



Some Thoughts on the Teaching Design of “Arts, Humanities and Science” General Education Courses in Colleges and Universities

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Abstract. It is a long-standing non-controversial issue whether science can bring beauty and whether art and humanities can promote human understanding and transformation of the world. And throughout the history of human civilization, it is indisputable that beauty is an important guiding principle in the process of inquiry into universal laws. Behind the laws of science, there is always profound beauty. This paper discusses the need for a general and comprehensive liberal arts course in China's higher education, especially in the era of fast development and quick commercial utilization of modern technology. Several teaching subjects and open-ended questions for discussion are proposed. The main purpose of this paper is to clarify that through offering similar courses, students can develop better aesthetic skills, and richer, fuller worldviews and values.

Keywords: General Liberal Arts Education · Teaching Design · Aesthetics · Worldview

1 Introduction

In the late 1950s, the British scholar C.P. Snow [20] made an important argument about the split between the two cultures, i.e., scientific culture and humanistic culture, but shortly after that, efforts to bridge the split between them have become more and more prevalent. In a sense, combining science and art-humanism is a way to recognize the beauty of science. The aesthetic content of science combined with humanities and arts should be regarded as an important part of scientific culture. As quoted from Zhuangzi: Heaven and earth have great beauty but do not speak, it can be understood that the great beauty of nature, includes not only the beauty of the creation of heaven and earth but also the logic, reason, harmony, simplicity, and law which are embodied in the process of human understanding of nature [1, 15, 16].

In the splendid civilizations created by mankind, there are countless examples that vividly testify to the beauty of the humanistic combination of science, art, and humanity. As quoted for example by Bertrand Russell: “Mathematics, rightly viewed, possesses not only truth but supreme beauty – a beauty cold and austere, like that of sculpture”.

Nowadays, based on the Bayesian theorem, using a very simple and beautiful formula originated from Thomas Bayes, an 18th -century English preacher, Bayesian ideas and rules are everywhere, from disease analysis, economic and financial prediction, machine learning, DNA decoding to Artificial Intelligence and space exploration, etc... For example, the term Quantum Bayesianism found in literature, referring to a point of view on quantum states originally developed by C. M. Caves, C. A. Fuchs, and R. Schack was inspired by Bayesian approach to probability. In a broad sense, Bayesian methods are related to the philosophical problems of the rationality of scientific reasoning.

The famous Dutch artist M.C. Escher created many paintings with rich connotations throughout his life. His profound artistic thoughts and mathematical principles were perfectly combined. The fact that many people think that his way of thinking is closer to that of a scientist than an artist made his works first accepted by scientists rather than artists. Mathematicians and physicists interpreted his artwork from different perspectives, and many of his works have been cited in numerous scientific works. On the cover of Chen-Ning Franklin Yang’s “Elementary Particles: A Short History of Some Discoveries in Atomic Physics”, his work “Knight” was used. Douglas Hofstadter’s world-renowned book “Gödel, Escher, Bach: An Eternal Golden Braid (GEB)” explores the connections between mathematics, the art of painting, and J. S. Bach’s music, reflecting profoundly on the commonalities inherent in things that can be reflected simultaneously through a high degree of abstraction and the richness in figuration [10].

In “Fearful Symmetry-the Search for Beauty in Modern Physics” [23], Physicist A. Zee delves into how symmetry (see as a simple illustration in Fig. 1, based on the function $z = |x|^q + |y|^q$) has profoundly and successfully provided a constant source of inspiration for the development of physics, especially modern physics, and modern mathematics. Although it is a slightly difficult science book, the experience that comes from the repeated reading is one that makes the reader deeply aware of the beauty of nature that lies behind any scientific truth. From a cultural history perspective, the Israeli mathematician Eli Maor’s “To Infinity and Beyond [13]: a Culture History of Infinite” explores in some chapters the concept of symmetrical groups, leading to a discussion of Islamic geometric decorative art, noting that “among the many ethnics who specialize in decorative art, none is closer to perfection than the Muslims, who brought their artistic genius to bear on the creation of abstract geometric patterns of great beauty and the expression of themes common to all Islamic art: geometric regularity, spatial coherence, and repetition of cycles up to infinity”. The exploration of infinity, meanwhile, is considered by many mathematicians as one of the most romantic and cosmic emotional behaviors.

