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5

SciComm, PopSci and The Real World

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A physicist's experience in science communication (SciComm), popular science (PopSci) and the teaching of a Science Matters (SciMat) course *The Real World* is presented and discussed. Recommendations for others are provided.

5.1 Introduction

Yes, yes, I know. I know that I am not supposed to use abbreviations in a chapter title; I should spell out the whole word. But like the French say: rules are set to be broken. And indeed it happened: Newton (1643-1727) broke the rules set by Aristotle (384-322 BC) in dynamics, and replaced them with his own three laws; Einstein (1879-1955) in turn broke Newton's three laws and replaced them with his theory of special relativity. This is called innovation or in rare occasions, revolution. Rules could and should be broken when one has a good reason. And I have *two* good reasons.

My background as a scientist is not atypical. I have been working in physics research in the last 40 years. I am now a professor in California, a job involving both research and physics teaching (with an unbelievable teaching load of 12 credits[1] plus office hours per semester). My research

[1] At San Jose State University, an undergrad lab of 3 hours is counted as 2 credits (*versus* 3 credits in the community college of City University of New York, a great city) as the instructor's teaching load is concerned. I end up teaching 2 courses and 3 labs per week.

was first in condensed matter physics and later in nonlinear physics and complex systems.

My involvement in Science Communication (*SciComm* or *scicomm*) began in 1994, in Mexico City, Mexico. In that year I was invited by Rosalio Rodriquez and gave a public lecture "Nonlinear Physics Is for Everybody" at Universidad Nacional Autonoma de Mexico. Since then, I have been doing physics research, teaching and scicomm simultaneously, trying to synthesize my activities in these three areas and, most importantly, trying to be creative and have fun in doing that. In recent years, these activities are heavily influenced by my involvement in histophysics—the physics of human history [Lam, 2002; 2008b] and Science Matters[2] (SciMat or scimat) [Lam, 2008a]. What follows is the adventure I went through in the wonderland of SciComm and my innovation in education on behalf of SciMat, and my recommendation for others.

5.2 Science Communication

Science communication [Gregory & Miller, 2000] involves four components:

1. Funding and organized effort from the government and learning societies
2. Engagement of scientists as individuals
3. Participation of the public
4. Development of SciComm as a research discipline, by scholars and students

Engaging scientists and the science community to participate actively and regularly is a daunting task. What the government can do is to provide funding and encouragement to scientists who are willing and qualified. The other part of the game concerns the scientists themselves, at the individual level. Leon Lederman, a Nobel physicist, proposed that working scientists should devote 10% of their time to communicating

[2] Science Mattes is a new discipline that treats human-related matters as part of science.

science. This may not be very practical for those professors who do not yet have tenure, because the competition in research is very keen and research requires undivided attention, not to mention that SciComm is not always appreciated and rewarded by the administrators. But let us say, a scientist—tenured or not—wants to contribute to SciComm, what can she or he do? This Section addresses this problem, from the perspective of a working physicist.

Six items concerning what science professors or teachers can do in SciComm are presented here [Lam, 2006a].

1. <u>What every science professor/teacher can do: Integrate popular science books into science teaching</u>

The quick pace of interdisciplinary development in science and the ever-changing job market demand a broad knowledge base from our students. For five or more years, I integrated popular science (*PopSci* or *popsci*) [3] books[4] into my physics classes by giving extra credits to the students who would buy a popsci book,[5] read it and write up a report [Lam, 2000a; 2001; 2005a]. The instructor does not actually teach the books, and hence will *not* find the teaching load increased—an important factor in any successful education reform. It is like a supplementary reading, a practice commonly found in English classes but rarely adopted by science instructors. The aim of this practice [Lam, 2000a] is to:

(1) Broaden the knowledge base of students
(2) Show the students the availability and varieties of popsci books in their local book stores
(3) Encourage the students to go on buying and reading at least one popsci book per year for the rest of their life
(4) Become a science-informed citizen—a voter or perhaps a future science-friendly legislator

It is about lifetime learning of science matters. Professors in other universities have copied this approach, with equal success. It is equally

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[3] The term PopSci is inspired by Pop Art, advocated by Andy Warhol (1928-1987).
[4] See Section 5.4.1 for the reasons of why popsci books are important.
[5] See Appendix 5.1 for a sample of books bought by my students.

applicable to high schools. Adopting this practice in the whole country or worldwide in large scale will fundamentally improve the science education of our students, the future average citizens. An immediate side effect is that in a few short months, all the popsci books on the bookshelves of every bookstore will be wiped out. The popsci book market will be drastically improved, attracting more skillful writers into the popsci books profession, benefiting everybody.

2. What every science professor can do (I): Inject popular science talks into departmental seminars, or set up a separate popular science seminar series in the department

Since 1994, I have been giving public talks on science, history and religion, starting with a title the audience are interest in and leading them to the topics such as the scientific method that I really want them to learn. The titles include:

- Wu Chien-Shiung: The First Woman President of American Physical Society
- Does God Exist?
- The Real World
- The Birth of a Physics Project: What Happened to My New Book
- Why the World Is So Complex
- How to Model History and Predict the Future

I usually tried them out first in my physics department. In almost all universities around the world, there is a weekly departmental seminar. Recent research results are presented by either outside speakers or the faculty members. These talks are usually boring and quite often poorly attended. The exceptions are popsci talks, because they are easy to understand, even for undergraduates.

What every science professor can do is to insert popsci talks into their departmental seminar series, which can be given by themselves or outsiders. If the department does not allow it, a separate popsci seminar series can be set up within the department, with the help of the student science club if it exists—if not, help the student to set up such a club;

your department chair will be thankful. And, of course, these seminars are open to the general public.

