A HISTORICAL PERSPECTIVE IN TEACHING
SCIENCE AND MATHEMATICS

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History can teach people a lot. Thus, it is necessary to teach history, and a teacher comes to the natural question how to use history in teaching. It is fairly clear how to do this when history itself is the subject of teaching or for such disciplines as political sciences, economics, art, humanities, and law. But what about science and mathematics? The general approach to these disciplines is that they give objective knowledge that is independent from the people who have obtained this knowledge as well as from the ways of its acquisition. Only the result, scientific knowledge itself, is important. As a consequence, this may give birth to the opinion that history is unnecessary, and perhaps even harmful, when mathematics or science is taught. In this article, it is demonstrated that this is not the case. When history is used properly, it is very useful in any course of mathematics or a scientific discipline (such as physics, chemistry, and biology). At the same time, improper utilization of history might be misleading and sometimes deleterious for the students. A technique for using history in teaching mathematics and science also is presented.

Introduction

Knowledge of different kinds is vital for people. Consequently, education is one of the most important areas of social activity. It gives people a diversity of knowledge, provides people for a better life in modern society, develops human personality, and satisfies people’s spiritual and intellectual needs. In this aspect, the role of universities cannot be overestimated. Universities are challenged to develop a new understanding and new approach to problems of education because they connect a scientific knowledge and the larger experience of society as a whole.

An important part of this experience is contained in history. Each person can learn a lot from history. As said by the famous German politician, Bismark (cf. Hart, 1971) “Fools say they learn by experience. I prefer to profit by other people’s experience.” The same point was made as well by Polybius: “There are two roads to the reformation for mankind - one through misfortunes of their own, the other through the misfortunes of others; the former is the most unmistakable [not always as it is demonstrated in Hart (1971), M.B.], the latter is the less painful … we should always look out for the latter, for thereby we can, without hurting ourselves, gain a clearer view of the best course to pursue … the knowledge gained from the study of true history is the best of all educations for practical life.”

We see that history can teach and thus ought to be taught. Consequently, a teacher comes to the natural question how to use history in teaching. It is fairly clear how to do this when history itself is the subject of teaching or for such disciplines as political science, economics, art, humanities, and law. But what about science and mathematics? The general approach to science is that it gives objective knowledge that is independent from those who have obtained this knowledge as well as from the ways of its acquisition. Only the result – scientific knowledge itself – is important. The same is true for mathematics even to a greater extent. As a consequence, it gives birth to the opinion that history is unnecessary, and perhaps even harmful, when mathematics or science is taught.
This article argues an opposite point of view. Namely, when history is used properly, it is very useful in any course of mathematics or a scientific discipline (such as physics, chemistry, and biology). However, an improper utilization of history might be misleading and sometimes deleterious for the students.

The emergence of a highly competitive and technological world economy has fundamentally enlarged the weight on mathematics and science education. The same changes make amplified demands of technical literacy for responsible and informed participation in our modern democratic society. Such pressures give a further practical edge to the traditional argument for the cultural enrichment and intellectual empowerment that mathematical and scientific ideas and thinking can bestow.

**Pedagogical Schemes for Organization of Teaching**

In teaching mathematics and science, two aspects are usually separated: mathematical content and teaching methodology. Well-known mathematician Hyman Bass (1996) writes about this pedagogy-content dichotomy discussing problems of mathematics education.

“The disposition of many mathematicians toward the problems of education well reflects their professional culture, which implicitly demeans the importance and substance of pedagogy. Mathematical scientists typically address educational issues exclusively in terms of subject matter content and technical skills, with the “solution” taking the form of new curriculum materials. Curriculum is, indeed, a crucial aspect of the problem, and one to which mathematically trained professionals have a great deal of value to offer. But, taken alone, it can, and often does, ignore issues of cognition and learning, of multiple strategies for active engagement of students with the mathematics, and of assessing their learning and understanding. Ironically, the mathematical preparation of school teachers is frequently entrusted to these same mathematical scientists, who are often neither trained in nor sensitive to the pedagogical aspects of teaching mathematics to young students. Pedagogy is not something to be added, after the fact, to content. Pedagogy and content are inextricably interwoven in effective teaching. Pedagogy, like language itself, can either liberate or imprison ideas, inspire or suffocate constructive thinking.”

