Innovative and Effective Teaching of the History of Science and Technology

Teaching Commission

(3 sessions, 18 participants)

Organizers:

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This session is open to all congress participants for presentation of their own experience of innovative and effective teaching. A comparable and well-received session on teaching philosophy of science was hosted by the IDTC at the 2015 DLMPS Helsinki congress.

Importantly, the session will be listed in the programme as an 'Information Session on Innovative and Effective Teaching'. This arrangement, suggested by the Programme Committee, avoids the 'no two presentations' policy of the congress. So folk presenting research papers in routine sessions and symposia, can also present in this IDTC session.

The session is designed as a way of sharing good, engaging and effective approaches to teaching the history of science and technology. Presentations can cover curriculum, materials, texts, web-resources, successful classwork, innovative assessment, use of social media, liaison with science and other disciplines, and anything else that has been found in practice to promote more engagement, interest in, and learning of history science, including of course web-based, at-a-distance teaching.

The expectation is that contributors will present for 15 minutes (discussion included) using power point, sharing examples of course outlines, giving accounts of class activities, providing titles and addresses of useful web sites, and providing some account of the effectiveness of what has worked and what has not. With consent, the presentations will be aggregated and made available on the IDTC web site (www.idtc-iuhps.com) for wider dissemination.

Keywords: Innovative – Effective Teaching – History of Science and Technology.
Designing a history of physics course at the University of Copenhagen: dilemmas, expectations and learning outcomes

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Although historians of science probably agree that history should play an important role in the education of future scientists, this is far from being a consensual view among the ones responsible for designing science curricula at university. Aware of this difficulty, we developed a new course on the history of physics at the University of Copenhagen that aimed at providing physics students with an insight into the original formulations of central concepts/theories they learn during the Bachelor’s courses. Since there is no consensual tradition on how to structure such courses, this task involved several dilemmas, such as: Which cases to choose? What sources (original and secondary) should the students read? How to structure teaching and evaluate the students’ learning outcomes? In this talk, the solutions proposed to these challenges and the way students perceived them will be presented. Furthermore, we conducted a systematic collection of students’ motivations and expectations for signing up for the course as well as their reflections on learning outcomes for each case study, which will be briefly outlined in the presentation.

Key Words: history of physics, University of Copenhagen, student motivation, learning outcomes

Teaching history of science in the elementary school

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In the present study, we report some experiences developed with children from six to eleven years old, covering the History of Science in the first years of Elementary School, in a public school in the City of São Bernardo do Campo (State of São Paulo, Brazil). Starting with the development of projects, research and didactic sequences, the students themselves created some games. For decades, the importance of a critical training of the students in Science Education has been being discussed, according to the perspective of fostering the full exercise of citizenship. Within the context of Brazilian education, for almost 20 years, official documents, such as the National Curriculum Parameters, justify the inclusion of the History of Science in the curriculum, highlighting this is an important source of knowledge in the field, and suggesting its introduction, already in the initial years of education. This could be done, accordingly to the documents, from the history of environments and the human inventions.  
Taking into account the age range of our students, we have mainly covered the history of inventions and pictures/conceptions about scientists, contextualizing certain periods and discussing specific aspects regarding the Nature of Science (NOS) historically, socially, economically and politically. The games that were created with, and by the students (card games, memory games, hiking), beyond the playful aspect, have aimed at systematizing the
knowledge effectively constructed, and socializing with the families of each child some of the work done in class. The results, in terms of learning, enthusiasm, and interest of the pupils were highly substantial, as was the positive response of the families.

Key words: elementary schools, Brazilian education, family education, learning outcomes

Reading and writing historical narratives in science education to discuss the construction of scientific knowledge

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The use of stories in science education have been growing and it is considered an effective tool in a historical and philosophical approach. It is also considered able to create interest and develop a more human and personal relation between the student and the scientific or historical content. Importance is also given to changing the role of the students in their educational experience, helping the switch from a passive behavior to an active and participating one.