3. <u>What every science professor can do (II): Set up a popular science lecture series in the university for general audience</u>

In December 1999, I established a public lecture series “God, Science, Scientists” at San Jose State University (SJSU). The first three speakers (Fig. 5.1) are:

(1) Michael Shermer, who gave a talk in May 2000 on “How People Believe: The Search for God in the Age of Science.” Shermer, a monthly columnist for *Scientific American*, is the founding publisher and editor of *Skeptic* magazine. He is the author of many popsci books such as *Why People Believe Weird Things*, *How People Believe*, *Denying History*, *The Borderlands of Science*, *The Science of Good and Evil*, *Why Darwin Matters* and *The Mind of the Market*. He is also a professor of history and science associated with Caltech and the Occidental College at Los Angeles.
(2) Eugenie Scott, the executive director of the National Center for Science Education in El Cerrito, California. Scott is a nationally known authority on creationism and evolution controversy.
(3) Charles Townes, the Nobel laureate in physics and co-inventor of laser.

These talks were attended by a large audience from different walks of life and were well received. I still get letters/emails from the fans who attended the lectures.

Every science professor can set up a popsci lecture series in their university, which will be highly appreciated by the administrators. It is not that difficult to do if you limit yourself to one speaker per semester. And don’t forget to invite your Dean or President to introduce the distinguish speakers.

Fig. 5.1. The first three speakers of the "God, Science, Scientists" public lecture series at SJSU. From left to right: Michael Shermer, Eugenie Scott and Charles Townes.

4. What every scientist can do: Give popular science talks in high schools, the community and other places

For a period of 11 years, I gave invited popsci talks in various high schools,[6] universities, TV interviews (CCTV, Dec. 18-19, 2003) and conferences in Mexico, the United States, Taiwan, Hong Kong and China.

In November 2000, Shermer [2001] was one of four PopSci experts I invited, in my capacity as a member of the International Advisory Committee, as a speaker at the International Forum on Public Understanding of Science, Beijing, organized by China Association for Science and Technology (CAST). We became good friends. I wrote an article on active walk for his magazine *Skeptic* [Lam, 2000b].

This article led to an unexpected invitation from the Foundation For the Future (in Bellevue, WA), as a keynote speaker in their annual seminar, Humanity 3000, held in Seattle, 2001. The 23 invited "participants" included the famous Edward O. Wilson (from Harvard)

[6] Such as the Provincial Senior High School, Hsinchu, Taiwan, whose graduates include Yuan-Tseh Lee (Li Yuanjie), Nobel laureate in chemistry.

and Richard Dawkins (from Oxford); I was the only physicist there. I gave a talk on “How to Model History and Predict the Future” [Lam, 2003], and became a futures-study expert, *ipso facto*.

After that, I was invited by Doug Vakoch of the SETI Institute (Search for Extraterrestrial Intelligence, based in Mountain View, CA), who also attended this Seattle seminar as an “observer,” to go to Paris in March 2002 and talk about what science-and-art message to send to the extra-terrestrials (ET), in case they exist. I proposed to beam them digitally the recipes to create the Sierpinski gasket, a fractal.[7] Vakoch liked the idea and included it in his workshop report [Lam, 2004a]. And I suddenly found myself an ET expert.

One thing led to another, like in a chain reaction. I met some artists during this Paris workshop, and we have been trying to collaborate on a physics-art-music (PAM) project[8] called “Candle in the Wind.”

Another participant in that Seattle seminar was Clement Chang, founder of Tamkang University in Taiwan. In December 9-11, 2003, I was invited to give the Tamkang Chair Lectures (Figs. 5.2). My host was Kuo-Hua Chen, Chair of the Graduate Institute of Futures Studies and Director of the Center for Futures Studies. The result is my first popsci book, *This Pale Blue Dot: Science, History, God* [Lam, 2004b] (Fig. 5.3).[9]

It is not true that every science professor is good at giving popsci talks, but every one can try and be successful. You just keep practicing, giving the same talk many times and modifying it with the help of PowerPoint. And as shown in my story above, the reward could be significantly large: It gains you many new friends, from all walks of life; it might even take you to Paris.

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[7] A fractal is a self-similar mathematical or real object with possibly a fractional dimension [Lam, 1998].

[8] The artist, Aprille Glover (www.aprille.net), and her husband are two Americans living in Lavardin, France [Glover, 2000].

[9] “Pale Blue Dot” refers to our dear Earth when observed from far, far away in space; it comes from the title of Carl Sagan’s popsci book [Sagan, 1994]. My book contains three chapters: Why the World Is So Complex, How to Model History and Predict the Future, and Does God Exist?

Fig. 5.2. The poster of my Tamkang Chair Lectures, titled "This Pale Blue Dot: Science, History, God."

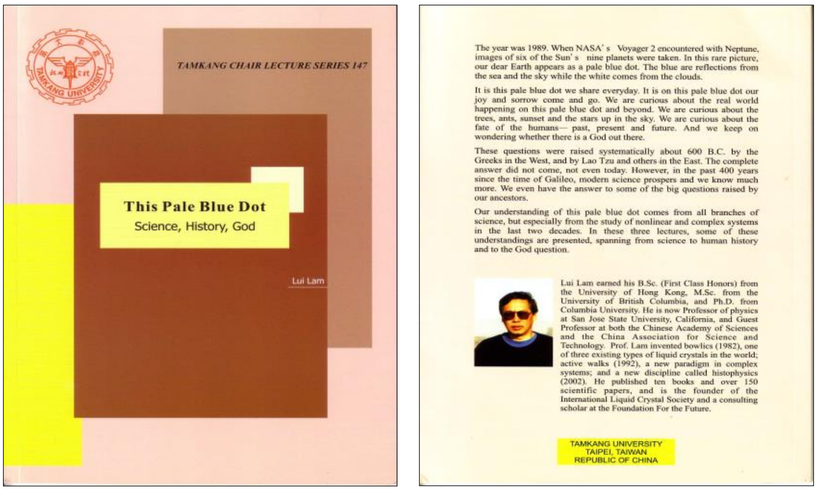

Fig. 5.3. The covers of my first popsci book *This Pale Blue Dot: Science, History, God*.

