membership and COVID-19 science perceptions; and how science teaching can effectively address NOS, sociocultural factors, and promote reasoned socioscientific decision-making.

Key words: SSI, Perceptions about science, Post secondary education

Evaluation of a NOS PD-program when NOS is not integrated into the curriculum

Anna Koumara
Aristotle University of Thessaloniki

Abstract The integration of nature of Science (NOS) in science teaching had been extensively discussed in the literature and researchers agree on its significance. However, it is not included in many countries' science curricula, Greece included.

In the present work, the evaluation of a PD-program about the NOS integration in the Greek science curriculum in Secondary Education is presented. The PD-program lasted for 18 hours, took place in Thessaloniki from April 2018 till May 2019 and 50 science teachers participated voluntarily. An innovation of the program is the inclusion of all three approaches for NOS teaching found in the literature; teaching through History of Science, Scientific Inquiry, and Socio-scientific Issues (in that order). The program is evaluated on whether teachers: a) learned NOS aspects, b) can design a lesson plan that integrates NOS aspects, c) can teach such a lesson in an explicit and reflective approach. Also, due to the aforementioned innovation of the program, it is evaluated on d) whether teachers prefer one of the three approaches during teaching and if they approve the structure of the program.

Plenty of tools and methods were used to answer the research questions, like questionnaires, interviews, classroom observations with a protocol, analysis of lesson plans with a rubric, and case studies for three teachers. The results for the first three research questions are positive. Furthermore, teachers approve the structure of the program, they regard all three approaches as important and necessary, and they show a slight preference for Scientific Inquiry.

Key words: Nature of science, PD-program, teacher education, Secondary education

Tuesday, 5 July 2022

Session 6, 8:30am–10:00am

Studio C

Consuming “Energy”: the recontextualization of a scientific concept in nutrition ads

Cecilia Molinari, Universidad de la República (Uruguay)

Zekai Ayik, Yildiz Technical University (Turkey)

Abstract The deep cultural penetration of advertising discourses allows them to compete with the discourses of formal education over the meanings of scientific concepts. However, science education tends to neglect these texts.

“Energy” is one of the terms that appear prominently in promotional texts selling products of applied Chemistry, particularly in the areas of nutrition and cosmetics. The discourse of advertising makes a strategic use of conceptions of energy that are part of the social imagery, which do not necessarily agree with accepted scientific knowledge.

What transformations does the scientific concept of energy suffer as it is recontextualised in promotional texts? How do advertising discourses use them to manipulate their audiences? How can these power effects be understood and resisted in the realm of scientific education?

In order to answer these questions, we carried out a multimodal analysis of a corpus of advertisements where the concept of energy plays a prominent role, discussing how the interplay of recontextualised conceptual and contextual elements allows the producers to strategically obscure the epistemic content of the text while retaining and foregrounding the legitimising power of science.

As members of the global community, we all share to some extent the identity of consumers. Seeing through the rhetoric of advertising discourses and recuperating the epistemic value of scientific terms would be a step towards becoming more discerning. In this sense, we propose that bringing to light the social and cultural dimensions of the public consumption of scientific discourses could play a productive role in promoting scientific literacy.

Key words: energy education, science representation in advertising, discourse analysis

Science-centric approach to study and teach geological hazards must change

Shah A. A^{1*}, Qibah Reduan¹,

¹Universiti Brunei Darussalam, Brunei Darussalam

Abstract Geological disasters have followed human footprints right from the start and although more than 200 years have been spent in accumulating the wealth of knowledge in understanding hazards and securing people, yet, the battle is still on. Our present work highlights the earthquake science education and outreach related fieldwork experience in India with a core motivation of mapping factors that are crucial in understanding disasters and have largely been neglected in the past. The fieldwork was done in Leh and Kashmir regions where we spoke to local people about their knowledge on earthquake and flood hazards, and it was later published in a journal, however, that publication briefly touched on the historical and political background of the region and its influence on hazards. Therefore, here we argue why it is important to use a holistic approach to deal with hazards. Our fieldwork location is in one of the most intense political conflicts in South Asia, and previous works have suggested that scientists are routinely using a science-centric approach to study hazards, which is why they have failed to achieve goals of studying geological hazards in improving science education and outreach and securing people from hazards. We discovered that the important factors such as the role of political, social, economic, historical, and religious aspects are seldom touched. And our work shows that geological, historical, and political aspects are the three vital ingredients to study and gain a better understanding of how to live with earthquake and flood hazards in the region.

Key words: geologic hazards, social aspects of science, science communication

Conceptual Metaphors in Geoscience Textbooks: Identifying Metaphors and their Characteristics

Droboth, Jason Curtis
Dolphin, Glenn
Karchewski, Brandon
Moldoveanu Constantinescu, Cristina
Sasko, Brolin
University of Calgary, Calgary, Canada

Abstract This presentation explores the role of conceptual metaphor use in geoscience teaching and learning. Conceptual metaphor is giving meaning to an abstract concept (target) in terms of a more concrete concept (source), one developed from embodied experiences. A characteristic of metaphor is that they highlight aspects of reality while hiding others. While experts are aware of what is highlighted and hidden, taking it for granted when teaching or writing textbooks, novices, who do not know which aspects they are supposed to consider or ignore, can interpret the metaphor in unintended ways, impacting learning. Metaphors can also be linked to references more familiar to students from a particular cultural or ethnic background, creating a bias in the learning experience that limits contributions from diverse learners. Using a systematic approach to identify metaphor-related words, we analyzed an online earth science textbook for direct metaphors (those used explicitly to teach a concept), indirect metaphors (regular scientific nomenclature, like “black hole”), and implicit metaphors incidental to the author’s voice. Initial results identify numerous examples of such metaphors including EARTH IS AN AGENT, and EARTH IS A MACHINE. Each has implications for how readers construct their knowledge about the Earth and relevant processes. Future research will explore how students experience such metaphor use in communication with each other and with instructors.

Keywords: metaphor, cognitive linguistics, earth science education

Tuesday, 5 July 2022
Session 6, 8:30am–10:00am
Studio E

Science Education in an Age of Misinformation

Jonathan Osborne, Graduate School of Education, Stanford University

Abstract We are living in an age of misinformation. While it has always been present, the ease with which it is spread threatens trust in well-established science and the foundations of democratic society. Hence, this paper examines how science education might best contribute to the development of the cognitive capabilities required to evaluate the credibility of science information on the internet. The paper is a product of a series of meetings of 10 international experts, both within and outside the field of science education. During each meeting, panel members presented findings and key insights from their research. Panel members were polled for the essential themes and recommendations for policy and practice in science education. The lead authors then produced the report which went through several rounds of revisions. This paper will report the major recommendations and their rationale

Specifically, panelists concluded that science education must teach students about *digital media and information literacy* and *the social practices of science* to prepare students to discern the credibility of science information online. The panelists agreed that digital media and information strategies such as *lateral reading*, *taking bearings*, and practicing *click restraint* would need to be taught alongside understandings of the social nature of the scientific community, such as *how science produces reliable knowledge*, *relevant expertise*, and *managing uncertainty*. These recommendations call for an urgent rebalancing of science curricula to teach more of what the competent outsider needs to know to evaluate and use science information in their daily lives.

Key Words: misinformation; science media literacy; social practices of science

Promoting Pre-Service Physics Teachers' Science Media Literacy

Kendra Zilz, University Hamburg
Dietmar Höttecke, University Hamburg

Abstract The *Science Media Literacy* framework (Höttecke/Allchin 2020) aims to prepare students for the rapidly changing mediascape. Especially social media, which are an increasingly popular source of scientific information for adolescents, contribute to a growing number of unscientific claims. Hence, in the role of consumers, science media-literate students should be able to make reasoned decisions about whether a claim can be considered scientific and trustworthy. In addition to epistemic strategies such as the application of one's own content knowledge, sociological criteria represent a promising, but so far neglected approach. An implementation of any educational strategy in the classroom requires teachers' professional development. Therefore, the promotion of *Science Media Literacy* among pre-service teachers is of great interest. Using a sample of 15 pre-service physics teachers, we investigated to what extent *Science Media Literacy* could be successfully promoted in a pre-post design. Firstly, we investigated which strategies participants used to examine scientific claims. We found that pre-service teachers applied significantly more versatile strategies in the post-test, using not only

epistemic but also sociological strategies. These included checking the professional background of the person making a (non-)scientific claim as well as reflecting one's own epistemic dependence. Secondly, a drawing instrument was used to reconstruct the conceptions of science communication in the scientific community, society and via the media interface. Several preconceptions, such as that science communication is merely based on a transmission of knowledge into society, could be identified in the pre-test. Post-test data indicated that initially shown preconceptions had been challenged.

Key words: pre-service physics education, science media literacy, judging science reliability

Nature of Science through the exploration of a photography

Paulo Mauricio, Instituto Politécnico de Lisboa

Abstract This communication presents the development of a historical case study suitable to use in high school and college as an approach to teaching and learning about science.

We will start from a photography widely available on the internet which first appeared in the journal "Le Radium" in 1904.

