

An Example of a Synergistic Connection between Formal and Informal Education

Max Bazovsky

SCHOLA LUDUS, FMFI, Comenius University, Bratislava, Slovakia

This paper describes a synergistic alteration of formal and informal science education based on teaching and learning methods that the author has developed in Schola Ludus, in a sequence of Schola Ludus seminars and some visits to Bratislava high schools. The preliminary finding is that the students and teachers “love” it. It is based on alternating formal and informal phases in a synergistic and coordinated way so that the students are “continuously” motivated and re-motivated in the various phases of the lesson plan. The teacher/presenter also uses WEB quest methodology to round out his/her presentation with interesting facts to stimulate and encourage the students into scientific fields and interests. The example presented here involves a lesson unit that starts out by telling a story, by asking some simple questions raised by the story. Then, it follows the discussions with a live simulation of the “physics in the dream” This leads to some interesting kinematics and modeling problems that the students are very motivated to follow and understand, because they want to explain a paradox that they perceive through the story. The lesson unit closes with a project for the students to gather information on the Internet by means of a formally described and control method, called a WEB QUEST. The method has been recognized in part by the Science on Stage committee, and by being described and presented this November 21, 2005, in CERN, Switzerland, (Ref 1).

1. Introduction

Nowadays, it is evident that physics education is being redefined for a variety of important reasons such as:

- a. the economic necessities of the modern competitive world depend on sophisticated science understanding of the “hi tech” work force
- b. the new relevance of science to a knowledge-based society in the new consciousness about the infosphere society. Such a society is a knowledge based society where people are supposed to act ethically (responsibly) and deliberately, as they are informed, by validated insights, into the probable consequences of their behavioral habits, life phase projects, and their life plans
- c. the inter-subject and inter discipline relationships that are leading the way for discovery and innovation in many fields such as nanotechnology, biomimickry or biomimetics, biotechnology, etc.
- d. the new findings of researchers in formal and informal education (constructivism, project based learning, problem based learning, minds on as well as hands on, etc)
- e. the new technology tools for teaching and learning (WEB, multimedia, BBC science programs, Discovery Channel, scientist and engineer visits to classrooms, etc)
- f. the new possibilities of play and leisure time activities which can, and should be, so as to help develop scientifically conscious individuals who use their scientific understanding in daily, economic and in political decision making ,

2. Motivation

We need innovative methods, to teach more and better physics in less time, to show the students how to do their own physics research, and to induce them to “love” it. And the important thing is that much of the traditional physics program teaches things that have marginal importance, while the really important things relevant to the modern development of science are regarded as being too inaccessible to high school students. One such very important piece of physics concerns the Doppler effect and its myriad of uses. As any WEB quest will soon show, the Doppler effect has an amazingly wide scope of applications in both pure and applied sciences

3. WEB Quest

WEB quests will become an important part of European science education, as they already are in parts of the USA and the UK. E.g., The author’s University of Comenius lectures (Ref 2) were developed very much with a WEB quest methodology. *Einstein’s dream and the jumping Doppler cows* (Ref 1) was developed in part by using WEB Quest methodology. All the lectures given in Bratislava high schools involved some new aspect of the Doppler effect that the students have just learned by actually doing and seeing a live simulation that shows the Doppler shifts in both frequency and in the period. Between consecutive events when the source and the observers are in relative motion.

A WEB QUEST is a teaching- technology tool for gaining more information for enhancing the effectiveness of one’s own creative efforts. Bernie Dodge (Ref 4,5) This applies to all web users; students, teachers, lay people, etc.

Definition: A Web Quest is defined as "an inquiry-oriented activity in which some or all of the information that learners interact with comes from resources on the Internet",

Back in the early days of the Web (was it really only 1995?), Professor Bernie Dodge began developing the WebQuest strategy at San Diego State University to help teachers integrate the power of the Web with student learning.

Why use WEB QUESTS? With the information explosion, education took a new turn. The information is easy to find, in books, with search engines, etc. The problem is to evaluate it and to use it. The problem is also to know what sort of information to look for, and to recognize it when it “comes up. How do we discern the good information from the bad? What organizations retain their quality control and their reliability, dependability?”. These are questions that need to be learned by doing projects like WEB quests. A WEB quest is also desirable to use for innovation and creativity in a synergistic mixture of alternating formal and informal teaching phases. If the lesson plan content is to be kept current, up to date, and of timely interest, better check for the latest and greatest results on the WEB, with a WEB quest. The basic tool of the informal part is to use a *WEB quest*, to “round out” the formal part of the teaching with less structured, less academic projects, which give the students something to do actively, a project of their own to pursue and shape according to their own interests - - as they have been informed, motivated and stimulated by the formal part of the lesson/unit plan.

The author has used this Formal/Informal interplay, together with the WEB QUEST results, with success at a Schola Ludus seminar for teachers (Ref 6,7), both for *A. Einstein’s’ Dream* and its generalizations (Ref 8) and for *Shadows and Inverse Modeling* (Ref 9), as well as with students.