5. What some scientists can do but all can try: Contribute to science communication research

Science communication as a discipline is at its very early stage; it is a profession without a formal name[10]—unlike the case in physics, say. A new and short word is needed. My suggestion is to call it SciComm or PopSci.

It is rare to find a scicomm course in American universities. In contrast, China has a lead here; there are already degree programs in SciComm in at least four universities, and a research institute on PopSci (under CAST) in Beijing—the China Research Institute for Science Popularization. Obviously, the contribution of working scientists in making PopSci a mature discipline is much needed; for example, they can provide different perspectives and help to clarify science issues.

In June 2004, I collaborated with Da-Guang Li of CAST (now at Chinese Academy of Sciences, or CAS for short) and Xu-Jie Yang of the *ScienceTimes* (a Beijing daily published by CAS) and presented a paper at the International Conference on Scientific Knowledge and Cultural Diversity, Barcelona, Spain, June 3-6, 2004, on the absence of *professional* popsci book authors in China [Lam *et al*., 2005] (see Section 5.4). This was followed by a paper on a new concept for science and technology museums, presented at the International Forum on Scientific Literacy, Beijing, July 29-30, 2004 [Lam, 2006b]. The idea is that unified themes governing natural and social sciences [Lam, 2008a] should and can be injected into the display in science museums, to avoid the possible misconceptions conveyed to the visitors that the two are completely separated from each other (see Section 5.3). And, reporting

[10] The absence of a formal name for the SciComm discipline or profession is due to the fact that the practitioners cannot agree on a single name, partly due to the shifting emphasis or concept in SciComm. Some favor Popular Science or Science Popularization; others, Public Understanding of Science; etc. In fact, these different terms could be the names of subfields within a single discipline—SciComm, like atomic physics and condensed matter physics, two subfields in physics.

for *ScinceTimes*, Yang and I co-wrote an article reporting on the 10th International Conference on the History of Science in China, Harbin, August 4-7, 2004 [Yang & Lam, 2004].

6. What some science professors can do: Merging science with humanities

Science and the humanities are considered by some as "two cultures" [Snow & Collini, 1998; Lam, 2008a]. But in fact, humanities are about humans, which is a (biological) material system of *Homo sapiens*. Thus, humanities could and should be part of the natural sciences, which is about *all* material systems. The two can be integrated, but how?

In 1992, two years after I founded the International Liquid Crystal Society [Lam, 2005b; 2005c], I came up with a new paradigm for complex systems. I named it *active walks* (AW), reviewed in [Lam, 2005b; 2006c]. An active walker is one that changes a landscape—real or mathematical—as it walks; its next step is in turn influenced by the deformed landscape. Active walk is now widely applied in natural and social sciences ([Lam, 2008a; Han *et al*., 2008]).

By 2000, the year that Shermer and I first met each other, I have been trying to create a new discipline by merging AW with a branch of the social sciences/humanities. Contact with Shermer, himself a historian [Shermer & Grobman, 2000], made me look at history seriously. Two years later, I presented my *first* paper [Lam, 2002] on the physics of history, or *histophysics* [Lam, 2008b], at the workshop celebrating the 80^{th} birthday of Chen Ning Yang, a physics Nobel laureate, at Tsinghua University, Beijing. Histophysics is a successful example of SciMat, the new discipline that treats all human-related matters as part of science [Lam, 2008a]. My work in histophysics leads us to the discovery of two historical laws concerning Chinese dynasties (from Qin to Qing) and a new general phenomenon in Nature called the *bilinear effect* [Lam, 2006c; 2008b; Lam *et al*., 2008]. My knowing of Shermer, made possible through our shared activities in SciComm, played an important role in the creation of this new discipline, histophysics [Lam, 2005d]. Subsequently I expanded my interest from history to the overall basic situation of humanities/social science and came up with the idea of SciMat [Lam, 2008a; 2008c].

In the summer of 2005, I presented a paper on the history of histophysics [Lam, 2005d] and worked as a reporter for *ScienceTimes* [Lam, 2005e; 2005f] at the XXII International Congress of History of Science, Beijing, China, July 24-30. I met Maria Burguete, another participant from Portugal. Upon a cup of Chinese tea, she invited me to visit her. Next year in March, with the award of US$ 1,000 travel money from SJSU, I found myself in Portugal, one of the few countries in Europe that I never visited before, despite my two-year stay in Belgium and West Germany during 1975-1977. It was at the bar of Vila Galé in Ericeira and after a few drinks that we decided to do something together next year, and that was how the First International Conference on Science Matters, Ericeira, Portugal, May 28-30, 2007, co-chaired by Maria Burguete and Lui Lam, came about [Sanitt, 2007].

My involvements in SciComm actually include something more. To help China's fight against pseudoscience, and sometimes "evil religions," I became the Chinese-copyright agent of Michael Shermer and James Randy. I got Shermer's *Why People Believe Weird Things* (Hunan Education Press, 2001) and Randy's five books on magic and pseudoscience fighting (Hainan Press, 2001) published in Chinese.

There are many things scientists can do in SciComm, as individuals and without funding. Six of these are recommended above, with the first four suitable even for untenured professors. SciComm is fun and adventurous; it enables one to meet interesting new friends/colleagues beyond their own discipline, or even helps one's research career. Chair Mao once said: When faced with a daunting task, learn from the ants; mobilize the masses and trust them. It worked for China, and will work for SciComm.