That photography allows us to inquiry upon itself, what it aims to communicate, what it shows and hides, and the surrounding socio-scientific and cultural environment at which it was produced and disseminated. Following the thread offered by the photography we can see how the discover of radioactivity is intertwined with the electrometer refined by Pierre and Jacques Curie in their early studies. With the instrument comes also a methodological approach adopted by Marie Curie which dates to Henry Victor Renault's approach to experimental work

We will develop a dialogue between the relevant literature, primary sources, and the photography we referred to, comparing, and contrasting discourses on the role of several people in early studies of radioactivity. The resultant narrative will portray a richer socio-cultural environment upon which we can appreciate science's collective and social endeavors. Also, within this context, we develop upon the role of instruments and the relation between them, physical phenomena, and theories in this context.

Key-words: nature of science, radioactivity, instruments

Tuesday, 5 July 2022

Session 7, 10:30am–12:00pm

Forum

IHPST Business Meeting

All are welcome.

Tuesday, 5 July 2022
Session 8, 1:00pm–2:30pm
Studio A
Featured Symposium

Approaches to NOS Teaching and Learning

This short symposium unites three papers each focusing on aspects of teaching nature of science and spanning the range of instructional settings from school based to free choice. Together they provide valuable insights into the challenges and opportunities related to effective NOS communication.

William F. McComas: What Research Says about Teaching Nature of Science

This presentation takes a wide look at what research says about NOS instruction. As such, the findings when applied appropriately can inform and enhance NOS instruction. The presentation features a consideration of how explicitness, contextualization and student reflection together impact the effectiveness of NOS instruction. This will be accompanied by a discussion of other vital elements related to NOS instruction including scaffolding, learner readiness, the role of targeting NOS misconceptions, and instructional frames (such as the history of science) that may facilitate NOS understanding.

Michael P. Clough: Learners' Responses to the Demands of Conceptual Change: Considerations for Effective Nature of Science Instruction – Clarification and expansion

This paper revisits the important topic of how learners respond to the conceptual change demands that must occur if NOS instruction is to be effective. Clough will highlight vital proposition and arguments from his original 2006 paper on the topic, provide an analysis of the citations of that manuscript illustrating the largely decorative and misunderstood nature of those citations, and expand on ideas touched on in the original article, but now see as fundamental to accurate and effective NOS teaching and learning.

Anna Pshenichy-Mamo and Dina Tsybulsky: Integration of the Nature of Science During Guided Tours of Natural History Museums

The final discussion, led by Pshenichy-Mamo and Dina Tsybulsky, considers NOS in the informal environment of museums. This opportunity for nature of science instruction is poorly discussed in the literature but remains an important venue for such instruction. Here we learn about how natural history museums can help make scientific knowledge accessible to visitors while mediate the different aspects of NOS. This qualitative study using the Family Resemblance Approach as a framework focuses on the ways in which museum educators address epistemic-cognitive aspects of NOS and, to a lesser extent, its social-institutional facets along with unplanned implicit pedagogical approaches to NOS integration.

Tuesday, 5 July 2022
Session 8, 1:00pm–2:30pm
Studio C

Epistemological, ontological and axiological assumptions in science teaching and learning

Ana Couló, Universidad de Buenos Aires. Facultad de Filosofía y Letras

Abstract Knowledge processes of different actors in science education, i.e. science students (as subjects of learning), science teachers (as subjects of teaching), and scientists (as subject members of communities of practice) are underlain by epistemological, ontological and axiological assumptions. The analysis of these assumptions can be related to what current research on conceptual change call the “coherence versus fragmentation stances”, and the *framework theory* approach.

We intend to bring up the effects some of these assumptions have on learning and teaching processes, and to explore ways of turning them into explicit issues for critical analysis in pre-service and in-service science teacher education. We choose the teaching of the natural selection model for evolution (NSME) as an example to examine the concepts of teleology and teleological explanation. Teleology and teleological explanations understood as ends (*telos*) in the sense of agency, intentions or purpose seem to represent important obstacles in the learning of NSME, and to explain several students’ misconceptions. Therefore, one aim of some biology teaching proposals has been to erase teleological thinking. Recently, however, philosophy of biology has questioned the interpretation that denies any role for teleology in the Darwinian theory of evolution. Consequently, similar stances have been taken in science education, revising the “elimination” objectives.

Starting from the basis of the effects EOA assumptions have on science teaching and learning, we aim to explore ways of turning the notions of teleology and teleological explanation into explicit issues for critical analysis in pre-service and in-service science teacher education.

Cognitive-Epistemic Categories of Science in the Turkish Science Curriculum

Gözde Kurt, Ebru Kaya
Bogazici University

Abstract Nature of Science (NOS) has been a significant research area in science education. Reconceptualized Family Resemblance Approach to NOS (RFN) is the recent approach explaining science from a holistic viewpoint. The RFN includes cognitive-epistemic and social-institutional categories of science. In this study, it was aimed to examine the Turkish science curriculum based on the cognitive-epistemic categories of the RFN, which are aims and values of science, methods and methodological rules, scientific practices, and scientific

knowledge. This science curriculum is the current national curriculum that is used for primary and middle school science courses in Turkey. The whole document was analyzed with content analysis by detecting related codes about categories and frequency values of these codes were determined. The frequencies of codes were found as 41 for aims and values of science, 49 for methods and methodological rules, 371 for scientific practices, and 64 for scientific knowledge. On the other hand, the frequencies of codes in special sections including different grade levels are 12, 31, 334, and 48 respectively for categories. The most representative category is scientific practices while the least representative category is aims and values of science. Additionally, it was found that the total numbers of codes are 43, 47, 72, 80, 94, and 89 respectively from 3rd to 8th grade. This means that 7th grade level represents cognitive-epistemic categories more in the Turkish science curriculum.

Keywords: cognitive-epistemic categories of science, science curriculum, content analysis

Energizing science education through critical thinking: An empirical analysis of the relationships between epistemic knowledge and thinking skills in elementary students

María Antonia Manassero-Mas y Ángel Vázquez-Alonso
Universidad de las Islas Baleares, España

Abstract Cognitive thinking skills are increasingly pervading general and science education and research, according to recent literature. Some studies suggest that thinking skills and the competency-based, epistemic and meta-cognitive knowledge, typical of the history, philosophy and sociology of science (HPS) approach, hold a mutual impact and dependence with each other. However, few studies have developed this intuitive relationship and even fewer have focused on empirically show the relationship between thinking skills and epistemic knowledge; further, the literature review suggest that most research on the issue is incomplete, as one of the two terms of this relationship, either thinking skills or epistemic knowledge, is often faulty defined or missing. This paper aims to empirically study the relationship between six thinking skills and four epistemic variables on science conceptualization in a 11-year-old elementary student sample. The empirical results confirm the hypothesis about the relationship between thinking skills and epistemic knowledge, although the data analysis point out some complexities: the relationship is positive and significant between the skills and the adequate ideas on science, but it is neither significant nor positive when the epistemic variables describe misinformed epistemic ideas on science. Furthermore, the interpretations and consequences of these results for research and for HPS teaching, scientific competences and critical thinking skills are discussed.

Keywords: scientific competence, epistemic knowledge, critical thinking skills, conceptualization of science.

Tuesday, 5 July 2022
Session 8, 1:00pm–2:30pm
Studio E

Reframing How We Think About The Design Process in Science Education For Transformative Change

Douglas B. Clark, David Scott, & Sandra Becker
Werklund School of Education
University of Calgary

Abstract This synthetic review explores traditional approaches to educational design that have predominated education for the past century, considers the limitations of these approaches for fostering transformative second-order changes in science education in ways that can counter normative hegemonic arrangements, and contemplates the possibilities of approaches to design from design fields and research on participatory design. The review closes with an exploration of potential approaches for educational design going forward to pursue changes that introduce new goals, structures, and roles to transform science education in service of more equitable futures.

Key words: design engineering, transformative teaching, science education

Teaching Nature of Science to address climate change

Lotte Boven¹, Jelle De Schrijver^{1,2}, Peter Van Petegem¹

1 University of Antwerp – Belgium

2 Odisee University College – Brussels, Belgium

3 Dr. Peter Van Petegem – University of Antwerp

Abstract Global warming is one of the biggest socio-scientific issues that has found its way to the classroom in the form of ‘climate education’. Effective climate education is nevertheless hindered by misconceptions that live among student. Misconceptions on climate change do not only exists about the content knowledge of climate change, for example the claim: ‘*climate warming prediction models of the 80’s did not reflect the real global warming well, therefore, we shouldn’t trust any predications that are made based on models that are used today*’, tells us that role of theoretical models and the alterability of science based on new insights, is not clear. To target these misconceptions a teaching approach that focuses on the epistemological

underpinnings of science and scientific knowledge known as ‘Nature of Science’ (NoS) might be beneficial.

In this presentation we will explore the arguments to incorporate NoS in a context of climate education based on a literature study. This study will also allow us to formulate design criteria for an educational approach which incorporates NoS in climate education. Finally, we will provide small examples illustrating how these design principles can be put into practice. We will also discuss the opportunities and pitfalls of climate education focusing on NoS.

