

**The *Third International Seminar on History of Science in Science Education* was convened by the *History and Philosophy of Science in Science Education Research Group* of the University of Manitoba and the University of Winnipeg, in collaboration with the Deutsches Museum, Munich. The Seminar was supported financially by a grant from the Social Sciences and Humanities Research Council, Canada.**

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# **ABSTRACTS**

*Third International Seminar on  
History of Science in Science Education*  
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## The University of Hamburg, Hamburg, Germany

Astronomy is the oldest science. Observing the stars and planets was always important e.g. for the determination of the time or for making a calendar. We find a great interest in astronomical questions in the ancient cultures as well as in the last centuries.

In spite of the great significance of astronomy it is not generally considered to be interesting as a school topic. In Germany astronomy is in the official 'Gymnasium' curriculum in only a few states, including Bavaria and some Eastern German states. But it could also be included in physics, geography, mathematics or other subjects.

Using the history of astronomy one could present the topics in an even more interesting and motivating way for a broader range of pupils. And this should start in the first years of the 'Gymnasium'. With interdisciplinary teaching one can combine science with cultural history.

After an introduction dealing with Ancient time and Middle Ages I would like to offer three examples mainly concerning the Early Modern period (about 15<sup>th</sup>–17<sup>th</sup> centuries).

In addition I think it is interesting to introduce practical work i.e., making instruments and learning to use them. This can be rounded out by a visit to a museum to see the original instruments or by a walk through the city to find sundials. I have chosen the construction of sundials according to Albrecht Dürer (1471--1528) [Vnderweysung der messung, Nürnberg 1525], making some of Peter Apian's (1495--1552) instruments like those he described in his 'Instrument Buch' [Ingolstadt 1533] and finally Georg Philipp Harsdörffer's (1607--1658) 'Erquickstunden' [Nürnberg 1636, 1651].

**Art Stinner**  
**The University of Manitoba, Winnipeg, Canada**

It is now commonplace to say that in order to be effective in the classroom, science teachers (indeed, all teachers) are required to have good content knowledge as well as pedagogical content knowledge of their subject. To possess the first is regarded as a necessary but not sufficient condition for successful teaching: teachers must also be well acquainted with good pedagogical practices and have a thorough understanding of how students learn the concepts presented to them. The possession of content knowledge presupposes a period of formal training in that subject, usually a minimum of a three-year general degree at the university level. It is also assumed that students have been exposed to and participated in learning about ways of applying sound pedagogical principles and what cognitive theories say about how students learn. This usually takes another two years of studying at a Faculty of Education. To sum up: the new science teacher should be:

1. Scientifically literate
2. Understand the nature of science (NOS)
3. Have a good understanding of cognitive theories and what they say about how students learn

To be scientifically literate on the level of a science teacher presupposes content knowledge of the subject as well as an understanding of the NOS. An understanding of the NOS, however, assumes more than a cursory knowledge of the history of science.

The two history of science courses now offered to education students as well as to science students at the University of Manitoba, team-taught by the author with Ian Cameron and Peter Loly of the Physics and Astronomy Department, will be discussed.

## **Some Remarks from the Century that is Passing**

**Ian Winchester**  
**The University of Calgary, Calgary, Canada**

The 20<sup>th</sup> century has seen the transition to the scientific professional become nearly complete. The role of the amateur, although strong in the early part of the century, has nearly entirely disappeared in the latter half of the century. Yet most of the greatest accomplishments of the century in science still have an amateur flavour. Is it possible that Kuhn's picture of standard science versus extraordinary science in our century is really an education problem surrounding the development of those who take science as a professional task or job versus those who live it. And if so, how do we educate for a 21<sup>st</sup> century in which the lover, the amateur is widespread?

In Ptolemy we have the culmination of Greek astronomy, yet he is surprisingly often given somewhat perfunctory treatment in introductory astronomy courses. For most students Ptolemy's contributions have now simply become an historical curiosity. However, an examination of the problems and methods of Greek astronomers can still be a useful instructional approach for introducing astronomy. Although Ptolemy's geocentric planetary theory does present some difficulties for effective presentation, these can be circumvented using modern technology. Ptolemaic solutions to astronomical problems can be readily demonstrated using a simple "Ptolemaic" computer.