5.3 A New Concept for Science Museums

A science museum (or a science and technology museum) is an effective medium in helping the public to understand science. However, in contrast to popsci books [Lam, 2001; 2005a; Lam *et al*., 2005] and TV science programs, museums are limited by their physical locations and large budgets. Yet, when available these museums allow the public to see the real objects and, apart from admiring the wonders of Nature itself, learn the science principles behind some natural phenomena.

In China new science museums appeared rapidly in the last 20 years. In other parts of the world, for example, in Barcelona, Spain, a brand new science museum is under construction. There is no doubt that the importance of science museums is well recognized.

The first step in making a good science museum is to have good exhibits. The next step is to make it physically interactive, partially or completely. Almost all science museums *stop* here. This could create a problem and is most unfortunate; most unfortunate because the problem is easily removable. What is needed is a new concept.

5.3.1 *Possible Misconceptions Imparted to the Visitors*

The exhibits in all science museums are displayed according to their subject matter, in other words, in compartments. For example, the exhibits may be put into four divisions: inanimate matters, life, intelligent matters, and civilizations. This classification is based upon the hierarchic construction of the material world, according to what we know. The world is made of atoms; in increasing size, atoms form molecules, molecules form condensed matter—inorganic matters and organic matters. Organic matters form living matters—plants and animals. Animals consist of cells and organs. In particular, we have human bodies. A group of humans form a society, leading to civilizations. (See Fig. 1.2 in [Lam, 2008a].) Consequently, the four divisions of the exhibits are logical and there is nothing wrong with that. However, science museums with these compartmental exhibits could create two misconceptions for the visitors:

1. The visitor may leave with the impression that science is neatly divided into compartments; that is, there is no unifying themes or principles behind many of those exhibits.
2. Since almost all science museums are limited to natural sciences only, the visitor may go home thinking that there is a rigid demarcation separating the natural sciences from the social sciences.

The fact that social science should and could only be based on natural science [Lam, 2002; 2006c; Wilson, 1998] is easy to see, but is sometimes overlooked. As explained in last Section, the reasoning goes like this: Social science is about the study of human behaviors and human societies. Humans are (biological) material bodies which, of course, are part of natural science since natural science is about *all* material systems. (See [Lam, 2008a] for more discussion.)

5.3.2 *A Simple Remedy*

How can these two misconceptions be avoided and corrected? Very simple! Before the exit of every science museum, there should be a room or a space showing some established principles that are able to unify many different phenomena found in Nature, with examples taken from both natural and social sciences. There are three such principles: fractals, chaos and active walks [Lam, 1998]. (See [Lam, 2008a] for a brief introduction to these three general principles.)

It is gratifying to note that in some science museums in China[11] [Ai, 2004][12] and perhaps elsewhere, some, but not all, of the three general principles mentioned above have been included in their exhibits. However, there is still no emphasize on the theme that social science and natural science are an integral whole, and the former is based on the latter, with unifying principles. And we would like to see that this is the case in *all* museums in the world.

Lastly, to have the greatest and lasting impact on the visitors, I still think that putting the unifying themes concerning all natural and social phenomena before the exit of a science museum is the best choice.

5.4 Science Popularization in China

In China, the term "popular science" or "science popularization" (abbreviated as *kepu* in Chinese) is favored over "science

[11] China Science and Technology Museum, Beijing: "Science Tunnel" (http://old.shkp.org.cn/xinxi/suidao/shuidao003.htm).

[12] Ai's article is an introduction to the Shandong Science and Technology Museum in Jinan, Shandong Province, China.

communication," due mostly to the fact that the former two terms (especially the second one) have been in use for a long period of time. A brief history of science popularization in China, from the time of late Qing Dynasty and up to 2006, can be found in [Li, 2008].

Essentially, before 1949, the year the People's Republic of China was established, PopSci was advanced by the intellectuals with hands free from the government; many of these people were educated in the West or Japan. After 1949, like everything else in the New China, PopSci was managed from the top by the government. The advantage is that PopSci is financially secure; the disadvantage, as pointed out by Li [2008], is that there were less free discussion and exchange of idea among the practitioners or scholars. As mentioned in item 5 of Section 5.2, in SciComm, China actually has a lead over many other countries in terms of scales. A summary of the current situation—official policies, programs, activities and studies of PopSci in China is available.[13] Those interested in PopSci research in China could consult the journal *Science Popularization*[14] which is based in Beijing.

Here is an interesting PopSci problem: Why *professional* popular-science book authors do not exist in China? The easy answer to this question would be that, like some other non-English-speaking countries, the sale of popsci books written not in English (and hence no worldwide sales) is not enough to support their authors full time. But China is a huge country with 1.3 billion people. The story is more complicated than this. The answer to and solution of the problem in China's case could be unique.

Before we proceed to the answer, let us first review why this question is important, not merely to China but to the whole world. And, after the answer, recommendations to improve the situation, applicable to China and *beyond*, will be given.

5.4.1 *The Importance of Popular-Science Books*

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[13] *2007 Science Popularization Report of China*, published by China Research Institute for Science Popularization, CAST (Popular Science Press, Beijing).

[14] This journal is managed by China Research Institute for Science Popularization, CAST. Since its inception in 2006, the author is a member of the editorial board.