Key words: nature of science, climate education, student misconceptions

How Scientists Perceive NOS and its Value for Science Communication

Sarah Poor, Dr. Ben Herman and Dr. Micheal Clough
Texas A&M University

Abstract A public that demonstrates functional scientific literacy is essential to the resolution of socioscientific issues (SSI) such as climate change. An important component of this functional literacy is a deep understanding of the nature of science (NOS) which enables people to make informed decisions regarding SSI. Scientists’ interaction with the public could be a meaningful form of public NOS education, yet very little research explores scientists’ NOS conceptions and their perspectives on public NOS communication. This triangulated, mixed-methods study investigated scientists’ NOS understanding and evaluated how scientists prioritized various NOS aspects for public science communication. Scientists’ NOS views varied in contextualization and accuracy. For instance, some scientists expressed that science generally should follow a step-by-step method while other participants, using specific research contexts, acknowledged the variety of methods are needed for scientific investigation. This investigation will contribute to the ongoing efforts to improve and leverage scientists’ interactions with the public to promote scientific literacy. The authentic and highly contextualized descriptions of scientists’ work outlined in this study will benefit both science communication specialists and science educators interested in NOS.

Key words: science communication, scientists' NOS understanding, science literacy

Trip to Heritage and Park and Conference Dinner

Please be at the International House by 2:45
See map section at front of program for direction

Wednesday, 6 July 2022
Session 9, 8:30am–10:00am
Studio B

Approximating historical cases to students' realities: a case using Brazilian science

Cristiano Moura, CEFET/RJ

Abstract In this work, considering that pre-formatted schemes for bringing historical cases to the classroom can limit the potential of historical approaches, we aimed to build a strategy to approximate historical cases to issues raised by students during classes. Based on action research, we developed an empirical intervention that was carried out by a teacher-researcher in physics classes in the twelfth year of a Brazilian school. The historical case corresponded to an episode about Brazilian science, focusing on the creation of a national funding agency. Besides purported discussions, as those about the role of funding and institutions in science, the students raised also other themes as gender issues and socioeconomic status of scientists during the intervention. From the data, we explore how the structure of the intervention, less pre-formatted, allowed the emergence of those questions and the discussion of specific issues of Brazilian science, linked to students' realities. We discuss, also, consequences to research and practice with historical cases in classroom.

Key words: historical cases, physics education, secondary education

The Relevance of Science Education Second Project (ROSES): Trends of Spanish Students' Opinions on Science and Technology

Ángel Vázquez-Alonso y María Antonia Manassero-Mas
Universidad de las Islas Baleares, España

Abstract The theoretical and methodological background of this paper is drawn from the multiple elaborations and contributions on the Relevance of Science Education (ROSE) project and related literature that has been energizing the affective side of science education along the last years. The second edition of ROSE, called ROSES (ROSE Second), has been launched on 2020 and this paper displays some early Spanish students' opinions on Science and Technology (ST), as they are strongly related to HPST issues. Further, this paper aims to check the evolution of these opinions by comparing the current trends are with those attained at previous ROSE. The participants are a group of 15-year-old students who rated their agreement with 13 indicators on

ST of the current ROSES questionnaire. The main findings confirm an overall positive opinion on ST that displays its peak at features such as importance for society, cures to diseases, opportunities for the future, healthy and comfortable live, development of countries; on the other hand, its bottom locates at issues such as help to eradicate poverty, solve nearly all problems, help to the poor and benefit the developed countries and cause environmental problems. Further, current students hold better opinions on ST than past ROSE opinions and is also noteworthy a specific item (help to the poor) that largely reverses this trend. Finally, some differences between groups, the psychometric properties of the ST scale and some recommendations for improving STE are presented and discussed.

Keywords: Attitudes towards science and technology; public image of science; scientific and technological education.

History of Technology in Enhancing Scientific and Technological Literacy: The case of Leonardo Da Vinci

Anastasia Ferentinou, National and Kapodistrian University of Athens, Athens, Greece
Constantina Stefanidou, National and Kapodistrian University of Athens, Athens, Greece
Dionisis Vavougios, University of Thessaly, Lamia, Greece
Constantine Skordoulis, National and Kapodistrian University of Athens, Athens, Greece

Abstract This research focuses on improving pre-service primary teachers' scientific and technological literacy combining the introduction of the history of technology and especially using the manuscripts of Leonardo da Vinci with the storytelling, as a teaching tool. The manuscripts of Leonardo da Vinci are demanding, regarding their didactical use. To overcome such difficulties, storytelling is utilized as a teaching tool so that the manuscripts can be used without adaptations which could lead to serious misunderstandings, and thus making the historical material functional. An inquiry-based didactical intervention was designed and implemented in pre-service primary teachers consisting of three two-hour lectures. Both a pilot and a main research were carried out. A total of 48 students participated in the experimental and 49 in the control group, in the main phase of the research. Regarding research tools, the same pre and posttest questionnaire were used. Worksheets and PowerPoint presentations, supporting the storytelling process, were given to the participants during the teaching intervention. Qualitative content analysis and descriptive statistics were used to analyze the data. Findings reveal

statistically significant improvement in pre-service primary teachers' understanding of the concept of force particularly its vectorial characteristics, the understanding of the basic characteristics of levers and the recognition of their type. Further research in the field could shed light on the advantages of learners' personal drawings and designs in conceptualizing simple machines and their applications.

Keywords: conceptual understanding, science education, scientific literacy

Wednesday, 6 July 2022
Session 9, 8:30am–10:00am
Studio C

Critical scientific realism and the teaching of the Nature of Science: proposing philosophical subsidies against naive realism and relativism

Felipe Prado Corrêa Pereira, Ivã Gurgel
Physics Institute, University of São Paulo

Abstract Over the last few decades, many contributions have been made in the field of science education in order to integrate scientific disciplines with meta-scientific knowledge. The insertion of History, Philosophy and Sociology of Science seeks to cultivate more faithful conceptions of scientific work, its history and philosophical and social implications of this activity, in opposition to naive views commonly propagated by common sense. The proposition of a set of consensual aspects about the Nature of Science is an important advance for the consolidation of this project, and are fruitful guides for teaching practice in basic and higher education. We will seek to show in this work the potential implications of the debate about scientific realism as an approach for teaching the Nature of Science. In particular, we discuss the cognitive status of theoretical systems in highly mathematized disciplines such as Physics. We

adopt a conception inspired by the critical scientific realism of the physicist and philosopher Michel Paty. His work leads to clarifications on the nature of the physical object and contributes to a philosophically critical view of some of the tenets of the Nature of Science, in particular: the subjectivity traits present in scientific activity; the role of imagination and creativity of scientific knowledge (Lederman et al, 2002; Lederman, 2007; McComas, 1998, 2020).

Key words: physics education, critical scientific realism, epistemology

Gods and Quarks: A Rhetorical Approach to Particle Physics

José Guilherme Licio, Cibelle Celestino Silva, Universidade de São Paulo

Abstract We present some considerations on how studies concerning the *rhetoric of science* are helpful in order to teach particle physics to high school students. We propose an original approach on particle physics by analyzing how rhetoric affects the arguments of scientists and science enthusiasts. We aim to foster a critical, meaningful learning of this important field of modern physics. The analysis was carried out by selecting specific historical episodes concerning developments of particle physics, in order to verify how scientists and science enthusiasts (for example, science journalists) use rhetorical arguments to persuade and convince their audiences of the importance of their fields of research. Typical rhetorical elements we highlight in our studies are, for example: use of exaggerations and metaphors in order to make the physical concepts more easily understandable by the audience, and possible conceptual distortions done on purpose to persuade or convince the audience. On the process of persuading and convincing other scientists, politicians and general audiences on the importance of particle physics, scientists and enthusiasts often distort scientific ideas in order to be more appealing or easily understandable. Being aware of this aspect of how science works in a historical, political society may lead students to achieve a more critical way to think about science, distinguish between a scientific argument and a rhetorical argument and understand why scientific developments are trustworthy.

Keywords: rhetoric of science, history of science, science teaching

Exploring the advantages of integrating philosophy of physics for reforming physics education. Theoretical and practical solutions for critical thinking, instruction, textbooks, and nature of science learning.

Roland M. Schulz, CIRCE, Simon Fraser University, Vancouver, Canada
Calvin S. Kalman, Dept. of Physics, Concordia University, Montreal, Canada.

Abstract This session is a follow up to the brief IHPST Panel presentation on the two authors' chapter submission for the forthcoming 2023 *International Handbook on Physics Education Research* (IHPER). It aims to provide more depth and allow time for questions and answers. The co-authored chapter is entitled: "*Philosophy of physics: Its significance for teaching and learning.*" It examines the nature of the philosophy of physics, what it is, why it is important, and its contributions to improving physics teaching and learning. It highlights problems in physics education culture that neglects philosophy, and surveys the relationship philosophy *and* physics (including skeptical voices against its use). It introduces for the first time "philosophy of physics" into the education research literature (including past and present problems), and builds upon issues raised in that academic sub-discipline while specifically addressing pedagogical and curricular themes. We hope to clarify the themes of philosophy *and* physics, philosophy *in* physics and philosophy *of* physics.