4. Description Of A Concrete Example

Schola Ludus has presented A. Einstein's dream in many presentations to school children, and developed materials, such as several versions of the board for the token model and such as a step-by-step teacher's aids for running the simulation, together with detailed colored pictures, power point presentations, and explanations of a minimalist effectiveness. Now a multimedia presentation is being developed for the 2005 Science on Stage festival in CERN, Switzerland (Ref 1). The CD will include also a collection of articles and solved problems that develop the author's plans and initial lectures on Einstein's Dream and the Doppler effect into a beautiful theatrical presentation, fit for pedagogically effective presentations, and now presented in Science on Stage, CERN (Ref 1) A Schola Ludus CD has been promised and is planned to be developed soon.

4.1 *What?:*

The synergy and effectiveness of the work stems from a combination of the Doppler effect, a WEB quest on the Doppler effect, and a very nice "dream" scenario described by J. Magueijo, (Ref 10). The author has improved the effectiveness of the presented, described method over the last two years of presentations in Bratislava, by developing a concrete set of teaching plans, papers, and by involving Schola Ludus in the enhancement thereof. In published papers, high school classes and informal summer camp Schola Ludus activities, the author, in interaction with Schola Ludus, has developed a layered education sequence, or unit, that consists of one to four lessons (depending on how many layers are used). The "unit" consists of (a) resenting the Einstein's Dream story, (b) involving the pupils in a live presentation, (c) leading the various modeling phases, (d) including the identification of the Doppler effect, for a moving source (e) identifying the Doppler effect for moving observers, (f) presenting problems to be solved, and (g) assigning a WEB quest project on the Doppler effect, its applications, its history, etc.

4.2 *Significance*

The unit, as described above, shows how informal considerations can transit smoothly in a fun way first into the first stage of formalization, and then to formal quantitative studies, that directly link to informal descriptions of current scientific interest. Students experience the fun and thrill of informally navigating over a large area of the physics concept network connecting the examined concepts (as developed in the unit's content) and some of their scientific/technological uses. Most significantly, however, the students experience a vertical growth that is within their ability and reach, which is at the same time very informative and which brings them almost to the forefront of science in several alternative areas.

5. An Outline of the Specific Example

5.1 *First Layer/Stage*

The first informal part starts with a science fiction story (originally called "Einstein's Dream, Who is Right?") that uses some emerging technologies as a background scenario and some imagined phenomena to highlight some interesting concepts and pose questions about the motion of a) some traveling causes, and b) the transmission of information about the effects of those causes *to observers*.

5.2 *Second Layer/Stage*

This is followed by the first stage of formalization in which live student simulations and measurements visually help develop a common vocabulary, as well as student understanding and explanation of the claims of the story.

NOTE: The measurement attempts are VERY important. They are sloppy, because of the variability of the people in the live simulation. But this motivates the Token Step model as first developed by the author (Ref 11) and further unfolded in great beauty by schola Ludus in Ref 1.

5.3 *Third Layer/Stage* The middle lessons of the unit help students develop a formal model of the story phenomena, study the model, relate it to the *Doppler effect*, and generalize the model still further (generalized Doppler effect) by deconstructing the original meanings.

5.4 *Concluding Layer/Stage* The unit closes with another informal phase that applies the Doppler models previously highlighted, studied, used and developed, to different contexts of classical and modern physics that are of current interest to physicists and educated laymen (parts of low temperature methods, medical technology, and astronomy). This is done in Ref 1..

The interesting thing about WEB quests is that they can often connect things that are surprising. E.g., Einstein's Dream is the name of a book (Ref 12), a Play, and a musical. There is even a related opera by a famous American composer Philip Glass (Ref 13). Certainly not only budding young physicists can benefit from the WEB quest for Einstein's dream. And the author learned that many researchers in cosmology and particle physics call Einstein's search for the *Theory of Everything*, as "Einstein's dream. Perhaps that was, and is, Einstein's *biggest dream*, and his best dream, that will soon be realized. But whether it can even be realized is still a controversial point among leading physicists.

NOTE 1: *The concluding stage lesson is not really an end to the modeling, Doppler, generalized Doppler activity. Rather it is the beginning.* Toward the end of the concluding stage, (and after this stage, e.g., as homework, and projects work), the students begin to navigate the WEB to gain validation and empowerment about using the concepts and hints that they have learned during the earlier phases of the multilevel lesson plan presented herein. They participate in a project (as in project based learning, or PBL), that opens up their creative energies, their creative instincts, and lets them "go their own way" while navigating the web for relevant things related to their lessons and their recent realizations

NOTE 2 The unit and lessons plans described encourage and liberate students who want to go farther, who can go farther, and who do go farther, according to their own interests and abilities. There is no limit to open-ended questions. Once interest is awakened it is almost a crime to limit it abruptly, because abrupt limiting of newly stimulated interest, eagerness, or enthusiasm will dull the will power and the force to self-assertion. This in turn will either remove those unfortunate people from the quest for science by self discovery/constructivism, or by dulling creative impulses it will tame the "wild visions" and turn even geniuses into decent, well behaved, "YES-MEN instead of dreamers, and speculators, explorers and seekers.