## **Teaching Physics Using a Web Quest**

**Andre Dagenais**

**Sanford School, Delaware, USA**

Teaching physics within a broader historical context has been made easier with the widespread availability of the Internet within high school settings. The content of this presentation will center on the wave-particle debate over the nature of light that surfaced during the late eighteenth century and continued into the early twentieth century. It will describe an Internet-based project that is suitable for high school classes. It is a project that requires students to learn about the contributions of scientists within that time period by reading primary source material. They must then place these contributions within the context of the continuum of ideas that eventually led to quantum mechanics and quantum electrodynamics. Students are also asked to assess these two competing theories based on Kuhn-like criteria. The culmination of the project is a mock scientific conference on the nature of light where students present what they have learned.

## **A Historian of Science Looks at Science Education**

**Michael Eckert**

**Deutsches Museum, Munich, Germany**

Debates about the inclusion of the history of science in science teaching have a long history themselves. A review of some arguments and statements of this debate is presented - and contrasted with the actual situation of science education at the end of the twentieth century: Decades of discussion among academics produced a lot of wishful thinking but few tangible results when it comes to the implementation in high school teaching (at least in German secondary schools). There are many examples how history of science is added as an additional item to science teaching, but there is a lack of concepts by which history becomes an integral part of science teaching.

Two examples are presented as an illustration for such integral concepts (suitable for physics in grade 11):  
1) Newton's geometrical style provides a historical feel for mechanics. If combined with modern means of presentation (a JAVA-applet is presented) the power of this style becomes apparent.  
2) The explanation of aerodynamic lift is erroneous or misleading in most textbooks. A historical approach can help to avoid widespread misconceptions.

A feel for the history may serve as a useful corrective against such misconceptions in the teaching of science. But no attempt should be made to blur the different orientations of the history of a science and the science itself. This would only cause new misconceptions.

Switzerland is a small country, in size about as large as the German Bundesland of Bavaria; but it has many different school systems. At Secondary School II every student has to take Physics. The curricula give the teachers quite a lot of liberty, although the structure of physics does not allow too many different ways of proceeding. Textbooks are not prescribed; a Swiss physics textbook does not even exist. Unfortunately it is almost impossible to teach modern physics, so that for students with the minimum curriculum physics ends at the close of the 19<sup>th</sup> century.

Mechanics is not always the first topic; some teachers prefer ray optics or thermodynamics. But when the chapter of mechanics is the first topic, most teachers do not proceed chronologically. The succession is determined rather by the increasing mathematical difficulties than by the history; therefore a logical and not a chronological order is preferred by many teachers.

Many physics teachers are very much interested in astronomy. Due to the fact that the teachers are relatively free in choosing their teacher topics and that astronomy indeed allows preferences, the variety of subjects is wide. This is certainly the primary reason why the motivation of astronomy teachers - and as a consequence the students - is high. Even years later former students say that it was the only time that they were really interested in physics!

The second reason why teaching and attending astronomy classes is so motivating is that astronomy has a lot of historical aspects - actually astronomy is history. The third reason is the fact that astronomy, even complicated things, can often be understood without any detailed knowledge of mathematics. And at last - a meaningful point - astronomy is personified.

## **Replicating historical experiments: Coulomb's law**

**Peter Heering**

**Carl-von-Ossietzky-Universität Oldenburg, Germany**

One of the central parts of what we today call Coulomb's law is the relation indicating that the force between two electrostatic charges is inversely proportional to the square of the distance of these charges. This relation will be the central aspect of my presentation. In the first part I am going to discuss the electrostatic investigations of the Frenchman Charles Augustin Coulomb that enabled him to publish this relation in the 1780's. In doing so I am going to use the experiences made in replicating the experiments Coulomb had described. In order to illustrate some of these experiences I am going to demonstrate the measurements with the reconstruction of the torsion balance. Having made clear that the measurements Coulomb described are not easy to be performed I am going to discuss two other experiments that were performed with a similar motivation: The first one was published by the Scotsman John Robison in 1801 although he claimed to have performed this experiment already in 1769. The other was published by the German Paul Louis Simon in 1808, being an attempt to overthrow the force-distance relation Coulomb had tried to establish. Again, the discussion of these experiments is going to be based on the experiences made during the replication. In the final part of my presentation I will demonstrate how the insights of these case studies could be – together with the reconstructed set-ups – applied to physics teaching.

## **Teaching Physics in a Classroom**

**Inessa Rozina**

**Technical Vocational Institute, Winnipeg, Canada**

Mathematical complexity of the subject has been identified as one of the major factors that prevent students from studying physics. This paper distinguishes between the conceptual and mathematical aspects of physics, and considers ways to adjust the balance between the conceptual and mathematical aspects of physics for classroom teaching. Newton's planetary laws will be viewed conceptually and mathematically to illustrate that there is no sharp boundary between qualitative and quantitative perspectives on the laws of physics. Four different teaching approaches will be discussed, each with a different perspective on incorporating both the conceptual and the mathematical into students' understandings of physics.