KEY WORDS: Philosophy of Physics; physics pedagogy; curriculum reform

Wednesday, 6 July 2022
Session 9, 8:30am–10:00am
Studio D
Symposium

Praxis oriented research on Nature of science teaching aiming at Social Justice

Organisers:

Andreia Guerra, Centro Federal de Educação Tecnológica Celso Suckow da Fonseca
(CEFET/RJ), Brazil

Lena Hansson, Kristianstad University, Sweden

Abstract This symposium takes a starting point in a recently suggested research program focusing on the characteristics of nature of science (NOS) teaching aiming at social justice (SJ) (Yacoubian & Hansson, 2020). We take a starting point in a need for science education research to engage in empirical investigations of what can characterize such teaching. Different research projects performed in 'ordinary' science classrooms situated in different political, social, and educational contexts are presented during the symposium. However, they share a common interest in praxis-oriented research exploring characteristics of NOS teaching that aims at SJ. Without intending to present generalizations about what teaching NOS for SJ entails, the symposium seeks to advance the discussion on NOS-teaching for SJ building on the experiences and empirical results from the different projects. The discussion focuses on the challenges and

benefits of different focuses, contents and approaches, and outlines ways forward for research and practice.

Presenter names:

- **Haira Gandolfi**, University of Cambridge, UK.
Title of the presentation: *Decolonising science curricula: reflections on decoloniality, HPSS and school science in the 21st century*,
- **Hagop A. Yacoubian, Joelle Barbar & Rein El Maarawi**, Lebanese American University, Lebanon. Title of the presentation: *Nature of Science in Science Textbooks through Gender Representation*.
- **Andreia Guerra & Priscila Amaral**, Centro Federal de Educação Tecnológica Celso Suckow da Fonseca (CEFET/RJ), Brazil.
Title of the presentation: *Challenging the non-situated human body' teaching: a study developed in a Brazilian school*.
- **Lena Hansson & Lotta Leden**, Kristianstad University, Sweden
Title of the presentation: *Nature of science, open-ended investigations, and students' agency*

Keywords: Nature of Science, Social Justice, praxis

Wednesday, 6 July 2022
Session 9, 8:30am–10:00am
Studio E

The Science Teachers' Views on Social-Institutional Aspects of Science Represented in the Science Textbooks

Beyza Okan & Ebru Kaya

Bogazici University

Abstract Reconceptualized Family Resemblance Approach to Nature of Science (RFN) is one of the approaches of nature of science (NOS) emphasizing the epistemic, cognitive, and social-institutional aspects of science. This study which is a part of a funded project examines the science teachers' views on social-institutional aspects of science represented in national science textbooks and their suggestions to integrate them into science textbooks. Semi-structured interviews were conducted with eight science teachers who were selected by convenient sampling method. The interview questions are about the representation of social-institutional aspects of science including social certification and dissemination, professional activities, scientific ethos, social values, social organizations and interactions, financial systems, and political power structures in science textbooks. Almost all teachers stated that they do not use textbooks to teach social aspects of science because the textbooks don't include NOS ideas

adequately. Some teachers stated that it is not necessary to integrate some social categories which are scientific ethos, social values, financial systems, and political power structures in science textbooks. On the other hand, they offered suggestions to include NOS ideas in textbooks such as integration of the history of science, technology, questions, and activities to teach social-institutional aspects of science explicitly. Overall, the study has implications for the integration of social-institutional aspects of science holistically in science textbooks.

Keywords: Family Resemblance Approach, Science Teachers, Science Textbooks

6TH Grade Students' Understanding of Nature of Science and Their Metacognitive Awareness

Dilara Goren, Boğaziçi University
Ebru Kaya, Boğaziçi University

Abstract This study investigates the relationship between middle school students' understanding of Nature of Science (NOS) with theoretical framework of the “*Reconceptualized Family Resemblance Approach to Nature of Science (RFN)*” and their metacognitive awareness. In NOS learning process students' metacognitive processes and skills might be related with their NOS understanding. Totally 167 6th grade students completed “RFN Student Questionnaire” and “Metacognitive Awareness Inventory for Children”. In addition, three students were interviewed. The data was analyzed through Pearson correlation and thematic analysis. The result of Pearson r correlation shows that there is a statistically significant positive relationship between 6th grade middle school students' RFN understanding and their metacognitive awareness. The interview findings show that students' responses to the RFN and metacognitive awareness-related questions were similar and compatible. The student who was metacognitively aware had a higher RFN understanding. This high-level student was using some metacognitive strategies such as evaluation, management of learning, awareness in his learning process and was able to explain many categories of science with diverse examples including epistemic-cognitive dimensions. The student with low metacognitive awareness were less likely to express use of strategies and possess naïve views on categories of science. Alignment in high- and low-level students' expressions and quantitative results point the possible relationship between NOS understanding and metacognitive awareness. This study adds to the growing body of research for inclusion of the use of metacognitive strategies in NOS teaching and learning.

Keywords: Nature of Science, Metacognitive Awareness, Middle School Students

Exploring Preservice Teachers' Pedagogical Content Knowledge for FRA-related NOS Teaching

Jerrid Kruse, Drake University

Sarah Voss
Isaiah Kent-Schneider
Ren Daemicke

Abstract To support preservice teachers' learning to teach NOS, more work is needed to understand how they conceptualize, learn, and enact NOS instruction, particularly with respect to more nuanced NOS frameworks such as the family resemblance approach (FRA). Throughout a semester-long course targeting the nature of science (NOS) in science education, preservice teachers' NOS pedagogical content knowledge (PCK) was assessed to determine how and when understandings grew. The preservice teachers demonstrated growth in PCK across the semester, but variations across PCK constructs and the rings of the FRA NOS framework were observed. These differences may inform teacher educators as they work to help preservice teachers develop pedagogical strategies for teaching NOS beyond the consensus view. Findings illustrate the importance of explicit and reflect instruction concerning NOS pedagogy as well as NOS content and the importance of NOS teaching experience for the development of NOS PCK.

Key words: preservice teacher education, pedagogical content knowledge, family resemblance approach

Wednesday, 6 July 2022
Session 10, 10:00am–12:00pm
Fourm
Plenary Session

Tamaratt Teaching Professor in Geoscience Invited Speaker

How Anomalies Drive Scientific Discovery

Dr. Carol Cleland, University of Colorado, Boulder, Center for Study of Origins

Abstract This talk discusses the pivotal role that **recognition** of anomalies plays in scientific discovery and its application to the search for extraterrestrial life. I begin by discussing the difference between an anomaly and a merely puzzling or ambiguous phenomenon. I then explore cases from the history of science illustrating how difficult it is for researchers to initially recognize that a phenomenon is **truly** anomalous. Subsequently, I analyze how scientists have responded historically to recognition that a phenomenon is anomalous, identifying the stages involved in moving from recognition that a phenomenon is anomalous to scientific discovery. Discovery may involve major theoretical changes but not always. It sometimes involves rejecting widely entrenched dogmas that are not well-grounded in theoretical considerations. One of the goals of this analysis is to show how to short-cut the process of recognizing that a phenomenon is anomalous, and hence worthy of focused scientific investigation, for the purpose of speeding

up the process of scientific discovery. The second part of the talk explores several unresolved contemporary scientific anomalies in light of the considerations developed earlier.

Wednesday, 6 July 2022

Session 11 (Posters), 1:00pm–2:30pm

Forum

A HISTORICAL ANALYSIS OF THE SCIENTIFIC PRACTICE OF THE BRAZILIAN ASTRONOMER D'ALMEIDA IN THE FRENCH SCIENTIFIC MISSION TO OBSERVE THE TRANSIT OF VENUS IN 1874

Maria Romênia da Silva, Center for Exact and Earth Sciences/ Graduate Program in Natural Sciences and Mathematics Education/ Federal University of Rio Grande do Norte (UFRN), Natal, RN, Brazil

André Ferrer Pinto Martins, Department of Educational Practices and Curriculum/Education Center/ Federal University of Rio Grande do Norte (UFRN), Natal, RN, Brazil.

Abstract The work addresses the participation of the Brazilian astronomer Francisco Antônio de Almeida Júnior in the French mission to observe the transit of Venus on December 9, 1874, in Nagasaki, Japan. The research aims to analyze, from the perspective of the Cultural History of Science, the scientific practice of the Brazilian astronomer in the 19th century as a possible way to rescue elements from the History of National Astronomy. As it is an investigation of a historical nature, we use the most traditional methods (consultations in primary, secondary, and local sources) as recommended by historiographical work. Upon returning to Brazil, d'Almeida published two works directly associated with the experiences he had during the expedition carried out to observe the traffic: a scientific report and a travel report. The works are distinguished by the nature of the content covered, one considered to be scientific (*Parallaxe do Sol and the passages of Venus -1878*) and the other more historical (*From France to Japan: Travel narration and historical description, uses and customs of inhabitants of China, Japan, and other Asian countries -1879*). Despite his contributions to different areas of knowledge, Francisco Antônio de Almeida Júnior does not appear in the history of National Astronomy as a character whose memory has been crystallized. However, the astronomer proves to have been a key character who expresses the desire and commitment of a generation of intellectuals interested in better understanding the country, with ways of making it move forward based on European references.

Key words: history of astronomy, scientific practice, transit of Venus

The Zeitgeist Concept in Science and Art Proposals and the Role of the Historical-Cultural Perspective in Science Teaching

José Claudio Reis, Professor do Programa de Pós-Graduação em Ciência, Tecnologia e Educação, CEFET/RJ – UERJ

Washington Luiz Raposo, Professor de Física - Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, Campus Nova Friburgo – CEFET-RJ/NF.