6. Schola ludus Methods

Schola Ludus is an organization devoted mainly to informal science education the training of teachers, design and presentation of festivals, exhibitions, and research into new methods. In keeping to this, the author has shown a concrete example, very powerful one, that unites formal and informal education in a dramatic way by developing many formal kinematics and Doppler effect problems to round-out the informal part (Ref 15). This joining of informal

with formal has created a stronger, Schola Ludus. But the method is general, and available for all organizations and teachers, not only informal science education.

In addition, there is a strong correlation between the author's methods and the parallel method, with one exception. E.g.,

- a. The *key example* in this case is the A Einstein dream scenario, which started the whole work, Ref 14.
- b. This was followed by *parallel graphs, parallel problems* of kinematics and Doppler effects, and *parallel examples* (Ref 15).
- c. Then some top cases were developed, first where singers on a boat were heard in different sequences with reversal of notes due to reflection or echoes with moving source (Ref 6). Next, both time and space were "layered" and this lead to the GDE, generalized Doppler effect. (Ref 6) Next the parallel case of a winding river was developed (Ref 15). In this case the "information" carriers were in fact "demanders for service". So in a sense this generalized Doppler effect example is a Doppler effect in Queuing theory, a subject in the broader category of Operations Research. Later, "another" top case of two dimensional Doppler effect was developed, also with demands for services showing a Doppler shift in frequency due to a moving source (Ref 16)

6.1 Deciding What Is Top Case

As discussed above, the author considered several top cases as Einstein's Dream lesson plans and Unit plans developed. This leads to the question, "How do we decide what is the 'top case'?" Can we really define "top case" apriori? It is a matter of judgment and understanding as well as personal preference as to what is taken as the "top case". Pursuing this question lead to another modification to the Schola Ludus method. I.e., the author did not psychologically admit any such "limitation" as a "*real* top case" might imply when understood at it primary meaning in the English language. I.e., the phrase "*top case*" is a matter of semantics and language as understood by Alfred Korzybsky, Sapir, Whorf etc. See for example Ref 17. So "top case" has to be taken in the sense of "*an example with different quality*". In this sense, it has no association with finality. it is actually like the "*best yet*", or like the "*greatest and latest*" phrases used in advanced American engineering design circles. These do NOT imply in any way that there is nothing higher than the current "top" as it is momentarily understood.

Note, It is currently the author's hypothesis, that this interpretation of *Top Case*, as the "greatest and latest" case or idea, is what provided the author with the energy and guidance, to continue researching the key example in a vertical direction, and that lead to so much stepped vertical development from such as simple beginning as a live simulation, based in part on what the author saw being done in Schola Ludus theatre plays and also in San Jose, CA, USA education circles by some innovative teachers. But then this is exactly the author's experience when dealing with complex engineering systems that continue to be developed and improved in a cyclic manner, not only during the design phase itself, but also during the data logging of the users and operators of those systems, - - in a never ending continual improvement of cycle following cycle. And this is also what the parallel method should become.

Appendix WHY Web Quests and Informal Education Should Be Synergistically Joined in Lesson Plans and in Unit Plans

- a. There is more and more science to be done. We want to understand, in an operational and predictable way, ALL things that are interesting, or that could lead to interesting applications. But the person who learns science the traditional way, is already bored, “turned off” and “lost” to science very quickly
- b. The need for science knowledge in a Knowledge Based Society, or in the INFOSPHERE society, is becoming more and more evident. E.g., in the more enlightened societies, the case against public smoking is very strong and smoking is regarded as a rather “unfortunate habit that is to be dropped”. In less developed societies, the people still feel “strong and much” about smoking” They want the right to smoke in restaurants. They are not aware of the physics neither of second hand smoke, nor of the chemistry or biology of the toxic chemicals therein.
- c. Students are busier than ever, and live a faster paced life. What they learn in their early university days can be obsolete, and “low tech” by the time they graduate.. So the professors and teachers too, can benefit from doing their own WEB quests, and from encouraging all students to follow a more individual path of studies, a more “independent” path of study, as Einstein himself recommended.
- d. With the idea that informal learning precedes the formal part, the WEB quest can be a magical means to prevent professors from becoming pedantic wizards left behind in the backwaters of change.
- e. New education tools and concepts are available, to help teachers and students to skip over/ from the “DEAD, OLD stuff, to the relevant, PROMISING CURRENTLY ALIVE stuff; to the content that is being used by current researchers; to the content that points directly to the state of the art. The Doppler effect is one such very powerful area that the author has tested even on twelve year olds. (Ref 18).

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