Our project proposes activities that start with reading a short literary historical narrative text (which is interrupted with questions for debate). From this historical narrative a scientific content is taught in a historical-philosophical approach. At the end of the didactic sequence, students write their own historical narrative in groups. This product has to follow some criteria, as being different but correlated to the one read at first (like being based on a character or concept), having scientific and historical content and bringing elements from the in-class debates. These debates were inspired by questions from the narrative but also from interventions from the students while reading. These questions raised by the students guide the teacher to plan following activities and interventions done in class and also students’ decisions when writing their narrative.

The historical narratives constructed by students are evaluated, handled back and some are chosen to evoke new debates in class (now with new stories). Then, students have more time to rewrite following the teachers’ comments and the final version reevaluated. The whole process (reading - final story) takes five weeks.

Key words: stories, narratives, Brazilian education, student motivation

How much history of science research can secondary school students do?

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This paper presents experience of an innovative pedagogical program which initiates secondary school students from Hong Kong in history of science in China, through a research-oriented summer program at the Needham Research Institute (NRI). The yearly program, started since 2013, brings a selected group of students (aged 14-17) of the Independent School Foundation Academy (ISF), Hong Kong, to a three-week stay in NRI, during which each student conducts individual research on a specific topic related to history of science in China, using resources in the NRI library. More than forty substantial essays (3,000 to 10,000 words) in both English and Chinese have been so far produced, covering a wide range of topics, from notion of negative numbers and quest of immorality before Common Era to the Sino-Japanese naval battle in 1894 or the Manchurian Plague in 1912. Some have been published in dedicated journals. Students also collectively assisted NRI staff in their work on the Institute archives,
creating a Geographical Information System for Joseph Needham’s journeys in wartime China (1943-1946).

The presenter, as the ISF post-doctoral fellow at NRI and academic supervisor of the students, proposed some reflections on the role of history of science and the use of individual research as a way of learning in a secondary curriculum, with respect to the specificity of Hong Kong’s bilingual and bi-cultural education. I will also discuss the perceived possibility and fruitfulness of involving teenage students in our own academic work, in terms of effective out-reach and cross-fertilization of ideas.

*Key words: Hong Kong education, Chinese science, Needham Research Institute*

**History of science and education: interdisciplinary approaches**

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This paper presents some achievements of the research project: "History of science and education: interdisciplinary approaches in college courses (diagnosis, continuing and specialized teacher’s training)", sponsored by Capes (Capes/Obeduc process # 23038.002603/2013-47).

Its general objective is to increase the development of research covering the many interfaces between the history of science and teaching, considering the new historiographical perspectives in the history of science and its connection with the main pedagogical trends.

This Project has been guided by three considerations:

1) Researches on courses of history science offered in colleges and universities based on the South and Southeast Brazilian states, as well as their syllabus and bibliography

2) Specialized short term courses in History of Science and Education, both online and presential, aiming to promote the update of this subject.

3) The development of instructional materials in history of science for college and high school education, including proposals of activities developed by high school teachers.

Some of the results of this project are: books, publications in academic journals, participation in conferences, and a website http://hcensino.net.br/. Moreover, the analysis of statements from the teachers who were part of this project activities show many positive changes in their understanding of the role of the history of science in teaching, as we shall be presenting in the session.

*Key words: Brazilian education, interdisciplinary teaching, teaching materials*

**Writing, acting and engaging with historical scientific controversies**

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We present here the experience of elaboration of scripts and the production of video clips on historical controversies and discuss their potential as didactic strategies for teaching history of science. This activity has been tested in high school and college subjects that address history of science in some of its units. The methodology begins with the presentation of videos that had already been produced and that serve for initial discussions.

The class is then divided into groups of students who choose a scientific controversy from a menu presented by the teacher. Each couple of weeks, each group of students presents a version of the script, which is continuously re-elaborated after class discussion, paying attention
Session Two (Friday, 28 July, 3:30-5:00 p.m.)

From written words to abstract concepts: teaching medical history through text analysis.