Popular science books have a long history in existence [Gregory & Miller, 2000]. Unfortunately, they are a neglected tool in the science education of students and ordinary citizens [Lam, 2005a]. Popsci books are unique among the science media:

1. They are available in every bookstore in every town, unlike the technical science books which are available in special book stores in a university town.
2. Many popsci books are written by the pioneers themselves, Nobel laureates, or very gifted science writers who could be journalists or other scientists.
3. These books are affordable to almost everybody (about 20 yuans in China, and 15 dollars for a paperback in USA).
4. These books are the place to learn how research was actually done and how discoveries were made in very recent times.
5. These books, at least in the USA and for the majority of them, contain no equations; they, if well written, are easy and entertaining to read.

Obviously, to ensure the continuous supply of new and good popsci books, a large number of competent authors must be available.

5.4.2 *Popular-Science Book Authors in China*

In spite of China's large population of 1.3 billion, there is not yet a single *full-time* professional popsci book author in this vast country. This is in contrast to the case in literature, because China does have professional writers who can support themselves by publishing novels. And this is not due to lack of support from the Chinese government. In fact, the Chinese government recognizes science and technology as an important pillar in raising the living standard of its population and the economic well-being of the country as a whole. In 2002, China passed the *law*,[15] the one and

[15] *Law of the People's Republic of China on Popularization of Science and Technology*, issued June 29, 2002 (Popular Science Press, Beijing).

only one such law in the world, which protected and encouraged science popularization at every level of government.

In the years from 1949 to about 25 years ago and *before* market economy was introduced, every writer in China was government employed. During this period of time, the government saw the need to support full-time novelists, but not full-time popsci writers. Obviously in China (and everywhere else in the world) popsci books are not deemed to be equally important as literary books.

These days, *after* market economy is in place, quite a number of self-employed literary writers already exist and, as usual, *the government still supports a sizable number of literary writers*. Yet, we still see no full-time popsci book authors in China, self-employed or government employed. Why? To find out what happened, we interviewed a number of popsci book authors and publishers in China [Lam *et al*., 2005]. We were told that:

1. Science popularization is considered lower in status compared to science research or teaching.
2. Work in science popularization is not counted in job evaluations in many places.
3. Lack of systematic and large-scale government effort or program to train popsci professionals.
4. Insufficient personal income to support free-lance, full-time popsci writers.

Points 1 and 2 are definitely true in almost every other country; some countries are doing something to tackle point 3; point 4 is untrue, for example, in USA.

Point 4 is particularly interesting. With such a huge population in China, how can this happen? In fact, presently, the sale of an average popsci book in China is less than 5,000 copies. There are exceptions: for example, *The Complete Book of Raising Pigs* did sell 3 million copies. What this implies is that a popsci book (not on pig raising) geared to the need of the masses is still waiting to be written.

5.4.3 *Recommendations*

To address points 3 and 4 above, here are six recommendations:

1. The government should recognize the importance of popsci books, in line with the popsci law they put into effect in 2002, and support popsci writers the same way they support literary writers.
2. The government could extend the policy of supporting literary book projects to popsci books, too. That is, prospective writers can apply for a grant to write a particular popsci book.
3. In every science funding agency, for example, the Chinese National Natural Science Foundation, a new division of funding should be set up to support popsci activities, including book writing.
4. In major research institutes, such as those in the Chinese Academy of Sciences, one-year visiting positions for prospective writers could be established, enabling them to observe the research in action, learn about recent major research findings, and discuss with the experts or perhaps even collaborate with them to write popsci books.
5. Most importantly, to guarantee that popsci books will be sold in large quantities in the immediate future, all science teachers in high schools and universities should incorporate the use of popsci books in their classes. It is done by offering the students extra credit if they buy a popsci book, read it and write a brief report. This is a sure way to excite the students in science and to enlarge their knowledge base. (See item 1 in Section 5.2.)
6. Since natural science forms the basis of all social sciences [Lam, 2008a; Wilson, 1998], and since science and literature are equally important in shaping modern lives, the time has come to include several popsci books—such as James Watson's *The Double Helix* [Watson, 2001]—into the list of required readings in the general education of every student in every university.

In points 1-4, the prospective popsci writer should be allowed to come from any place (especially magazines and newspapers) as long as the candidate is qualified. Naturally, points 5 and 6 are equally applicable to other countries. China is a country with a strong central government and these recommendations do not need that much new funding; they can be implemented quickly. What is needed is the willpower to do so. Luckily for China there is a tremendous amount of willpower, as impressively demonstrated in her organization of *Olympic 2008*.

5.5 Education Reform: A Personal Journey

Education reforms in universities could involve any of these three components:

1. Contents of the course
2. The teaching method of the instructor
3. The learning method of the student

No matter how it is done, an unavoidable constraint that will crucially affect the success of the reform is usually not mentioned, or ignored completely by the reformers; that is, *the reform should not increase the teaching load of the instructor*. Also, the quality of the student taking a course—like the quality of a sample in a physical experiment or the raw material in a factory—is of primary importance; this factor is never emphasized enough. Obviously, with a defective sample, no good experimental result can be expected, no matter how skillful the experimentalist is. This last factor points to the need to start any education reform from grade one on, or even better, from the kindergartens. And I am not kidding.

With the constraints understood and resources limited, I tried to do my best as a teacher. There is not much we can do about item 3 above. It is very hard for the student to change her/his learning habit after being wrongfully taught for 12 years before they show up in college, and this is not their fault. I therefore concentrated my effort in the first two items.