## **Scientia Latina Occasionibus Omnibus**

**Wesley Stevens**

**The University of Winnipeg, Winnipeg, Canada**

Models of the Earth with or without the Antipodes, planetary orbits eccentric to the Earth, and astronomical instruments known and used in Latin Europe during the ninth century will suggest some aspects of common knowledge and common sense shared by students, their parents, and their teachers.

It will be proposed that old science from the Middle Ages would be useful in the classroom today. These examples will be offered not to discard them. Rather, it will be suggested that students may be induced to use what they and others thought they knew, in order to develop and improve their thinking and to move step by step towards more adequate data and towards better methods for analysing natural phenomena, as it once happened and is still happening.

'The Earth and the Solar System' is one of five units in the Province of Manitoba's Grade 6 science curriculum. It introduces learners to six basic ideas, namely: (1) Earth is spherical; (2) Earth rotates on its axis; (3) Earth revolves around the Sun; (4) Earth is one of the planets of the solar system; (5) each planet differs in size and characteristics; and (6) technology has provided information about the planets. Lessons focused upon helping twenty-six children in a multi-age (Grades 4-5-6) classroom understand these ideas were developed and implemented. Embedded in the lessons were pedagogical practices intended to foster talking, deliberating, and questioning and stories from the history of science designed to develop an understanding of scientific knowledge, the nature of science, and scientific imagination. The stories focused upon ancient models of the universe, evidence for a rotating and revolving, spherical Earth, Greek myths about the objects in the night sky, contemporary astronomical news reports, brief discussion of the theories developed to explain the formation of the universe as well as the origin of the moon and how it came to orbit Earth, and a space exploration/technological timeline. The children's experiences and conceptual development as a consequence of the social constructivist framework and attention to history by means of Matthew's minimal approach will be described and analyzed.

**The Historical Development of Conceptual Models:  
Building a Framework for Teaching and  
Understanding the Nature of Science**

**Donald J. Metz**

**The University of Winnipeg, Winnipeg, Canada**

This paper reports on the research findings that students, and their teachers, lack an understanding of the nature of science. Additionally, curriculum reforms at the international, national, and provincial level are examined to illustrate their support for the inclusion of nature of science outcomes in the development of new curriculum. It is concluded that this support, through lack of context, rarely finds its way into the classroom. A curriculum guided by the historical development of conceptual models is proposed as a context for teaching the nature of science.

**Jana Jilek**  
**Red River College, Winnipeg, Canada**

Technological knowledge can be defined as having four components: technical skill, engineering theory, scientific concepts, and problematic data. The two-year technology programs in western Canada focus on teaching the students technical skills and engineering theories. They also tend to concentrate on only one narrow area of their discipline, and often produce graduates unfamiliar with other types of even closely related technologies. Incorporating history of science and technology into individual technical courses can give technology students a broader view, a greater appreciation of their chosen field, and assist them in making informed decisions on the advantages and drawbacks of technology and science related issues. I use several examples from electrical technology to illustrate that the history of technological developments can deepen all four types of knowledge. History, blended into technical subjects, provides a wider context to the direction technological developments take and also give a counterbalance to the widely held belief that only the “leading edge of technology” counts.

## **A Theoretical Framework for Using Stories in Science Education**

**J. Stephen Klassen**  
**The University of Winnipeg, Winnipeg, Canada**

Leading scholars in science education have long advocated the use of history of science in science instruction as an effective pedagogical strategy. However, research has indicated only a moderate degree of effectiveness of various history of science approaches in science teaching and there has been a remarkable lack of consensus among science educators on both the theoretical basis and methods for implementing and incorporating of the history of science.

Thomas Kuhn has argued that a lack of consensus is a sure sign that a research community is struggling to establish a viable theory. Establishing a viable theory for the incorporation of history of science in science teaching is essential to forming a stable foundation for future empirical studies.

In this paper, I argue that the development of the events in a story proceed in the same fashion as the steps in learning a concept. Structural models of a story consist of a three-stage temporal sequence including a causative element. The temporal conceptual change process can also be viewed as a three-stage sequence similar to the story. The story can, in this light, be thought of as the re-enactment of a particular type of learning process. This knowledge can serve as a guiding principle in the designing and writing of effective stories based on the history of science.