Giselle Faur de Castro Catarino, Professora do Programa de Pós-Graduação em Ciência, Tecnologia e Educação, CEFET/RJ – UERJ.

Abstract

In this study we discuss the assimilation of the concept of Zeitgeist (“Spirit of an age”), from German idealism, in proposals for Science and Art in science teaching. We also present an appropriate concept of culture for such activities and defend the use of themes in which, in fact, these areas dialogue historically and culturally. The concept of Zeitgeist, for G. W. Friedrich Hegel (1770-1831), represents a kind of consciousness that presents itself collectively in a given historical and cultural context. For Hegel, there are no “truths” detached from the moment and the historical context of each epoch (REALE and ANTISERI, 2005). In our view, this concept fits perfectly as a contextualization element for interdisciplinary science teaching proposals. That is, finding a Zeitgeist for the desired period, with a theme suitable for both sciences and arts, would promote an interdisciplinary convergence by nature. We cite as an example the discussions regarding the fourth dimension of the philosophy of hyperspace, the visual arts, science fiction literature, and physics, at the end of the 19th century (HENDERSON, 2013); the idea of evolution, in the biology, social sciences, anthropology, politics and economy of the 19th century (MELLO, 1982); the idea of the fragmentation of matter, which appeared in physics, philosophy and visual arts in the mid-twentieth century (REIS, GUERRA and BRAGA, 2006).

Keywords: Zeitgeist; Historical-Cultural Approach; Science Education

The construction of Scientific knowledge and its teaching: a study about the Nature of Science and Scientific Literacy

Giselle Faur de Castro Catarino, Professor do Programa de Pós-Graduação em Ciência, Tecnologia e Educação, CEFET/RJ – UERJ

José Claudio de Oliveira Reis, Professora do Programa de Pós-Graduação em Ciência, Tecnologia e Educação, CEFET/RJ – UERJ

Abstract In this article, we aim to reflect on the construction of scientific knowledge and its teaching based on fundamental matters pertaining to Science education, considering the pandemic scenario that reinforced the need for changes. In this sense, we see the need to develop

spaces for reflection and decision-making regarding the promotion of an education that is more committed to socializing the knowledge that has been consolidated in this research field.

Aiming for an education that seeks to provide a scientific education for citizens that worry about sustainable social development, we begin with a more general question that has already been posed by many authors in the field – What is the role of Science Education? Our focus is on reinforcing the sense of urgency in conducting necessary changes already indicated by the research, especially regarding the Nature of Science and Scientific Literacy. The historic-philosophical viewpoint is also necessary to enable a view of Science as non-cumulative and non-linear knowledge, emphasizing the historical evolution of the concepts and facilitating the understanding of Science as a human activity and as Culture (ZANETIC, 1989), directly influenced by social, cultural, political, and ethical factors (GUERRA, BRAGA e REIS, 2013).

We hope to contribute to the Science Education research field and to the subjects' future practices, emphasizing that not knowing what Science is and how it was historically produced can lead to distortions and to what are known as post-truths and anti-science movements (LIMA et al., 2019).

Keywords: Physics teaching; Nature of Science; Scientific literacy

What is the point of science education? Students' ideas about the usefulness of science education analyzed through the lens of Nature of Science

Johanna Andersson, Lena Hansson and Lotta Leden
Kristianstad University

Abstract The study presented here is part of a doctoral dissertation project and aims to investigate students' ideas about how science can be useful and of relevance to them, and in what ways Nature of Science (NOS) is related to these ideas. The project is part of a line of research focusing on NOS teaching that aims for agency and social justice. Previous research shows that students who do not strive for a career in science often view science education as irrelevant. A science education aiming for agency could possibly increase the relevance. The students in focus are upper secondary students in Sweden who are not specialized in science, but study other preparatory or vocational programs. Data was gathered through six focus groups, each group consisting of three to five students (in total 24 students) who all have studied, or were at that moment studying, a mandatory science course for students who do not study the science program. The analysis is thematic and empirically grounded. The first step of the analysis focuses on identifying different ideas about the usefulness and relevance of science education. The second step scrutinizes if and how NOS is related to the different themes that emerges from

the first step. The results are discussed in relation to ‘critical science agency’, as described in Basu et al. (2008).

Key words: citizenship, agency, usefulness

“I know the science of it but I won’t eat it”: A study of high school teachers’ knowledge and attitude of food safety

Lee, Huei and Chiang, Chia-Ling

Department of Education and Human Potentials Development, National Dong-Hwa University, Taiwan.

Abstract Food safety is one of the key areas of focus in public health; however, the information about food safety in the media is full of pseudo-science. There is no denying that scientific media literacy is seldom discussed in school science, and students get the most of the information about food safety from the media and generally have pseudo-scientific beliefs (Martin, 1994). Duschl (2012) pointed out that the teacher is the key that will help [students] unlock how to fully understand the best coherent sequences for learning and teaching; therefore, this study aims to explore teachers’ knowledge and attitudes of genetically modified food (GMF) and food additives, and the correlation between their knowledge and attitudes. 180 high school teachers were invited to complete two questionnaires about food additives and GMF. The results showed that the science-background teachers significantly had better knowledge and positive attitude of GMF than non-science teachers. No gender difference existed in both knowledge and attitude. The teachers’ knowledge and attitude were medium-correlated in GMF, but had no correlation in food additives. Besides, high school teachers tended to trust the information from the independent experts, not from the government (72.1%). Despite the government had repeatedly stated that pork with ractopamine is of no safety concern, high school teachers still had no willing to buy or eat it (82.8%). It showed that there is still a gap between teachers’ knowledge and attitude of food safety, and studies about teachers’ reasoning and arguments could be explored in the future.

Keywords: food additives, genetically modified food, scientific media literacy.

Merging climate policy simulation games and systems thinking approach in an environmental education program

Sena Yildiz Degirmenci¹, Gaye D. Ceyhan², Meltem Ceylan Alibeyoglu³

¹Systems Thinking Association, Turkey

²Bogazici University, Department of Mathematics and Science Education, Istanbul, Turkey

³Bogazici University, Institute of Environmental Sciences, Istanbul, Turkey

Abstract We live in a world with complex and dynamic socio-environmental problems. However, individuals have difficulty in critically evaluating the complexity of the systems. Explicit instruction of systems thinking is effective in promoting scientific thinking and

problem-solving skills. With this purpose, we developed the *Environmental Education with Systems Thinking and the World Climate Game* project to provide a comprehensive climate change and environmental education program for middle school students. This study aims at exploring how simulation games, within that project, influenced students' attitudes towards climate change. Nineteen academically-talented low-income 8th grade students participated in the study. The systems thinking approach was implemented as a methodology and two simulation games, climate change policy simulator (C-ROADS) and climate solutions energy simulator (En-ROADS), were utilized as educational tools. C-ROADS (Climate-Rapid Overview And Decision Support) is a simulation-based role-playing game in which students simulate the United Nations climate change negotiations and test emission reduction policies in the simulator program. En-ROADS (Energy-Rapid Overview and Decision Support) is, on the other hand, a policy simulator that lets students explore the impact of policies on various factors like energy prices, temperature, and air quality. Findings revealed that the majority of the students emphasized their hopefulness about fighting with the impacts of climate change. The students expressed the importance of countries working together in coping with the climate crisis. The results of this study may contribute to environmental education literature by providing some insight for designing systems-based instructional programs that can potentially improve students' systems thinking skills.

Key Words: Systems thinking, climate change education, simulation games

Wednesday, 6 July 2022
Session 12, 3:00pm–4:30pm
Forum

Meet the Editors of Science & Education

Sibel Erduran, Editor-in-Chief
Olivia Levrini, Associate Editor
Mauricio Pietrocola, Associate Editor
Gabor Zemlen, Book Review Editor

Abstract A significant academic activity involves publication of research findings in journals. Publications enable researchers to disseminate their work and the process of publishing engages the research community in the certification and validation of knowledge. How can researchers make their manuscripts suitable to journals for publication? What are the criteria for evaluation? How does the peer review process work? The session will visit such questions in the context of *Science & Education* which is published by Springer and is affiliated with IHPST. The journal publishes research using historical, philosophical, and sociological aspects of science in order to improve teaching, learning, and curricula. Furthermore, it promotes the discussion of the philosophy and purpose of science and mathematics education and their place in and contribution to the intellectual and ethical development of individuals and cultures. *Science & Education*

fosters collaboration among scientists, mathematicians, historians, philosophers, cognitive psychologists, sociologists, science and mathematics educators, and school and university educators. The session with the journal editors will facilitate the participants' understanding of the journal processes and it will provide an opportunity for in-depth conversations.