However, this approach is now essentially criticized. For example, Shulman (1986) rejects the usual pedagogy-content dichotomy as ineffective and takes a look in depth at the content knowledge. He breaks content knowledge into three parts:

1) Subject matter content knowledge;
2) Pedagogical content knowledge; and
3) Curricular content knowledge.

According to Shulman, pedagogical content knowledge is the “particular form of content knowledge that embodies the aspects of content most germane to its teachability.... the ways of representing and formulating the subject that make it comprehensible to others.”

All three components are essential for a well-matched educational process. In contrast to this, most contemporary educators put heavy emphasis on subject matter content knowledge and curricular content knowledge. But too few are ready to discuss pedagogical content knowledge.
However, until this century the focus for teacher qualifications was pure subject content. In 1875 only 5% of the California Teachers Examination questions dealt with theory and practice of teaching. The other 95% were utter content - the subject matter to be taught. During this century (Shulman, 1986), the pendulum swung away from content to the point that teacher evaluation deals almost exclusively with procedures such as:

1. Organization in preparing and presenting instructional materials;
2. Evaluation;
3. Recognition of individual difference;
4. Cultural awareness;
5. Understanding youth;
6. Management; and
7. Educational policies and procedures.

In Shulman (1986), these categories are compared to those of 1875: “The contrast is striking. Where did the subject matter go? What happened to conventional content? The sharp distinction between knowledge and pedagogy does not represent a tradition dating back centuries, but a more recent development . . . A century ago the defining characteristic of pedagogical accomplishment was knowledge of content.” It is possible to suggest that this tendency to ignore pedagogical factor of content knowledge is the underlying cause for the many problems and shortcomings of math education in the U.S. That is why some educators think that both the “back to basics” and the modern reform movement are trying to push the pendulum back to the traditional content.

Shulman’s classification of content knowledge may be developed further. Really, the third part of this classification reflects organization of knowledge to be taught. For example, when you teach college algebra, it is necessary to give to students such concepts as polynomial, algebraic expression, function, and relation. Doing this, it is possible to begin with relations, then proceed to functions, and only after this to cover algebraic expressions and polynomials. At the same time, it is possible to go in the opposite direction beginning with polynomials and ending with relations. This example demonstrates that the same content may be organized in a different way while teaching and this organization is very important. However, curriculum is only the general organization of the whole course. At the same time, there are also organizational schemes of a topic as well as of a session or lesson. Thus, one can come to the following classification.

1) Subject matter content knowledge;
2) Pedagogical content knowledge; and
3) Structural or organizational content knowledge.

Organized teaching of some subject (for example, mathematics or physics) presupposes that the subject matter content has to be determined at first, before the course begins. After the subject knowledge has been chosen, it is necessary to organize it so that it would be possible to convey this knowledge efficiently. From the whole body of relevant knowledge on the subject, some parts are taken, divided into topics, and ordered into a definite sequence making teaching systemic. In such a way, subject matter content knowledge is structured and this structure (or more exactly, its description) form structural content knowledge.

This structural content has to be considered on different levels. There are three main levels.

1) Topic level organization;
2) Session level organization; and
3) Course level organization or curriculum.
It is important to remark that while the topical and session levels are independent (one session may include several topics and one topic may be distributed through several levels), the course level is situated higher in the hierarchy than the first two.

At the same time, content knowledge is the cognitive component of the educational process. Two other components are the pedagogical component comprising pedagogical interaction and the structural component that encompasses organization of teaching and learning. Organization or structure uncovers itself in three aspects:

1. Organization of knowledge (structural aspect);
2. Organization of teaching/learning (physical aspect); and
3. Organization of mental processes (mental aspect).

While organization of teaching/learning is well-known and frequently researched component of educational processes and organization of knowledge is also considered (cf., for example, Shulman (1986), where it is treated as curricular content knowledge), organization of mental processes is treated only in some particular cases. As an example of such mental organization in pedagogy, we can take establishing motivation for learning.

At the same time, organization of teaching/learning, or teaching/learning strategies always attracted the attention of educators. Years of intensive research in the field of higher education resulted in different approaches to organization of teaching/learning as well as in elaboration of organizational principles for these purposes. For example, leading scholars in faculty and student development of Brigham Young University created Seven Principles for good practice in undergraduate education (Chickering & Gamson, 1987). These principles were distilled from decades of research soliciting, among other things, the ideas of hundreds of faculty members and administrators in North American colleges and universities (Hartfield, 1995).