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In recent years there has been growing debate about how to make medical history available to undergraduate and graduate medical students. The discussions are linked to at least three aspects. On the one hand about what would be the best educational resources used, ranging from the blackboard and chalk to the use of resources based on hyper connectivity and Internet. A second aspect explores the use of images in contrast or in complementarity with the use of texts. A third aspect discusses whether it is possible - or not - to work with students directly with primary sources and, if so, how best to do so.

This presentation intends to show our experience in the use of textual analysis of primary sources of classical antiquity to initiate undergraduate and graduate students of the School of Medicine of the University of Buenos Aires in the curriculum of medical history. We will present a model text - The Oath - taken from the Corpus Hippocraticum in Loeb's classic bilingual edition. We will show the way in which we analyze it with the students in successive layers and conclude with the learning that can derive from such analysis, thus going from the specific text to the most general concepts.

The ultimate goal is to present history of medicine course in a clear, understandable, interactive and entertaining way that arouses the interest of medical students and stimulates a critical reading of the texts of the health sciences history.

Key words: history of medicine, primary sources, University of Buenos Aires

Teaching history of science, technology and medicine in an interdisciplinary programme

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This presentation will address some of the opportunities and challenges regarding the teaching of the history of science, technology and medicine (STM) in an interdisciplinary context. I will be referring in particular to a cross-disciplinary MA in Cancer Studies, an innovative programme that was designed to capitalise on collaborations across the university and emphasised the interaction of biomedical sciences with the social and humanities disciplines: sociology, psychology, law, philosophy, and history. This pioneering approach aimed to capture the increasingly interdisciplinary nature of contemporary work in the cancer field. The presentation will also focus on different aspects of teaching history of STM in one core module of the programme, where I will dwell on issues such as the rationale for embedding the discipline into the curriculum; the selection of themes; learning activities; and the delivery of
content in shared sessions with other disciplines. In doing so, I will also be reflecting on my teaching experience of history of STM for a student cohort with different academic backgrounds, and some of the issues emerging within this context.

Key words: history of medicine, cancer studies, interdisciplinary teaching

Learning history of medicine with Voicethread

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In 2015, the Department of the History of Medicine at Johns Hopkins University, Baltimore, USA, launched an Online Program in the History of Medicine. Students take for-credit courses leading to a Certificate or MA degree. One of the challenges for the Program is how to replicate, as far as possible in a virtual environment, the learning experiences of small-group graduate seminars. Discussion-based communication is facilitated with synchronous (live talks) and asynchronous methods (written response forum). Another example of an asynchronous approach has been the use of Voicethread (www.voicethread.com), which encourages a collaborative approach to learning and teaching through video, audio and text. This paper provides illustrative examples of how the Online Program has used Voicethread to create a space for the discussion and analysis of primary and secondary sources. The advantages and disadvantages of using this technology at a graduate level are outlined.

Key words: Voicethread, online teaching, collaborative learning

Teaching the History of Computer Technology with Art and Artifacts

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The proposed presentation will discuss and demonstrate the use of artistic elements and technological artifacts in the teaching of two STS undergraduate courses: History of Computing and Information Technology and Technology in the Modern World. The artistic elements consisted mainly of graphical representations of early 20th century technology. I offered examples such as the paintings of Diego Rivera, drawings of computers in their social context as they appeared in various magazines, film clips from the mid-1950s illustrating the real and imagined social tensions generated by the then new technologies, and so on. The students were asked to interpret in class those artistic representations in the context of the course curriculum. Students’ participation and level of engagement in those discussions was higher than usual. The artifacts were used only in the History of Computing and Information Technology course. Most of them originated from a rich, historical collection of computers hardware, software and documentation in the possession of York University. At various points during the course, pieces of equipment were brought to class and the students were encouraged to explore the vintage computers and peripherals, compare them and ask questions about their design and functionalities. The computers and related artifacts presented generated a marked interest in the computer technologies of the 1970s and 1980s and an appreciation of the progress made since then. Stimulated by their encounter with the aforementioned artifacts, some students opted to write their term papers based on the York University computers collection’s archives. Thus, third-year students effectively engaged in research based on primary sources.