On item 2, the instructor's teaching method, I have tried something radically different. It is called "MultiTeaching MultiLearning" (MTML) [Lam, 1999]. We note that in a physics class, the instructor usually does not have enough time to cover everything. The attention span of a student is supposed to be about 15 minutes. Students in a class have different learning styles. Some students are more advanced than others. Active learning and group learning are good for students. Around 1999, to overcome these problems in the teaching of two sections of a freshmen course in mechanics, I have tried a zero-budget and low-tech approach. In this course, we covered about one chapter per week, using *Physics* by Resnick, Halliday and Krane as the textbook. In each course, there were three classes per week, each 50 minute long. In the last session of every week, the class was broken up completely. Different “booths” like those in a country fair were set up in several rooms, manned by student volunteers from the class. The rest of the class was free to roam about, like in a real country fair, or *like what professional physicists do in a large conference with multiple sessions*. In this way, we were able to simultaneously offer homework problem solving, challenging tough problems for advanced students, computer exercises, Web site visits, peer instruction, and one-to-one tutoring to the students. The students seemed to enjoy themselves and benefited from it. However, this approach was soon discontinued. It did require a little bit of extra preparation from the instructor; but more importantly, it did not seem to raise significantly the grades of the students. The “inferior raw material” factor might be at work here.

The next thing I tried, with better luck this time, is to integrate popsci books into my physics classes, as described in item 1 in Section 5.2. This practice was quite successful; the students liked it very much.[16]

This popsci book program is not trying to alter the course content *per se*. My first attempt in this direction, item 1 in education reform above, actually happened earlier. Soon after I started teaching at SJSU in 1987, I created two new graduate courses, Nonlinear Physics and Nonlinear Systems.[17] But these two courses were for physics majors. In Spring 1997, I established a general-education course called *The Real World*, opened to upper-division (that is, third and fourth years in college) students of *any* major. It results from my many years of research ranging from nonlinear physics to complex systems [Lam, 1998]. The description of this course is given in the flyer in Fig. 5.4. There were only nine

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[16] American students are crazy about extra credits in a course, even though the time they would spend to do the extra-credit work could or should be used in learning the course itself. It is a psychological thing, probably frequently used by teachers from grade one on.
[17] These two courses resulted in two textbooks, one for undergraduates [Lam, 1998] and the other for graduate students [Lam, 1997].

students in class, majoring in physics, music, philosophy and so on, plus two physics professors sitting in. It was fun. The course stopped after one semester due to nonacademic reasons, falling victim to the sociology of science education.

Five years later in Fall 2002, the course was resurrected with the same name but modified to suit incoming freshmen students. It is this general-education freshmen course that will be described in detail in the next Section.

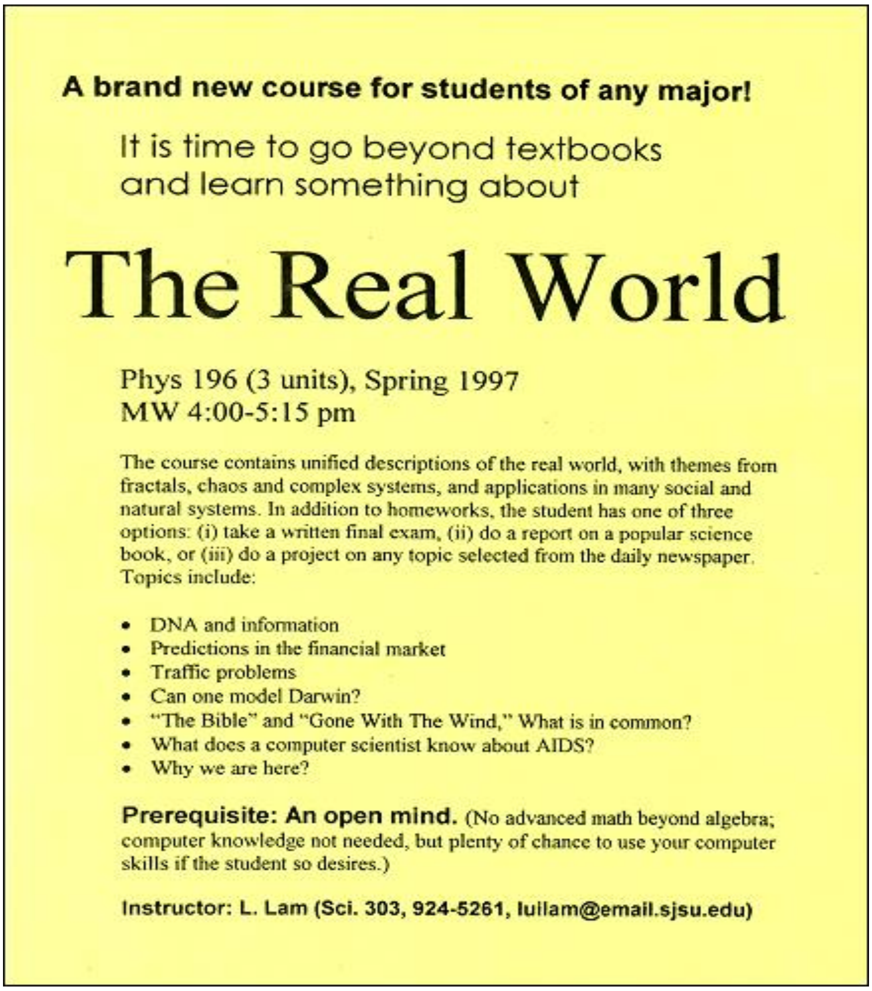

Fig. 5.4. The upper-division course, Phys 196: The Real World, offered in Spring 1997.