Organization of the subject knowledge and, consequently, of teaching itself can follow three patterns (frameworks):

1. Logical;
2. Historical; and
3. Psychological.

It is necessary to remark that sometimes teaching does not follow any pattern. In this case, teaching becomes chaotic.

A logical approach to the organization of subject knowledge and, consequently, teaching itself, means that the sequence of the taught topics is ordered with respect to the logical or informational interrelations and ties between different parts of this knowledge. For example, in teaching college algebra, according to logical dependencies, it is natural to explain logarithmic function after exponential function.

A psychological approach to the organization of subject knowledge and, consequently, teaching itself, means that the sequence of the taught topics is framed by the psychological aspects of teaching/learning. As an example, one can take the principle “from less complex material to more complex topics” or the necessity to explicate different ties between studied concepts and properties because it helps memorizing.

Another example of the psychological methodology is given by the learning style approach in teaching (Butler, 1998; Dunn & Groggs, 1998; Felder & Silverman, 1988;
A growing body of research suggests that increased learning gains can be achieved when instruction is designed with learning styles in mind. In addition, attention to learning styles and learner diversity has been shown to amplify student motivation to learn.

In the same way, types of intellectual activity are used for improving teaching efficiency (Burgin, 1997; 1998). A historical approach to the organization of subject knowledge, and consequently teaching itself, means that the sequence of the taught topics is ordered in a similar way this knowledge has been obtained in the process of subject development. For example, when number systems are taught, at first natural numbers are introduced, then positive fractions, then integer numbers, then rational numbers, then real numbers, and at the end, complex numbers are explained. At the same time, logical ordering of the same material implies that fractions and rational numbers have to be taught together (as one topic) that is posed between integer and real numbers.

However, a historical approach, as will be discussed later, may be complete and may be partial when only some parts of the subject material are ordered by the historical process. Besides, history may be used in other frameworks as a source of illustrations and examples as well as a tool for explanation, attraction, and development. The trick is to devise curricula that use different approaches to support one another. In this way, analysis of the historical approach could help to inspire curricula with greater range, power, and motivation without abandoning the core knowledge of science and mathematics.

**History in Teaching**

The range of history in teaching science and mathematics spans from the absolute absence of history to the complete historical framework for a course or even for a whole subject. Trying to place history in teaching mathematics and science, it is necessary to begin with analysis of the historical framework for teaching.

Pedagogical theory as well as practical experience and even experiments demonstrate that the complete historical framework for teaching mathematics and science is inefficient. To repeat the actual historical process of the development of such huge fields as science or mathematics is indeed impossible. Really, such a repetition demands too much time to be employed in teaching.

In addition to this, there are three more roots of inefficiency of the historical approach in teaching science and mathematics. First, scientific inquiry does not go in a straight line. Often it resembles walking in a maze. To teach in such a way necessitates a lot of time. It is possible (and even useful) to do this from time to time in the research groups of students. But not always. In everyday teaching, it is necessary to take shortcuts in exposition of the subject material. Such shortcuts happened in the history of science and mathematics very frequently. However, the most important and impressive cases of shortcuts are connected a historical breakthrough (such as creation of Calculus in mathematics, or discovery of electro-magnetic waves and building the corresponding theory in physics).

Second, following a historical path can mislead students by giving them knowledge that has been superseded later. Such elimination was due either to incorrectness of knowledge itself or to appearance of the more developed for of the same knowledge. As a vivid example of incorrect scientific knowledge, take the statement that the Earth is not moving while the Sun is rotating around the Earth. In teaching astrophysics, it is reasonable to speak about ether only as a historical predecessor of vacuum but not to develop theories that are based on the concept of ether. What concerns correct but out-of-date knowledge can be found in many
examples in mathematics. Thus, all methods of solving quadratic equations that were used before the general formula for its solution was elaborated are now obsolete. The same is true for many of those methods of mathematical analysis of functions that existed before Calculus was created.

The third reason for irrelevancy of the complete historical approach is not so obvious, so that may be worth amplification. As a rule, less efficient methods appeared in science and mathematics before their more advanced successors were developed. However, if one teaches people at first how to use less efficient methods, then it is very difficult for them to comprehend new advanced methods that solve the same problems. It is the consequence of conservatism and bias in society. For example, many difficulties in teaching mathematics such as breaks of learning and epistemological obstacles (cf. Artigue, 1999; 1996; Bachelard, 1938; Tall, 1991) are caused by inappropriate utilization of a historical approach to the choice of the content knowledge.