Key words: history of computing, art, Diego Rivera
The effect of historical case-studies in the teaching and learning mathematics

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Recent approaches in the philosophy of mathematical practice propose to pay close attention to the specificity of problem-solving activities rather than foundational topics stressing the value of historical case-studies to bring to light the most fundamental cognitive strategies that come into play in mathematical discovery and innovation. In our paper we argue for the interest in using historical case-studies in math education. Given that understanding, rigor and creativity are aptitudes of paramount importance for mathematically proficient students, paradigmatic cases selected from the history of mathematics will help students to participate ‘virtually’ in the process of doing mathematics.

The approach aims to provide students with deeper understanding of the processes involved in doing mathematics by grounding teaching activities in the use of primary historical sources. The relevant sources to be used in teaching must be scrutinized in the context of the corresponding mathematical culture where it originated with the aim to provide a comprehensive explanation of the nature of important mathematical concepts without neglecting their original significance.

In our presentation we propose to consider the study of the squaring problem of the circle in Leibniz’s De Vera Proporzione Circuli, an article first published in 1682 in Acta Eruditorum. Leibniz’s approach to this problem requires to formulate a suitable expression for the irrational number π. In this piece of writing Leibniz’s concern is to make explicit the way he obtained his results thus illuminating “the origin of inventions” and, in so doing, he also points to the scope and limitations of previous attempts to deal with “problematic” number π.

**Key words:** Leibniz, history of mathematics, primary sources, student learning

Interdisciplinary Teaching of mathematics, computer sciences, natural sciences, and technology courses at the University of Stuttgart

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At the University of Stuttgart, an interdisciplinary range of courses has been offered to students of all specialisations since summer term 2014, to strengthen MINT subjects: mathematics, computer sciences, natural sciences, and technology. The project started with the series of lectures on “History and Practice of Materials Research” focusing on the topics “History of the Materials Testing Institute University of Stuttgart”, “Superconductivity” and “Liquid Crystals”. Within the scope of the series of lectures, the historical development of all mentioned main topics was introduced in one lecture for each one at the Chair of History of Science and Technology. Scientific publications on the topics were analysed and discussed with the students in three further lectures.

Professors of the following institutes introduced each of the main topics in an introductory lecture from the perspective of current research: the Institute for Large Area Microelectronics, the Institute of Physical Chemistry, the First Physics Institute and the Materials Testing Institute University of Stuttgart. Those lectures were supplemented by guided tours through the laboratories of the respective institutes which the students had to take part in additionally. The experience gained with the series of lectures was published in a book. Due to its success, a second series of lectures with the title “History and Practice of Research Technologies” has
started in winter term 2016. It is based on the model of the first series and its main topics are “Electron Microscopy”, “Fibre Composite Technology” and “Laser Technology”.

**Key words:** University of Stuttgart, interdisciplinary teaching, computer science, modern technologies

**Session Three (Friday, 28 July, 5:15-6:45 p.m.)**

**Innovative teaching of global warming: history, science and politics**

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I will talk about an honours seminar that I taught for two years at the University of Wisconsin-Madison, before I moved to my current position in the University of Cambridge. This course featured several unusual modes of teaching and assessment designed to convey distinctive aspects of research in and public debate on the climate sciences. The first part of the course was devoted to seminar discussions of course readings. Students were asked to present two “pro” and two “con” reviews of selected readings, which they posted on the course website. These summarised the argument - and then advocated or attacked it, giving some insight into adversarial writing. In the second part of the course, students selected four researchers from the university or beyond, who were each invited to send one research paper and one paper representing its public dimension, and then speak about their experience in both realms. Students invited a range of researchers including a climate modeller, public health researcher, anthropologist and climate change skeptic. Finally, the major assessment was a research paper that each student wrote in collaboration. Students served as the first author on a project that they led, and a second author on a project led by one of their classmates. This was designed to give some insight into collaborative research and writing. It was possible to teach different aspects of the process and assess the contributions each student made by requiring students to offer a research proposal, a proposal review, a draft and an oral presentation before the final paper was submitted. They also submitted a brief account of their perception of the process and the contribution they had made to each other’s work.