Wednesday, 6 July 2022

5:00–6:00

Original dramatization

University Theater

Formations

By Meg Braem

Created by Drama Faculty Christine Brubaker & April Viczko in collaboration with Dr. Glenn Dolphin, Geosciences

This performance is an exciting collaboration between UCalgary Drama & Geoscience. It explores the lives of Marie Tharpe (1920-2006/ ocean cartographer), Eunice Foote (1819-1898/ atmospheric warming), Dollie Radler Hall (1897-1995/ discovery of oil using seismic energy), and Florence Bascom (1862-1945/ Geoscience educator) four under-recognized female scientists and their discoveries, and how the role of gender influenced their practice and how history recorded - or forgot them. This event is presented as part of the Alchemy Festival.

Thursday, 7 July 2022

Session 13, 8:30–9:30

Studio A

An interpretative analysis of Werner Heisenberg's "Science and Religion (1927)"

Daniel Pigozzo, Federal University of Rio Grande do Sul

Abstract Considering how positivist and pragmatic the teaching of quantum physics can be and the difficulty in finding primary sources capable of contributing to pedagogic discussions and to a complex understanding of the Nature of Science, we discuss the seventh chapter of Werner Heisenberg's "Physics and beyond", entitled "Science and religion (1927)". Through the theoretical lens provided by the works of the Bakhtin Circle, we hope to propagate a pedagogic perspective in which both the development of mathematical skills and the comprehension of historical and epistemological elements of scientific practices can be justly valued. We base our analysis on the different theological and epistemological arguments within the text, and their sociocultural context. In conclusion, we argue for the recognition of the fact that the most famous interpretations of quantum mechanics did not solely depend on mathematical or empirical

arguments for their developments and were inspired and complemented by diverse and unorthodox, or ‘alternative’, philosophical ideas.

Key words: Heisenberg, physics education, science & religion

An aesthetic and philosophical approach to teaching the Uncertainty Principle

Eduardo Gois, Colégio Franciscano São José
Nathan Willig Lima, Universidade Federal do Rio Grande do Sul

Abstract The contemporary scenario, in which anti-science movements proliferate, and in which different groups dispute the acceptance of public opinion, establishing what some authors call post-truth, requires us to reflect not only on how it is possible to teach science; but above all about how it is possible to impact public opinion on science. We argue that the only way for the scientific community to gain space on the public stage is to increase the dialogue between the specialized community and the different sectors of society. In order to contribute with this perspective, our objective, in the present work, is to discuss the development of a concept of Quantum Physics, the Uncertainty Principle, in the light of Bakhtin’s reflections on aesthetics and communication. Our research method is what Bakhtin calls Metalinguistic Interpretation, an interpretation of the texts studied, in which characteristics of the statement (such as theme, structure and style) relate to elements of the social context. We analyzed three statements written by Werner Heisenberg: his article on the Uncertainty Principle, a book on Philosophy of Physics and a book with a collection of his texts on various subjects. We evaluated the themes addressed by Heisenberg, his philosophical commitments, and his political concerns in the three utterances. We also analyzed how the enunciative style (a typically aesthetic characteristic) is mobilized in the different statements to meet the scientist’s speech project.

Key words: Schrödinger, history of physics, epistemology

Thursday, 7 July 2022
Session 13, 8:30–9:30
Studio B

"Ethics against Chemistry": History of Science and Alternative History as Essential Science Communication Tools for Middle-School Students

José Ferraz-Caetano; Dora Dias

LAQV-REQUIMTE Faculty of Sciences, University of Porto – Portugal

Abstract Developing an entertaining science dissemination activity can be a great challenge to teach and communicate science to a young audience. But creating an insightful science outreach narrative from scratch can be quite a challenge. With this in mind, tools like storytelling can be a valuable element to promote interest in science, enhanced by the rich episodes of the global History of Science.

In this communication we will explore how we developed a science outreach activity, combining the prerogatives of storytelling, gamification and historiography. We will demonstrate how the inclusion of Alternative History elements can be useful when designing an educational game, forming the basis of educational storytelling of scientific topics. A practical case will be presented in which the Portuguese History of Science and the inclusion of alternative hypotheses proved to be essential tools for the creation and implementation of a science communication activity. We will also explore the students' feedback on their learning experience and their scientific performance during the game.

Key words: history of science, gaming, chemistry education

Developing interactive e-books for teaching about the nature of science

*Eleni Gentzi & Fanny Seroglou
ATLAS Research Group, DiDes Research Lab,
School of Primary Education, Faculty of Education,
Aristotle University of Thessaloniki*

Abstract This paper is part of a larger study that attempts to design and evaluate educational material about the nature of science (NOS) teaching. In particular, this material concerns interactive e-books, enriched with elements of the nature of science, the history of science and the philosophy of science. These books are part of a series of books for children, named *The Adventures of the ATLAS Group* that is commercially available in print. The interactive e-books are hosted in an interactive, multimodal, online environment, which is free to the general public. This paper presents the basic principles of their design, the tools used for their development as well as for the development of the interactive applications that are included in them, their analysis with the GNOSIS research model and also their analysis with a research model developed for analyzing interactive e-books. This is the presentation of the first attempt to develop an interactive, multimodal, online environment, enriched with elements of the nature of science, the history of science and the philosophy of science. The digital library of interactive

e-books aims to be a source of inspiration for science learning and teaching for future and current teachers, students, parents and visitors, who have free access. The goal is to redefine the traditional written discourse in this multimodal online environment and move science learning to the digital citizenship era.

Key words: interactive e-books, nature of science, educational material

Thursday, 7 July 2022

Session 13, 8:30–9:30

Studio C

Uncertainty as NOS-Facet? An analysis of existing conceptualizations of NOS

Britta Lübke & Julia Schwanewedel (University of Hamburg)

Abstract Uncertainty can be described as a necessary element of scientific knowledge acquisition (cf. Kampourakis & McCain 2020). The previous research on uncertainty in science education argumentatively refers to the existing NOS discourse and to NOS conceptions - in particular to the aspect of "tentativeness" (cf. e.g. Buck et al. 2014, p. 2393f.). Nevertheless, a systematic relation of the two discourses to each other is still missing. The aim of the presentation is to discuss to what extent uncertainty can and should be described as a facet of NOS. In a first step, we analyze different conceptions of NOS and investigate the extent and the form uncertainty is thematized. Based on the systematization of Heering & Kremer (2018), the following three approaches were selected for analysis (1) Nature of Scientific Knowledge and Nature of Scientific Inquiry (cf. Lederman 2007; Lederman et al. 2014), (2) Nature of Whole Science (cf. Allchin 2013), and (3) the Family Resemblance Approach (cf. Erduran & Dagher 2014). In a second step and based on the results of the analysis including findings on the role of uncertainty in the scientific knowledge process from science studies (e.g. Latour & Woolgar 1986; Knorr Cetina 1999 or Nowowty 2016), we will discuss in which form science education can and should deal with uncertainty in classroom. In addition, the resulting consequences for the conceptualization will be mooted.

Keywords: uncertainty, nature of science, scientific knowledge

Learning about History of Science and Nature of Science in a student-centred classroom to change science students' conception of science

Fereshte Heidari Khazaei , Baptiste Roucau and Calvin S. Kalman
Concordia University, Montreal, Quebec, Canada H4B 1R6

Abstract Nature of Science (NOS) covers the aim, development, criticism and explanation of science. This study examines the impact that studying philosophy and history of science has on undergraduate students' views about the NOS. Studying the NOS helps students to understand what science is, how to characterize the nature of its practitioners' activities, and what is the significance of the whole enterprise. It is shown that having students study scientific concepts through the eyes of philosophers and historical scientists, actively engages them in the process of inquiry and challenges them to increase their understanding of the NOS. This study showed that studying philosophy and history of science in a student-centered classroom had a strong influence on students' views about the NOS in that many students changed their views about the NOS. Students who did not change their over-all perception gave much clearer expositions of their views.

Key words: history and philosophy of physics, physics education, post-secondary education

Thursday, 7 July 2022
Session 13, 8:30–9:30
Studio D

Service mathematics teachers' knowledge: A case of Discipline Culture Approach in mathematics.

Lina Vinitsky-Pinsky, Achva Academic College
Sabine Segre, Achva Academic College

Abstract Knowledge organization is a subject which is of particular importance during the “knowledge revolution” and “information explosion”. It is especially relevant today, during the Covid-19 pandemic, when educational institutions need to learn to work with online instruction. We argue for a new approach in teaching mathematics that may provide initial guidance through the appropriate knowledge organization, by converting the curriculum from a strictly disciplinary one to a discipline-cultural (DC) curriculum, and by converting content knowledge to cultural

content knowledge (CCK). By adopting the idea of “summary lectures” , we have developed new educational materials in three subjects for teachers and student teachers of both elementary and high school mathematics in the following subjects:

- John Napier and of the concept of logarithms.
- Cantor and Infinity.
- Rational numbers vs irrational numbers throughout history.

The aim of the study is to examine the attitudes of student teachers and current teachers towards the history of mathematics, content knowledge and a summary lecture, after participation in the summary lectures.

The questionnaires which were used in a study had both quantitative and qualitative parts.

The study results suggest that teachers recognize that the purpose of summary lectures is to connect different areas and pieces of knowledge, it allows them to see connections and to see the development of mathematical ideas in an historical context. It shows the importance of organizing existing knowledge, key ideas and hierarchy of knowledge.

Key words: knowledge organization, math Education, secondary education

The nature of engineering in science classrooms: How do teachers portray engineering, and how should they portray it?

