Astronomical and mathematical instruments as pedagogical tools

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Introduction

This paper will discuss considerations to be taken into account in designing activities involving historical instruments.

The use of history in math classes

The use of the history of mathematics in math class presents numerous challenges. For those of us who are real fans of history, those challenges clearly outweigh the benefit and the pleasure of dealing with information reminiscent of the past. For those who are not particularly interested in history, those challenges are sometimes seen as obstacles. If the obstacle is too difficult to overcome, then history may become a burden, rather than an aid in teaching mathematics. I became particularly aware to this issue when the provincial math curriculum, at the elementary, as well as, at the high school levels, introduced history of mathematics as an official tool to try to bond mathematics with real life and cultural environments. This new curriculum was first implemented at the elementary level (first 6 years) in the late 20th century. This year, it will be implemented in "secondary 4", the penultimate year of high school.

The introduction of history in the curriculum provoked a deep insecurity for most teachers. They felt ignorant, unprepared, fearful of giving inaccurate information, and often uncertain that this "new" trend would actually motivate their students. I encountered the same reaction, to a lesser extent, with my students at the university. In general, our students know little about history, and they are not particularly interested in the subject either. The reason is simple: as with mathematics, history is not related to their lives. Certainly, they love anecdotes, but this does not change their perception of history, or, as a matter of fact, of mathematics. For history to have a more profound impact on the students' perception of mathematics as a human endeavor, it must be evocative of domains of everyday life. In so doing, history will acquire a *de facto* meaning.

Looking at history from a daily-life perspective, I considered that instruments, astronomical or mathematical, might facilitate the establishment of a link between today's omnipresence of

measurement and numbers, and periods where the importance of measurement was on the rise. As part of my course on the history of mathematics to teachers in training, my students visit a museum that has a fine collection of 16th- to 18th-century astronomical and mathematical instruments. This visit is clearly the highlight of the course for the students. The simple contact with the original instruments, as opposed to reproductions, is exciting for them. In addition, since these instruments were actually used for military and navigational purposes, the student's interest generates a flow of practical questions on how the instruments were used, and how precise they are.

In the Quebec school curriculum, instruments are often cited as potential pedagogical tools. In textbooks, one encounters activities involving instruments to measure inaccessible objects. Sometimes, calculating instruments, such as Napier's rods, are also used. Unfortunately, often, when these instruments are used, not much time, if any, is spent understanding why they actually work. One must not forget, as Anthony Turner said in one of his books on the history of scientific instruments, that those instruments were invented precisely to avoid calculation as much as possible. Using an instrument, therefore, is not enough to develop an understanding of it. It is often the construction of an instrument that is mathematically rich, rather then its use.

What underlies the use of an instrument?

We will focus first on the necessity of understanding the model on which an instrument has been designed. As an example, we will consider some sundials. The model behind sundials is the armillary sphere. The armillary sphere, as a physical model of the Aristotelian universe, has by itself a great power of intellectual and even mystical attraction. We will discuss how, being in this Aristotelian universe, we may consider a sundial as a way to determine the actual position of the universe at the present time. This vision of a sundial has a great appeal. Forgetting for a moment that the sun is at the center of our planetary system, one can then mentally put a giant armillary sphere around us and thus give a very strong and concrete meaning to such concept as a meridian.

I will also analyze, with an 18th-century text, what is behind the slide rule.

Those examples lead us to ask ourselves, as teachers, if we are not entering a too complicated land and if the student will actually be interested. The real question may be in fact: How can we relate such kind of considerations to the life of our students?

The usefulness of such models: Exploring new worlds

The work of the Greek astronomer Hipparchus, the source of trigonometry, is certainly of great interest. One might ask, however, if it is of practical interest or rather of intellectual interest. The age of an idea does not necessarily make it relevant to our students. I suggest, therefore, looking for a historical context that will bring the ancient Greek notions closer to our students. For example, astronomy was of prime importance to late Middle Age and Renaissance explorers. This year, the 400th anniversary of the founding of Quebec City in 1608 by the French explorer and cartographer Samuel de Champlain, offers an opportunity to explore astronomical notions in the classroom as applied to navigation and mapping. Champlain wrote a short treatise on the art of navigation in 1632 (*Traité de la marine et du devoir d'un bon marinier*). The possibility of navigating in high seas without any costal reference (or a GPS) is intriguing, as well as, the challenge for an explorer arriving at a land until then unknown to his civilization to be able to return to this new land. How was he able to find his ship position using the sun and the stars? How was he able to navigate in the right direction? The model of the universe in this case is central to giving a meaning to the notion of latitude and longitude, and to understanding how more or less difficult it is to determine them. What instruments did Champlain use? What level of precision did he require? What mapping techniques did he use to record the new land he discovered? Were those maps accurate? The fact that Champlain actually wrote about all those questions helps give a context and some answers. This could be done for other explorers. The art of navigation in the 15th and 16th centuries was primarily a Portuguese and Spanish art. In fact, Champlain probably learned it on his uncle's ship while sailing to the Caribbean for the Spanish.

Instruments and mathematics

Historical mathematical instruments in the classroom could be a means of applying mathematical results in more "concrete" ways. Using mathematical instruments in an historical context ,which may be seen as an adventure by the students, is a way of putting students in question mode. As a teacher, I must make sure that mathematics are embedded in this mode.