**Key words:** global warming, argumentation, collaborative learning, project teaching

**Myths about Africa’s scientific legacy: Rigour throughout history and contemporary epistemic advantages**

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Recognizing one’s scientific heritage and one’s right to technological benefits begins by recognizing how scientific and technological progress is the cumulative outcome over millennia of speculation and results obtained on different continents. Such an overview begins with paleontological evidence of systematic observations of nature conducted in Africa before the origins of written language. This presentation will feature counterevidence undermining three popular misconceptions about modern science and African traditional beliefs.:

Myth (i): Modern science could have arisen only as it did in the 17thc. Euro-Enlightenment’s age of mechanism due to the unique demands of industrialization; whereas in fact libraries and
university centres from 15th-18thc. throughout the Maghreb and Sahel, mathematical breakthroughs during 9th-12thc. Abbasid Empire, relied upon by Newton and Leibniz. Myth (ii): Traditional African cultural values pre-empt scientific progress; whereas in fact traditional proverbs in Ga-Dangme, Akan, and kiSwahili reflect descriptions of natural processes e.g. anticipating Newtonian thermodynamics. Myth (iii): a stark distinction polarizes reliable evidence-based inductive hypothesizing from the folkways and ritual mimicry that typifies traditional African herbal practice; whereas in fact key contributions to pharmaceutical research feature the direction, knowledge and germplasm provided by indigenous African medicinal experts in Cameroun rainforests, Madagascar and elsewhere in Africa. The objective is for students to become astute in applying rudimentary principles of evidence based hypothesizing, statistical arguments, the importance of falsifiability or correctability and eliminative induction. Students are encouraged to critically evaluate pseudo-scientific interpretations delivered from the global arena concerning African public health needs and socio-economic development priorities. Flagrant shortfalls in standards of best practice are evident in the fallacies of inferential statistical analysis published by the WHO, CDC, The Lancet, BJM, and diagnostic tools in use re. AIDS and Ebola in Africa, e.g. shortfalls crisis response of 2014-2015.

Key words: African traditional belief, evidence assessment, hypothesizing, statistical inference

Innovative teaching of computational metaphysics
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In Summer 2016 we held for the first time a lecture course on Computational Metaphysics at FU Berlin. This course, which attracted students of maths, computer science, philosophy and physics from the three main universities in Berlin, addresses the semantical analysis of (selected) rational arguments on the computer. A particular focus has been on modern, higher-order modal-logic variants of the Ontological Argument for the Existence of God. As enabling technology, shallow semantical embeddings of very expressive non-classical logics in classical higher-order logic are used. Utilising this technology, the students worked very successfully with the Isabelle/HOL proof assistant in their exercises and group work. The lecture course concept has won the central teaching award of FU Berlin.

Course Website: http://www.inf.fu-berlin.de/users/lex/lehre/compmeta/

This course won the central teaching award 2015 of Freie Universität Berlin: http://www.fu-berlin.de/campusleben/lernen-und-lehren/2016/160428-lehrpreis/index.html

Key words: computational metaphysics, logic, ontological argument, computer-appraisal of argument