Jacob Pleasants, University of Oklahoma

Abstract In recent years, there has been a growing trend to include engineering as part of pre-college science instruction in countries around the world. In the United States, where the present study was conducted, engineering is now a part of science standards and many science curricula across all grade levels. Engineering and science are not the same, and the attention being given to the engineering disciplines raises new and important questions for educators, researchers, and teachers. How is engineering being portrayed in classrooms? To what extent do those portrayals provide students with an accurate view of the nature of engineering (NOE). What should students learn about the NOE, and to what ends?

To engage with those questions, I first present the results of an empirical study conducted in upper elementary (grades 3-5) classrooms in the United States. In this study, classroom observations were conducted of the engineering instruction implemented in nine classrooms. Analysis of those lessons revealed a consistent portrayal of engineering. Engineering design was

portrayed as a highly structured (often step-by-step) process of creating a physical product to meet a set of requirements (derived from a “problem statement” provided by the teacher or hypothetical client). While this portrayal accurately conveys the NOE in some respects, it includes several distortions. However, a crucial question is the extent to which those distortions matter from an educational perspective. In this presentation, I will advance a set of recommendations regarding NOE instruction and interpret the results of the study in light of them.

Key words: nature of engineering, STEM education, engineering education

Thursday, 7 July 2022

Session 14, 10:00–11:30

Studio A

Teaching Histories of Medicine and Science in Canadian Medical Schools: arguments for its relevance to formal training in medicine.

Dr. Fedir Razumenko, Ph.D., University of Calgary, Canada.

Abstract Histories of medicine and science explain how we got to where we are now and contextualize the present. By getting to know some of the chequered past, medical students could become a bit more humble or cautious about scientific advances, and a little more aware of social factors in health. Teaching histories of medicine and science may also make the students skeptical about everything else that they are being taught. To what extent the proposition that future doctors benefit from an objective understanding of historical thinking and method is valid?

In the Canadian context, historians produced little scholarship to appreciate how clinicians, non-medical professionals, and policymakers balanced decisions on the relationship between scientific-medical pursuits of knowledge about human bodies and compassionate care in a healthcare system. Since at least the 1960s, patients demanded a voice in determining more compassionate outcomes through law courts and the media, as they wanted greater access to novel treatments, more involvement in control of research, and harsher punishments for wrongdoing. This was especially evident in cancer care and research. I argue that Canadian cancer patient activism made patient-oriented approaches to oncological research and care possible through amassing different forms of credibility which complemented expert knowledge in the long run. It was critical knowledge for balancing different scientific-medical claims about available treatment modalities. Thus, cancer patients became activists in the construction of scientific-medical knowledge. This scholarship indicates that history as a research discipline could be of use to training in medicine and clinical research.

Key words: history of medicine, medical training, patient oriented care

Political Uses of Science Education in Pre and Postwar Japan: Cultivating Scientific ‘Japanese Spirit’ in Primary and Secondary Schools in Japan, 1931-1958

Duim Huh, The University of Tokyo

Abstract Recently, historians of science education have become increasingly aware of the close relationship between science education and its social, cultural, and political settings. In the Japanese context, however, scholarly attention has rarely been paid to this politics of science education, despite the historical experience of political and ideological conflicts on educational aims and methods, especially in interwar and postwar Japan. This paper aims to redress this neglect by examining the (re)building of postwar Japanese education in its twisted relationship to the wartime science curriculum, which was meticulously designed for cultivating ‘Japanese spirit’ against what was seen as the decadent materialistic Western scientism during WWII. My focus will be on Shiono Naomichi (1898-1969), a curriculum and textbook revision director for science and mathematics in the MOE from 1924 to 1944, and a best-selling textbook writer in the 1950s. Shiono composed a set of textbooks implementing ‘Japanese spirit’, distinctively Japanese ways of thinking, during the interwar and wartime periods. After WWII, he vigorously promoted reversion to the wartime textbooks and their underlying spirit, criticizing then imported American style progressive education, designed to demilitarize and democratize Japan, as ‘outdated’. Shiono’s postwar promotion of Japanese ways of thinking as universal principles and educational methods was crucially hinged on erasing their original political implications. By examining various documents and science textbooks, this paper will show what political functions science education had in wartime imperial Japan, how such political functions were ‘depoliticized’ in the postwar era, and what was the historical legacy.

Key Words: political use, school textbook, Japan

Teaching Gene Editing Differently? Exploring the Intersection of Reflection and Gene Editing

Roshanne Sihota, University of Calgary

Abstract The current landscape of science governance is transforming in ways that highlight the importance of reflection. The uptake of formal reflexive frameworks into interdisciplinary research and education is gaining traction. Despite these reflective initiatives, linear, top-down conceptions of science are deeply entrenched in the broader culture of academia. One key challenge lies with the operationalization of reflection in practice, notably in cases of novel emerging technologies. Gene editing is an example of a cutting-edge, emergent biotechnology that has given rise to diverse interdisciplinary applications. While gene editing holds promise for addressing socio-economic challenges in medicine, agriculture, food and conservation, it is a novel technology that warrants broader attention to its intersection with reflection. Reflecting on the social implications of gene editing is at the forefront of academic and public conversations alike. As such, gene editing can serve as a case study to examine the broader imaginaries of reflection in science discourse. The purpose of this presentation will be to (1) discuss the findings of a scoping review that examined how reflection appears in the academic literature on gene editing, and (2) to highlight some of the key implications these findings put forward for undergraduate science education.

Key words: gene editing, reflection, post-secondary education

Thursday, 7 July 2022

Session 14, 10:00–11:30

Studio C

Reasoning from consequences: from nature of science (NOS) to pragmatics of knowledge (POK)

Charbel N. El-Hani

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Abstract We will explore ways of thinking of science education based on an *intercultural* attitude, interpreted in non-relativistic terms. Once one recognizes diverse knowledge systems and epistemologies, this does not entail a commitment to incommensurability. An alternative interpretation can be proposed from a pragmatist, realist, and pluralist perspective based on *reasoning from consequences*, according to which knowledge resulting from distinct ways of knowing can be judged comparatively, but this judgment can (and should) be done without sheer hierarchization, since ways of knowing are incommensurable *in abstracto* and are only commensurable in a situated manner, before problems arising from well-defined circumstances. Knowledge as intervention in the real – not knowledge as representation of the real – can be taken as the measure of realism, and the credibility of cognitive constructions can be measured by the type of intervention in the world that they provide, help or impede. From these ideas, we propose a new curricular goal, *pragmatics of knowledge* (POK), besides *nature of science* (NOS), discussing how to deal with it in the classroom based on the conceptual profile theory, the partial overlaps framework, and a conception of intercultural translation as a creative act. To illustrate how to work with *POK*, we apply the partial overlaps framework to the case of the use and predictions of two ecological models and an Amerindian ontology in managing sustainable hunt in an extractivist reserve in Brazil.

Keywords: interculturality, pragmatics of knowledge, conceptual profiles.

What's the difference between knowing and believing? Philosophical dialogues to tackle sensitive topics in the science classroom

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Abstract Teaching science to a highly diverse student population can be challenging. A broad range of worldviews may induce polarizing student debates about ethics or science. These can lead teachers to avoid potential sensitive (or controversial) topics. Yet, sensitive topics can also provide opportunities to help students engage in dialogue and reflect about science and socio-scientific issues.

An approach based on philosophical dialogue introducing both ethics and philosophy of science may provide helpful. In a philosophical dialogue, students collectively investigate philosophical questions by developing arguments, discussing the logic of their reasoning and explore relevant examples. In this approach the teacher takes the ‘socratic stance’, this means he acts as a facilitator guiding the dialogue rather than as a knowledge authority. By participating in the dialogue students explore different perspectives on knowledge or ethics without necessarily aiming for consensus.

In this proposal we discuss how Belgian teachers were trained to engage in philosophical dialogues to tackle sensitive issues in the science class. Afterwards, the teachers implemented this approach in secondary school science classes. We will demonstrate how philosophical questions about epistemology and ethics can be introduced to help students discuss the philosophical topics underlying the sensitive topics. Teacher and student interviews allow to explore how this approach was perceived. Thus, we will discuss the role philosophical dialogue about science and ethics can play to help counter polarization and ‘demine’ sensitive topics in the science classroom.

Key words: science education, sensitive topics, philosophical dialogue

Philosophy of science: The central issues for science education

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Abstract Well-designed science teacher education programs with a dedicated history and nature of science (HNOS) course have been shown to have a longitudinal positive impact on teachers NOS understanding and instructional practices (Herman, Clough, & Olson, 2013a & b; Herman & Clough, 2016), but such courses are rare (Backhus & Thompson, 2006; Olson, Tippet, Milford, Ohana & Clough, 2015). Requiring a HNOS course offered in philosophy and history departments may appear to be a viable solution. However, history of science courses have been shown to have little impact on science teachers’ understanding or teaching of the HNOS (Abd-El-Khalick & Lederman, 2000), and the same is assuredly the case for traditional philosophy of science courses. These challenges may explain why simplistic and problematic NOS tenets are so ubiquitous in science education. While advocates of NOS tenets maintain that teachers must unpack them, this presumes teachers have sufficient understanding to do so. The challenge remains regarding how to effectively prepare science teachers and researchers who

possess sufficient NOS understanding for promoting robust science content and HNOS teaching and learning.