The author had an opportunity to observe, in one of the advanced schools in the U.S., processes of teaching mathematics, art, and music based on the historical framework. Students studied all these subjects by reflecting the state of art in the corresponding field century by century. In art and music, everything looked natural. Students, who lived inside the modern pop-culture, were able to acquire treasures of art and music that had been accumulated by humankind through its history. Everything in these courses enriched students and developed their personalities.

At the same time, the impression from mathematical classes was rather different. For example, students were taught how people had solved algebraic equations in ancient Egypt, Mesopotamia, and medieval Asia and Europe. The process of teaching and learning was the same as when the conventional approach is utilized. Even though some algorithms were more complicated (and much less powerful, giving only partial answers), students comprehended these methods and were able to use them. However, when the same students were introduced to more advanced procedures for solving equations that are taught in contemporary schools, they did not understand why they were studying different methods for the same problems, and internally opposed the introduction of new methods. Those who were able to see that new methods were much better did not realize why before they had had to study something so out of date.

Moreover, students saturated by old fashioned methods were mostly unable to comprehend new ones. This is a psychological law of human conservatism. It is vividly expressed in programming, where everything has been changed very rapidly. The majority of programmers knowing some programming language for a given application do not want to study new more advanced languages for the same application.

Besides, teaching these obsolete constructions and algorithms demanded time that is so precious for a teacher as well as for students. It might be done for students' entertainment, but in this case there was nobody who was able to appreciate mathematical complications. Thus, we come to the conclusion that it is necessary to select adequate knowledge for teaching and the historical framework is far from being the best for this purpose.

At the same time, a partial historical approach is used frequently in teaching science and, mathematics, giving good results in many cases. According to this approach, some subject material is ordered with respect of the historical process of obtaining knowledge. For example, famous astronomer Johannes Kepler found his laws of the planet motion before Newton discovered his laws of dynamics. Thus, a historical organization of the pedagogical process demands that students have to be taught Kepler laws before they are introduced to Newton laws.
Another example is given by Calculus. Now there are two rigorous approaches to the grounding and, consequently, to the exposition of Calculus. The most advanced and complete approach is called the non-standard analysis. It was created by American mathematician Abraham Robinson in the second half of the 20th century. The nonstandard analysis provides means of introducing infinitesimals, or “infinitely small” quantities basing on model theory. Only 300 years after its invention by two such geniuses as Isaac Newton and Gottfried Wilhelm Leibniz, a sound foundation for the differential and integral calculus using infinitesimals was created. In addition to this, the nonstandard analysis made it possible to ground the method suggested by one of the greatest mathematicians and scientists, Archimedes, who all his life (287-212 B.C.E.) lived in Syracuse and was the undisputed leader of all his contemporary mathematicians. This method (approx. 250 B.C.E.) is based on the supposition that an interval, the area of a geometrical figure and the volume of a body consist of a very big quantity of elementary atoms of length, area of volume. Explication of this method demands the actual infinity. In geometry, this idea corresponds with the representation of geometrical objects as sets of points. For number systems, such a model was made precise only in the non-standard analysis.

But the great importance of the nonstandard analysis for mathematicians is not simply foundational and it is not only due to the intuitiveness with which infinitesimals can be taught to students (which is also important). What is impressive and of great utility is the power nonstandard analysis brings to the solution of various significant mathematical problems.

However, in spite of all the advantages of the nonstandard analysis, contemporary teaching of Calculus imitates the historical process. At the beginning of this process, only procedures and constructions for Calculus were created mostly in the works of Isaac Newton and Gottfried Wilhelm Leibniz. Then strict mathematical foundations were elaborated for Calculus by French mathematician Augustin-Louis Cauchy (1789-1857). He successfully executed d’Alambert’s suggestion by developing a mathematical theory of limits. It made possible to define rigorously convergence, continuity, differentiation, and the definite integral in terms of the limit concept. It is essential that his definitions and construction (in a little bit modernized form) can be found in the most carefully written today’s elementary textbooks on the calculus. The limit concept is certainly indispensable for the development of analysis (Eves, 1983).

Similar to the historical process, the teaching of calculus begins with introduction of constructions (such as the derivative and integral of a function) and procedures (such as differentiation and integration) are given to the students. Then only at the university level, and mostly only for mathematics majors, the grounded exposition based on the theory of limits is suggested.