Teaching the Scientific Heritage of Croatia– Faustus Verantius

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We have developed a project Get to know Croatian scientific heritage with a specific goal: to present and promote results of scientific research in the field of history of science not only to the scientific community but also to a wider community, especially younger generations. This year, under instructions from UNESCO we are dedicated to the celebration of the 400th anniversary of the work Machinae novae (New machines, Venice 1615/1616) written by inventor Faustus Verantius (1551 - 1617), croatian Leonardo da Vinci.
For this we designed and prepared interactive workshops with a series of different activities. Through the workshop, the participants are encouraged to test and analyse the problems, which are also presented in Machinae novae, and reach their own conclusions. The workshop starts with an introduction of the desired theme and is continued with a discussion which is encouraged by various questions (Socratic dialogue). Inspiration for these workshops was also found in the new technologies which are nowadays available. Various activities such as examination of digitized work of Faustus Verantius or virtual and physical reconstructions of the projects are conducted. We also use different simple computer games based on Faust's projects. This all shows how new technologies, which are especially interesting and close to younger generations, are not just a passing trend but an extremely useful tool in the field of teaching and popularizing history of science and technology.

All our workshops combine introduction to the inventions presented in Machinae Novae that have been developed in the past, in the context of development of science and technology. Participants are encouraged to think about the contributions of those inventions as well as their present use. This is a process in which they form an opinion about the continuity of joint development of science and philosophy, and their universality transcending the boundaries of time and national identity. In our presentation at this congress we plan to present the methods and educational tools which we use and display the feedback we obtained from conducted workshops.

A project seminar creating a website and books about the history of Stuttgart University Campus

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In five summer terms between 2006 and 2014, the speaker has conducted interdisciplinary "project seminars" with students from all ten faculties of the University of Stuttgart. Founded in 1829, it is currently divided into two campus areas, one in the center of town, and one at the margins at Stuttgart-Vaihingen where most of the technical and natural sciences are residing. Prior to this project, there existed no guide to the rich and interesting architecture of the university buildings, ranging from representative 19th century buildings to fascinating postmodern constructions. Each participating student was doing research on the history, materials and architects of one or two such buildings and wrote a five to 15 pages long text with select images on their financing, planning, construction, on their early and later usage and on the laboratories or other special features (art) inside.

These contributions were collected and edited in three volumes Historischer Campusführer der Universität Stuttgart (170-250 pp. each), available in print with a subsidy of the special university program for innovative teaching, and they can also be accessed online by means of an interactive map of both campuses done in conjunction with geo-mapping specialists from the Institute of Applied Geodesy at the University of Stuttgart.

Please look at www.uni-stuttgart.de/hi/gnt/campus and the various subpages on c. 100 buildings, labs and other prominent sites at the two campi of the University of Stuttgart. Since there are very few such books on individual university campus areas so far, similar projects might be worthwhile at other universities worldwide.

Key words: University of Stuttgart, project teaching, primary sources, geo-mapping
Re-create experiments from history: inform the future from the past

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This presentation reports from experiences, resources and experiments garnered from twelve years in my teaching of a lab seminar where students explore the physical world while responding to investigations of historical science. Seminar activities extend from the lab to the outdoors, museums, rare book library, and beyond. Participants are undergraduate and graduate students in science and engineering, teachers, and new teachers. Explorations encompass: sky observing; balance; periodicity; sound; optics; magnetism and electrostatics; time; and space. Historical readings and examples include: Euclid, Archimedes, Galileo, Franklin, Faraday, the Wright brothers and others. Students engage with authentic artifacts including: historical and reproduction astrolabes; manuscripts and early printed books of science; 19th century surveying apparatus and MIT’s centennial buildings. Online resources extend these studies, through: digitizations of historical works of science; online museum exhibits; animations of historical instruments; online videos or accounts of historical science; and educational websites. Central to the experience of this seminar is the interactive emergence of questioning and experimenting among students, as they become aware of uncertainty in their science understandings. In illustrating how students’ explorations develop, this presentation provides documentation from classroom video excerpts, photos and student work. The conditions for exploratory learning are facilitated by the teacher. The teacher’s work involves: following students’ thinking with respect; taking risks together with students; and safe-guarding the classroom community as a space for authentic uncertainty. As these examples demonstrate, students’ experience evolves as their thinking is challenged, reinterpreted, and understood by explorations that they initiate, and by dialogue with historical investigators.

Key words: historical experiments, online resources, uncertainty, dialogue