5.6 The Real World

In 2001 we have a new provost in campus. This very energetic and ambitious man, Marshall Goodman, wanted to make SJSU distinctive among the 20 plus campuses of the California State University system. Introducing international programs with a global outlook was his way of doing that. But perhaps more important, with lightning speed as administrative things went, he was able to push through the university senate and actually had 100 brand new freshmen general-education courses set up and running in about half-a-year's time. Each of these courses is limited to no more than 15 incoming *freshmen* students. The program starting in Fall 2002 was called the Metropolitan University Scholar's Experience (MUSE). Here is the official description of the MUSE program:

> University-level study is different from what you experienced in high school. The Metropolitan University Scholar's Experience (MUSE) is designed to help make your transition into college a success by helping you to develop the skills and attitude needed for the intellectual engagement and challenge of in-depth university-level study. Discovery, research, critical thinking, written work, attention to the rich cultural diversity of the campus, and active discussion will be key parts of this MUSE course. Enrollment in MUSE courses is limited to a small number of students because these courses are intended to be highly interactive and allow you to easily interact with your professor and fellow students. MUSE courses explore topics and issues from an *interdisciplinary* focus to show how interesting and important ideas can be viewed from different perspectives.

5.6.1 *Course Description*

"MUSE/Phys 10B (Section 3): *The Real World*," created and taught by me (Fig. 5.5),[18] was one of the 100 incoming-freshmen MUSE courses.

1. Course description

To *understand how the real world works from the scientific point of view*.[19] The course will consist of two parallel parts. (1) The instructor will introduce some general paradigms governing *complex systems*—

[18] I was so enthusiastic about this course that I delayed my sabbatical leave by one semester, from Fall 2002 to Spring 2003, in order to teach it in Fall 2002.

[19] SciMat by *design* restricts itself to the scientific study of *humans*; it is thus part of this course which is about *everything* in the universe, as indicated by this statement (and the contents of the course). In turn, histophysics by *definition* is part of SciMat.

fractals, chaos and active walks—with examples taken from the natural and social sciences, and the humanities. (2) Students will be asked to pick *any* topic from the newspapers or their daily life, and investigate what had been done scientifically on that topic, with the help from the Web, library, and experts around the world. Outside speakers and field trips are part of this course.

Fig. 5.5. The plastic card certifying Lui Lam as a MUSE faculty.

2. <u>Student learning objective and goals specific to this course</u>

After successfully completing this course, the student will:

- Realize that there are general paradigms—fractals, chaos and active walks—governing the functioning of complex systems in the real world, *physical and social systems* alike.
- What nonlinearity is.
- How "dimension" is defined mathematically.
- The meaning of self-similarity and fractals.
- Recognize and able to evaluate data to show that any physical structure or pattern in the real world is a fractal or not.
- What a chaotic system is.
- Able to distinguish a chaotic behavior from a random behavior given the time series of a system.

- To realize that many complex systems in the real world can be described by Active Walks, and be familiar with a few examples.
- Recognize that there are multiple interpretations or points of view on some ongoing, forefront research topics, and that these interpretations can co-exist until the issue is settled when more accurate data and a good theory become available.
- Know the difference between science and pseudoscience, and the real meaning of the *scientific method*.
- How scientific research is actually done.
- Able to find out the latest scientific knowledge about any topic of interest in the future.
- Have improved your skills in communicating both orally and in writing.
- Have increased your familiarity with information resources at SJSU and elsewhere.

3. Course material

The following book is required:

Lui Lam, *Nonlinear Physics for Beginners: Fractals, Chaos, Solitons, Pattern Formation, Cellular Automata, and Complex Systems* (World Scientific, 1998), paperback (list price: $28). Reading assignments from this book will be announced in class. Additional material will be provided by the instructor. Other information could be found from the Web, magazines, research journals and books from the library.

4. Grading

The final grade of 100% for each student is split among several items:

Homework	20%
Tests (3 total, including final; 10 points each)	30%
Term project and presentation	20%
MUSE activities	15%
Field trip	5%
Participation	10%
Total	100%

A *term project* is required. It is a group effort with three to four students in a group. The topic will be chosen by the group, with the help and consent of the instructor. Progress of project will be presented by group members orally in class throughout the semester. A written progress report is to be handed in about the middle of the semester, and a written final report is due at end of semester.

5. Teaching philosophy

The class is run like a *research group*, with flexibility in content and timing according to the progress and need of the students, and with the injections of other foreseeable and unforeseeable academic activities. The instructor will teach some basic knowledge about complex systems, while each term-project group will be treated like a research group. Each student will be trained to be a scholar, working individually and as a member of a team.

6. Topics covered by the instructor

Part I

1. *The World is Nonlinear*
   - 1.1 Nonlinearity
   - 1.2 Exponential growth
   - 1.3 Gaussian distribution (the bell curve)
   - 1.4 Power laws
   - 1.5 Complex systems are nonequilibrium systems
2. *Fractals*
   - 2.1 Classification of patterns
   - 2.2 Self-similarity
   - 2.3 Definition of "dimension"
   - 2.4 What is a fractal?
   - 2.5 Fractal growth patterns
3. *Chaos*
   - 3.1 Sensitive dependence on initial conditions
   - 3.2 The logistic map
   - 3.3 A dripping faucet
   - 3.4 Chaotic *vs*. randomness
4. *Active Walks*

   4.1 What is an active walk?
   4.2 Examples of active walks
5. *Conclusion*
   5.1 Simplicity can lead to complexity
   5.2 Order can arise from chaos
   5.3 The world can be understood scientifically

Part II

These special topics will be inserted between the chapters in Part I, as time allowed:

- How scientific is the scientific method?
- Science *vs*. pseudoscience
- How research topics are born
- Diversity: The first woman president of the American Physical Society
- Does the world have any meaning?

5.6.2 *The Outcome*

There were 12 students in the class. In the beginning, every student was asked to buy and read a newspaper, pick out the topics that interested her or him, which could be about international conflicts, movies or television programs, sports, or anything. After class discussion, three topics—Creativity, Predictions, and What Is Life?—were chosen. Three groups with four students each were formed; each group focused on one of the three topics. Each group tried to find out the current status and the frontier in the scientific study of the chosen topic—through books, the Web and interviewing of experts. Each group gave regular progress report in class and, at the end of semester, handed in a written report after orally presenting it. Simultaneously, the instructor gave lectures on nonlinear and complex systems (see item 6 in Section 5.6.1).