Mathematics is developing, and this development induces changes into mathematics education. New concepts and theories that enrich mathematical knowledge come after some time to the mathematics classroom. It is possible to predict that in some future Calculus will be taught in the form of Neoclassical Analysis (Burgin, 1995b), a new direction in which conventional functions and sets are studied by fuzzy concepts (such as fuzzy continuity, fuzzy convergence, etc.).

One more argument for inclusion of history in teaching mathematics and science stems from the following dilemma. Is it necessary to teach mathematics or science only as a system of knowledge or it is more relevant to educate people in the field of mathematical or scientific activity? The second point of view, when mathematics and science are treated as specific kind of human activities, implies that teaching of these disciplines needs to appeal to the history of these fields. Only history on par with modern state of art can reveal the essence and
character of this activity. For example, the best argument for training students to apply mathematics to practical problems is to show them how great mathematicians and scientists have done it. Moreover, such historical cases can teach how to find the best ways for application.

Thus, one comes to the conclusion that while the complete historical approach is not appropriate for teaching mathematics and science, the opposite approach claiming uselessness of history for these purposes is also inefficient. The reason is that historical perspective and examples provide a beneficial grounding for pedagogical problems solution. Consequently, to explain this better approach that lies between two extremities, it is necessary to explore the tasks of education. These tasks are divided into three categories: individual, social, and inter-relational. Here only individual tasks that are associated with the personality of a student (learner) are considered.

Concerning the individual, education has a three-fold aim. The first one is to enrich student knowledge in some field. The second objective is to develop her/his skills in some field. The third goal is the development of the personality of a student. In conveying mathematical/scientific information to students, history may help a lot to achieve better understanding, give better explanation, and to attract students to the beauty of science and mathematics. The following illustrates all these potentialities of history.

The first task of a teacher is to give more knowledge for a student. To achieve this, the teacher has to develop her/his skills in explanation while student her/his abilities in understanding. Relevant explication of how the corresponding knowledge has been obtained facilitates both explanation and understanding as show two following examples.

For all people (not only for mathematicians), it is important to understand numbers and how to use them. Numbers surround everybody and are utilized by everybody. There are different kinds of numbers: natural, integer, real, whole, decimal, prime, etc. They have a quantity of properties and operations. A teacher introducing numbers has not only to give definitions, examples and rules for manipulation but to tell how and for what purpose each kind of numbers was introduced by people and how these numbers were used at the beginning, later, and now. As a consequence, it would be much easier for students to grasp and recognize the value and beauty of this marvelous building of the mathematical symbols called numbers.

Another issue in algebra that is hard for understanding is the solution of algebraic equations and their application. The linear case is comparatively simple while quadratic equations cause many problems. One of the problems is that students at first learn how to solve these and higher order equations taking into consideration only real roots. The history of imaginary and complex numbers helps to understand the situation. The names “imaginary” and “complex” that were coined for these numbers reflected the attitude of people (even of the experts in mathematics) towards such numbers.

To motivate learning mathematics, it might be very useful to demonstrate examples of discoveries in science that would be impossible without mathematics. Such examples are considered later. It is possible to do the same for science, demonstrating how science helped to eliminate some crucial misconceptions (such as the commonplace belief that the Sun rotates around the Earth, or that people live in the empty space). In addition to this, it is possible to show the beauty of mathematics and science by explaining some tricky argumentation in mathematics that leads to an unclear result or some unexpected discoveries in science (Burgin, 1995).
The usage of history has to be relevant to the tasks of mathematics and science education. However, these tasks are not the same in all situations. For example, for mathematics majors, the value of a mathematical course may lie primarily in how clearly and thoroughly the subject material is communicated. For other students, the value of such a course lies more in how it fosters the analytical skills essential in their professional activity. In both cases, it is possible to find a lot in history.

Thus, in teaching Calculus to mathematics majors, it is beneficial to tell them how Calculus appeared and how it was made a rigor mathematical discipline at first to some extent by Cauchy and then more fully by Robinson. For science and engineering majors, it is much more important to explain that differential equations, which are so important for science, are rooted in Calculus. Using contemporary and past history, it is possible to demonstrate that application of differential equations to physics, chemistry, and biology has changed the essence of these disciplines. For example, modern “non-linear revolution” in science has been caused only by utilization of higher order differential equations instead of linear ones for modeling natural phenomena.

The history of mathematics might be especially useful in teaching mathematics to liberal arts students. However, even in this case the history of mathematics should not be just a framework but a source of interesting examples and entertaining stories.