This paper recommends the study of the history of physics in teacher education as a way to increase their potential as teachers. It describes a method using manuscripts, first publications, and photographs and biographical information about the scientists, along with actual data from important discoveries in the fields of atomic, nuclear, and particle physics. The method will be demonstrated through a set of examples from the life and work of two Hungarian physicists, Zoltan Bay and Dennis Gabor. With students preparing to be physics teachers, seeing first publications and information about the scientist as a person increases interest. Details about the birth of new ideas such as the operation of the scientists' original apparatus contributes to improved understanding of the ideas the scientists were investigating.

## **Bakhtin's Narrative Theory as a Tool for the Analysis of Science Teaching**

**Fritz Kubli**

**Swiss Commission for Physics Education, Zürich, Switzerland**

Teachers promote stories in their teaching, even if they are not aware of it. Narrative theory has developed conceptual instruments which are helpful in analysing the teaching process, such as the concepts of authoring, of addressivity and answerability, of intertextuality or of the voices noticeable in a text, etc. These notions, mainly developed by the Russian linguist Mikhail Bakhtin (1895-1975) with regard to literature, can be used to improve science teaching as well. Scientific subjects can be presented more easily to the students if they are taught in the light of this theory.

## **The Story of the Electron**

**Mark Larchez**

**The University of Wisconsin, USA**

The story of the electron can be a useful case study in the classroom. The electron's Thomson family connection, with individual Nobel prizes for father and son is impressive. There is irony in the contrast between the father's honor for establishing seemingly once and for all that the electron is a particle, and then later the son's honor for establishing that it is not. The elusive wave/particle duality of physics has a special personal aspect to it. Teachers can easily demonstrate for the students pretty much the same lab phenomena shown by the senior Thomson in his prize-winning experiments. At a time when magnetic fields and forces may seem uncomfortably abstract to the students, a concrete demonstration of something easy to see can be a welcome relief. The close connection to practical applications can provide helpful motivation. The younger Thomson's lab work is more difficult to demonstrate to students, but the teacher can exploit some of the human aspects to the story: One is the difference between the father's view of the electron and the son's. Another is the similarity in the discoveries of G. P. Thomson's team in the UK and of the industrial team in the USA. Another is the role of mistakes, accidents, and perseverance in laboratory science. The phenomena of wave interference are new to many students. Many non-science people are fascinated by the idea that light can be both a wave and a particle. When that same idea applies to electrons, it can generate additional interest.

Magic squares are arrays of different numbers where every row, every column, and (usually) the two diagonals all have the same total. A magic square from two millennia ago shows forty-five pebbles arranged in a three-by-three array, with each line of three positions totaling 15. This paper will look at the structure of four-by-four magic squares as representative of four-dimensional space. The construction of larger magic squares by compounding smaller magic squares will be demonstrated. Possibilities for further exploration will be suggested.

## **Joseph Loschmidt: His Work as a Physicist and the Principle of Diffraction as a Method of Cognition Acquirement in Teaching Physics**

**Dolf K. Machold**

**Pädagogische Hochschule Weingarten, Germany**

It was Amadeo AVOGADRO who was the first (in 1811) to express the idea that the same volumes of different gases contain the same number of molecules (at the same pressure and temperature). Half a century later, the Austrian physicist Joseph LOSCHMIDT (1821 - 1895) pointed out a method to calculate the diameter of “air molecules” on the basis of molecular kinetic theory. Loschmidt derived this result from the knowledge of the mean free path of gas molecules and from the supposition that a liquefaction of air is possible - a courageous idea that could not be performed until 30 years later by Carl von LINDE. On the basis of these assumptions Loschmidt obtained the diameter of air molecules in the magnitude of  $10^{-9}$  m - a result which is in accordance with research work of modern physics.

Furthermore, it is pointed out that we can give an experimental verification of Loschmidt’s calculations in teaching physics. The method is based on the phenomena of diffraction. We have to require atoms arranged in a periodical structure and a radiation characterized by a wavelength in the magnitude of the atomic diameter. These conditions are fulfilled by a crystal and by an X-ray beam. Thus, on the basis of Bragg’s equation we can calculate the atomic diameter. The result is a support of Loschmidt’s theory.

## **Isaac Newton: An Apple for the Teacher?**

**Ralph Mason**

**The University of Manitoba, Winnipeg, Canada**

The use of stories from the history of science and mathematics may allow students to perceive the personal lives behind the scientists they learn about. However, the way the stories are used affect their influence on students. Using Isaac Newton as an example, the paper presents three cautions about how we present the person who is the scientist: (1) We may oversimplify the cognition which is involved in scientific invention; (2) We may glorify a view not in keeping with current practice, of scientists working in isolation; (3) We may construct an out-of-reach figure, more myth/hero than person. The paper concludes hopefully, with a particular example of a scientist whose personal identity was shaped in part by stories about Isaac Newton.