At the end, we were all exhausted. The students seemed to have a good time. Did they really get the message that the real world can be understood and is governed by some unifying principles? Only time can tell. But it was a nice try.

My feeling is that this course is better offered to non-freshmen who are more mature and motivated. In fact, this course—with the content and approach intact but the depth of coverage modified—could be taught at any level, for undergraduates or graduate students.

5.7 Conclusion

Looking back, ever since I published my first paper on nonlinear physics, on propagating solitons in liquid crystals in *Physical Review Letters* in the year 1982 [Lam *et al*., 1982] while I was working at the Institute of Physics, Chinese Academy of Sciences, I have been doing research on systems of increasing complexity—from solitons to pattern formation to chaos and to complex systems. After the invention of active walks in 1992 [Lam, 2005b; 2006c] and after 1998, the year *Nonlinear Physics for Beginners* [Lam, 1998] was published, I tried to apply AW to human-related systems, ending with the creation of histophysics in 2002 [Lam, 2002]. From that point on, it was easy for me to enlarge the vision and come up with the idea of Science Matters [2008a], focusing myself on studying humanities from the perspective of complex systems.

The review of my past activities in SciComm and PopSci as well as teaching presented in this chapter makes it clear, at least to me, that my research direction is strongly coupled to and influenced by these activities; *vice versa*. I hope this example will encourage others to try the same. Many of the experiences I went through could be easily borrowed by others, or hopefully would inspire them to innovate, in the interest of SciComm, SciMat and education reform.

At this point, I hope you have found out and understand my two reasons for breaking the rule in writing the title of this chapter. If not, please go back to read item 5 in Section 5.2.

Appendix 5.1: Popular-Science Books Selected in Classes

Sample lists of popsci books selected in my classes are presented in Tables 5.1 and 5.2 here. (See also [Von Baeyer & Bowers, 2004].)

Table 5.1. Popular science books both chosen and bought by students themselves in a freshmen calculus-based physics class in Spring 2000.

Title	Author	Year
The Art of Happiness	Dalai Lama/Cutler	1998
Beyond Einstein	Kaku/Thompson	1995
The Big Bang Never Happened	Lerner	1992
Black Holes, Worm Holes, & Time Machines	Al-Khalili	1999
A Brief History of Time	Hawking	1998
Calendar	Duncan	1998
Clones & Clones	Nussbaum/Sunstein	1998
Comets	Levy	1998
Computer	Campbell-Kelly/Aspray	1996
Darwin On Trial	Johnson	1993
The Diamond Makers	Hazen	1999
Faster Than Light	Herbert	1988
Fuzzy Logic	McNeill/Freiberger	1994
Fuzzy Thinking	Kosko	1993
Genesis & the Big Bang	Schroeder	1990
The Hidden Heart of the Cosmos	Swimme	1996
Immortality	Bova	1998
The Little Book of the Big Bang	Hogan	1998
The Meaning of It All	Feynman	1998
The Mind of God	Davies	1992
Night Comes to the Cretaceous	Powell	1998
101 Things You Don't Know About Science and No One Else Does Either	Trefil	1996
The Physics of Star Trek	Krauss	1995
The Real Science Behind the X-files	Simon	1999
Relativity Simply Explained	Gardner	1997
Science, Technology & Society	Bridgstock et al	1998
Seven Ideas that Shook the Universe	Spielberg/Anderson	1987
Sex & the Origins of Death	Clark	1996
Skeptics & True Believers	Raymon	1998
Skies of Fury	Barnes-Svarney	1999
Steven Hawking's Universe	Filkin/Hawking	1997
There Are No Electrons	Amdahl	1991
To Engineer is Human	Petroski	1992
The Universe and the Teacup	Cole	1998
Why the Earth Quakes	Levy/Salvadon	1995
Why Sex is Fun?	Diamond	1997

Table 5.2. Popular science books selected by the instructor for the students to pick, in the upper-division class of Thermodynamics and Statistical Physics in Spring 2000.

Author	Title	Year	Remark
H.C. von Baeyer	Warmth Disperses and Time Passes: The History of Heat	1998	Story of heat and the scientists involved; Maxwell's Demon; time's arrow.
T. Schachtman	Absolute Zero and the Conquest of Cold	1999	Story of how scientists lower the temperature; not that exciting, author not a scientist.
M. Riordan & L. Hoddeson	Crystal Fire: The Invention of the Transistor and the Birth of the Information Age	1997	Very exciting story; shows how good science was done in Bell Labs.; a must read especially if you live in the Silicon Valley.
G. Johnson	Fire in the Mind: Science, Faith, and the Search for Order	1995	Science and religion near Santa Fe, including studies in information and complexity.
A. Guth	The Inflationary Universe: The Quest for a New Theory of Cosmic Origins	1997	Written by the inventor of inflationary universe; unique; exciting physics and story.
T.A. Bass	The Eudaemonic Pie	1985	The story of UC Santa Cruz students, applying what they learn about Newtonian mechanics and chaos to beat the roulette in Las Vegas.
W. Poundstone	The Recursive Universe: Cosmic Complexity and the Limits of Scientific Knowledge	1985	All about cellular automata, with computer program for Game of Life.
J.D. Barrow	The Artful Universe: The Cosmic Source of Human Creativity	1995	Power laws, fractals, music.
M. Schroeder	Fractals, Chaos, Power Laws: Minutes from an Infinite Paradise	1991	Fits our course; highly recommended

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