The second task of mathematics and science education of enlargement of student knowledge with practical skill development relating mathematical structures and results to real life is not less important than the first task. For example, for mathematics non-majors, acquiring mathematical knowledge is only a step to finding ways for its application. History has a lot of examples of such application and it is only necessary to use these examples properly demonstrating the endless power and efficiency of mathematics. For example, there are many practical and scientific problems that are impossible to solve without mathematics. It is possible to consider such of them as prediction of the Sun eclipses, determining taxes and profit, calculations that are necessary for constructing buildings and bridges, building cars and planes and so on and so forth. A brilliant historical example of such situation is the discovery of the planet Neptune.

As noted by Kline (1959), the climax of almost two centuries of most difficult work in differential equations applied to the heavenly motions was a purely theoretical prediction of the existence and location of the planet Neptune. Unexplained aberrations in the motion of the planet Uranus were conjectured due to the existence of an unknown planet whose gravitational pull on Uranus was causing these irregularities. Two astronomers, J.C. Adams in England and U.J.J. Leverrier in France, used the observed data on Uranus and the general astronomical theory based on mathematics to calculate the orbit of the supposed planet and directed observers to the location of it at a particular time. The planet, called Neptune, was located in 1846 by the German astronomer Galle. It was barely observable through the telescopes of those days and would hardly been noticed were astronomers not looking for it. This discovery was and still is an amazing achievement (and not the only one) of mathematics.

In addition to this, it is essential to develop student personality as a whole, especially, in intellectual aspects by developing his/her intellectual activity. It is also necessary to prepare college students to exercise their responsibilities as citizens. Both goals may be better achieved by using historical cases in teaching science and mathematics. Let us consider one example.

Many students think that mathematics is too difficult for them. To persuade them that it might be not their case and to increase their motivation in learning mathematics, it is useful
to tell them story of Nicolay Lousin. When he was a boy and studied in a gymnasium, Lousin lived in Siberia. He had great difficulties in mathematics and his father being afraid that his son would not be able to graduate invited a tutor. The tutor was a university student. He exposed mathematics to Nicolay in such an absorbing way that Lousin easily passed all exams in mathematics and after graduation entered School of Physics and Mathematics at Moscow University. Later he became an outstanding mathematician having worldwide recognition.

History may be also used as a base for actively engaging students in scholarly research that enriches educational experience dramatically. For instance, students can research how some important mathematical discoveries were made or to use historical examples as a model how to conduct their own research (Burgin, 1995a).

Conclusion

Thus, one can come to the conclusion that history might be very useful in teaching science and mathematics. Following problems in mathematics/science teaching might be better solved basing on utilization of the history of the corresponding subject:

1. Demonstration of practical applications.
2. Motivation and activation of learning.
3. Teaching how to behave in different situations by giving examples of the behavior of great scientists and mathematicians.
4. Explicating features of mathematical creativity and scientific research.
5. Giving better perspective for scientific and mathematical knowledge.
6. Helping to explain and to understand complicated material.
7. Showing social context of science and mathematics.

However, as it demonstrated in this article, this is the case only when history is used in an adequate way. Consequently, it is necessary to develop methodology and technology of utilization of the historical material in courses of science and mathematics. A teacher as well as an author of a textbook has to know how, when, and for what purpose it is appropriate to tell about some historical facts or to organize subject material and/or teaching according to the historical process.

These results have important implications for computer aided teaching/learning. As a matter of fact, the contemporary computer-based courseware hits the pedagogical content knowledge part very heavily. The courseware is not just heavy on content, it is equally heavy on putting the content into a proven learnable form. General methodology of organization of teaching/learning can help to eliminate these problems while computers provide very extended means for enhancing different courses in science and mathematics by historical ingredients.

At the same time, it is very important not to substitute teaching science/mathematics by teaching the history of science/mathematics. History of mathematics or science is a separate discipline that cannot stand-in the place of mathematics or science. It is necessary to offer a coherent, high quality educational experience in mathematics and science that prepares university graduates for the challenges they will face by creating a foundation for a lifetime of learning and principled conduct in an increasingly diverse and pluralistic society. It refers essentially to science and mathematics education. Science/mathematics is essentially different from the history of science/mathematics. Contemporary students, as a rule, need mathematical and scientific knowledge while history of these fields has only to facilitate acquirement of this knowledge.
References