This session presents our examination of central issues in the philosophy of science (Curd & Cover, 1998; Curd, Cover, & Pinock, 2012) to determine which issues are central for preparing (a) teachers to promote robust understanding of science content, science practices, and HNOS; and (b) future HNOS researchers. Pragmatic resources addressing the identified central issues are provided to assist in preparing science teachers and NOS researchers.

Key words: philosophy of science, demarcation, science education

Thursday, 7 July 2022
Session 14, 10:00–11:30
Studio D

Teaching energy concepts and principles in upper secondary school through the lens of thermodynamics history: a physics teachers' workshop

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Abstract Research on students' understanding of energy concepts and principles of introductory thermodynamics, in secondary school and university (science and engineering), indicates that traditional instruction does not result in the anticipated level of student sophistication toward this significant interdisciplinary domain. In this study, we support that the rich history of thermodynamics can play a role in the formulation of new teaching and learning approaches for the redesign of instruction in secondary school. Although the proper integration of the history of science has already been proven to be, in many cases, a powerful ally for the secondary school teacher, taking up such a task is nonetheless considered rather painstaking by the majority. In order for physics teachers to adopt thermodynamics history as a key component of their instruction, we designed, implemented, and evaluated a professional development workshop. The focus of the current work is the presentation of the research-based design of the workshop sections and the data collection tools we employ. The workshop introduces the history of thermodynamics and its other epistemological aspects, alongside the proper pedagogical tools to integrate into a teaching and learning sequence. To identify physics teachers' familiarization level with these epistemological and pedagogical aspects, we distributed a questionnaire to be filled by potential workshop participants and a follow-up interview protocol as pre- and post-workshop data collection tools, respectively. We anticipate that the results will shed light on the challenges and potential of history integration in thermodynamics teaching from the perspective of a teacher.

Key words: physics teacher education, history of thermodynamics, PD workshop

Investigating Elementary Teachers' Views, Implementation, and Longitudinal Enactment of Nature of Science Instruction

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Jerrid Kruse, Drake University, Des Moines, Iowa

Jesse Wilcox, University of Northern Iowa, Cedar Falls, Iowa

Abstract During a 10-week professional physical science professional development (PD) course, elementary inservice teachers ($n = 18$) in a large urban district were engaged in explicit-reflective nature of science (NOS) instruction. Teachers were also explicitly engaged in reflection concerning NOS pedagogy (e.g., explicit-reflective, role of context). During the last two weeks of the PD course, teachers attempted to implement NOS instruction in their classrooms. Teachers submitted videos of their NOS teaching and written reflections about their videos. Then, seven-months later, teacher participants ($n = 14$) submitted videos of their science teaching. During the PD course, most teachers were able to implement effective explicit-reflective NOS instruction and their reflections indicated strong agreement between participants' NOS pedagogical content knowledge and their enacted NOS instruction. Seven-months later, just over one-third of participants continued to include explicit-reflective NOS instruction in their science teaching. NOS views, prior NOS pedagogical views, and prior NOS enactment did not account for longitudinal inclusion of effective NOS instruction. The role of teachers' rationale for NOS and informal support networks are discussed.

Key words: elementary science teacher education, nature of science instruction

GNOSIS-ART: A framework for creating and analyzing educational videos for science education

Vasiliki Zervoglou & Fanny Seroglou

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Abstract Science literacy and education for citizenship require new teaching and learning practices that interrelate science, culture and society. STEAM education aims on the interdisciplinary study of Science, Technology, Engineering and Mathematics, while emphasizing the importance of the arts and proposing their effective integration into educational practice. There is a current demand for instructional materials for STEAM subjects that will re-contextualize abstract scientific concepts and engage students in creative and enjoyable learning experiences. Moreover, communicating and presenting these materials online could offer a meeting point for young people to explore, learn and collaborate. In this paper, we studied digital narratives created by educators and an analysis framework has been developed and applied. The videos we analyzed were created by undergraduate students of the School of Primary Education of the Aristotle University of Thessaloniki. Videos were grouped in categories such as: men and women of science, natural phenomena, health related issues (exercise and diet), and “Do It Yourself” tutorials. The GNOSIS-ART framework developed to analyze the videos consists of: i) parameters regarding aspects of the nature of science, including elements of the three complementary dimensions of learning (cognitive, meta-cognitive, emotional) and ii) artistic parameters that contribute to the creation of enjoyable and effective videos for science learning, such as the use of multiple representations, conversational language, friendly tone, intriguing questions or topics. Our study gives rise to several recommendations about the creation of effective educational videos that could engage young people in science learning inside or outside the classroom.

Keywords: educational videos, analysis framework, GNOSIS-ART

Thursday, 7 July 2022
Session 14, 10:30–12:00
Studio E

Third Space as A Window onto Viewing Hybridity in Learners’ Science Conceptions

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University of Calgary

Abstract In this abstract I argue for a research approach for the study of learners' conceptions of science concepts using *third spaces* as defined by scholars to account for existing hybridity and diversity among learners (e.g., Guiterrez, Baquedano-López, & Tejeda, 1999, and Mole et al., 2004). This approach to research emphasizes how scientific knowledge has been dominated historically by Western worldviews of science that have silenced multiple ways of knowing, knowledges, and the contributions of many scientists (Burns, 2019; Tan & Borton, 2018; Taylor, 2006, 2008; Alkhoully, 2018). From this perspective, hybridity and diversity “arises spontaneously from social diversity” (Tadrov, 1984, p. 57) by weaving racial, ethnic, and linguistic variations (Mole et al., 2004; Glasson et al., 2010; Simon & Pierre, 2000). Additionally, I draw on research that has adopted cross cultural and linguistic comparative analyses (e.g., Clark, D’Angelo, and Schleigh, 2011, Clark et al., 2013, and Tange, Yang, and Levin, 2020) to highlight linguistic, conceptual, and cultural resources that learners draw on. From this perspective, “[m]eaning is produced beyond cultural borders and is principally located in the Third Space, a sort of “in-between space” located between existing referential systems and antagonisms” (Wolf, 2000, p.135). I conclude by proposing that one way for ensuring racial equality and justice voicing multiple way of knowing and knowledge involves creating a heterogeneous “Third Space” (Gutiérrez et al., 1999; Moje et al., 2004). This poses multiple questions for future research with implications for how we view learning and meaning making processes in science.

Key Words: third space; heterogeneity; learners' conceptions

A comparative approach to decolonize science education: teaching Traditional Chinese science for university students in Hong Kong

Kai Ming KIANG and Wai Man SZETO
The Chinese University of Hong Kong

One of the biggest challenges for STEM education today, especially if the aim is to teach students about the nature of science (NOS), would be to reassess the validity of upholding scientific method and its products, i.e. modern science, with the concern of cultural diversity. However, modern science seemingly leaves little or no room for diversity, which often attracts doubts and attacks from the public. On the other hand, such criticism can easily fall into the trap of wholesale relativism. This tension is exemplified in the status of traditional Chinese “science” (TCS) which has been a controversial issue in Hong Kong, once a British colony and the place inheriting Chinese culture.

Our talk will explain how we teach our Hong Kong university students the NOS by introducing TCS in a general education common core course. This course adopted a seminar method of teaching by introducing and discussing the cultural-historical context. Via introducing relevant ancient Greek natural philosophies, modern science, and TCS, students were able to appreciate the diversity as well as compare and evaluate these various “cultures”. There are indicators that this approach is effective in decolonizing science education as the conflict between students'

own culture and what they are learning generated a deeper reflection and integration of the newly learned with their prior knowledge and personal beliefs. We believe our approach to teach NOS would be an invaluable reference for science educators exploring ways to incorporate their own NOS teaching with respect to their cultural context.

Key Words: nature of science, Chinese science, decolonization

Teaching with Emotions: Implications for Equity in Science Education

Sarah El Halwany & Jennifer Adams
University of Calgary

Abstract Emotions are part and parcel of cultures of science and knowledge production. Yet, too often, they remain absent in science teaching practices. Dismissal of emotions in science teaching and learning might maintain epistemological superiority of science as an abstract and rational body of knowledge only accessible for students with appropriate cultural and social capital for becoming future scientists and engineers. Relatedly, emotions have often been associated with impulsivity, femininity and subordination. When science and scientists are continually portrayed as disinterested and objective, science education remains unwelcoming of different ways of relating and doing science. This can have serious implications for equity efforts in STEM/science education. This theoretical presentation will discuss what it means to give attention to emotions in science education contexts for increased justice and equity in science/STEM education. We will further support our discussion with some anecdotal evidence of how ‘emotions’ figure within ongoing pedagogical efforts alongside STEM professors and instructors in a Canadian postsecondary institution who are trying to re-imagine their practices to foster equitable learning environments in their science/STEM education contexts.

Keywords: Emotions, Equity in STEM, Postsecondary education

Thursday, 7 July 2022
Session 14, 12:30–2:00
Forum

The Final Session

Come and thank the outgoing officers and greet the incoming officers. Find out where the next conference will be held. Experience some of your favorite memories of the conference.

Notes