Mathematician Shing-Tung Yau knotted the complex narrative structure of the Chinese novel “Dream of the Red Chamber” with the inspiration of his geometric discoveries, described in his autobiographical book “The Shape of a Life: One Mathematician’s Search for the Universe’s Hidden Geometry” and there is this paragraph as follows: “.... What I didn’t realize back then was that the structure of this novel would influence the way I approach mathematics. The story contains hundreds of different threads and introduces hundreds of different characters. It takes a while, and some measure of discernment, to see how these distinct strands and individuals relate to each other, combining to produce a complex and multifaceted though fully integrated whole. I see

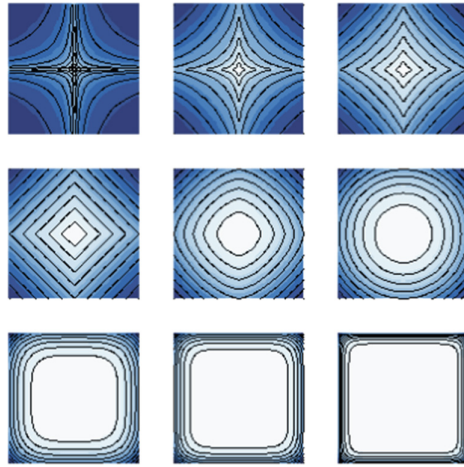


Fig. 1. The beauty of symmetry based on the function $z = |x|^q + |y|^q$, with different q values [Photo credit: Original]

mathematics, particularly my efforts in geometric analysis, in a similar light... The field has different branches that might seem unconnected until you step back far enough to realize they are all part of the same vast tree—not unlike the family tree that could be drawn to trace the lineages of the Jia clan from the Red Chamber” [21].

Argentine writer Jorge Luis Borges, an eternal traveler of time, famously said in one of his many works “The Garden of Forking Paths” [2], that time is forever bifurcated and leads to infinite possibilities. His profound thought and simple words show repeatedly the reader in different ways his understanding and imagination of the possible forms and potential laws of our universe. In his colorful literary world, time seems to be an intricate web. Albert Einstein imagined space-time as a giant mollusk.

As shown from these above examples, it is clear that beauty, an elusive thing, and the accompanying infinite imagination, become something both science and art [4]. Many scientists who have received rigorous scientific training and precise scientific insight, have both high levels of artistic and humanistic qualities and extraordinary artistic imagination, and wonderful writing skills, which have resulted in many excellent works of science popularization. By offering a general liberal arts course in colleges and universities focused on reading, studying, and discussing the history and related literature, students can be guided to discover the relationship between the rational, romantic, and moral aspects of science, arts, and humanities, which is of great significance in helping them cross cognitive boundaries, raise their aesthetic heights, and better shape their worldview and values.

The paper is organized as follows. In Sect. 2, we describe related teaching concepts and objectives. In Sect. 3, possible teaching contents selection and some open questions discussion are proposed. Section 4 is a brief GP simulation example to illustrate the artistry and scientific logic of Bayesian thinking. Section 5 deals with the teaching and learning suggestions in modern technology-driven times. Finally, the conclusion is in Sect. 6.

2 Teaching Concepts and Objectives

2.1 Teaching Concepts

The progress of science has always been driven by a constant infusion of energy from other fields, and before it was coming into being, science was a romantic fantasy. In the history of the development of world civilization, major scientific revolutions have usually been closely associated with imaginative artistic activity. The scientific discoveries during the Arab Golden Age left a splendid legacy for the future, later giving rise to Renaissance, a movement that originated in Italy and spread throughout Europe, including the fields of art, philosophy, literature, architecture, and science, which brought about an impact so profound, worldwide and highly paradigmatic. And now we are following in the footsteps of Artificial Intelligence towards the peak of another wave of the so-called fourth industrial revolution. It is a very important and meaningful question to think about science and social phenomena from a new perspective, to explore the close interconnection between humanities, arts, science, and the moral and ethical dimensions of society related to them. It is also essential cultivation to shape the worldview of modern students and citizens, to broaden their horizons out of the narrow garden.

2.2 Teaching Objectives

This course aims at the connotation of the concept of general liberal arts and liberal arts education, which is different from professional education and aims to lead students to experience the inspiration and imaginative insight between arts, humanities, and science in numerous occasions of human historical development through the reading and discussion of classical literature and cases related to arts and science, in order to better cultivate students' knowledge of different fields and their abilities of thinking that integrates arts and humanities with scientific knowledge.

3 Selection of Teaching Content and Discussions

The course is proposed to combine several relevant modules for creative and open discussion.

- 1) Module on the relationship between Bayesian thinking and scientific thought: nowadays, Bayesian thinking is gradually occupying an increasingly important place in the basic paradigms of philosophical and epistemological research. This module will help students to develop Bayesian thinking in their learning and to evaluate and critically analyze various scientific and social phenomena from a better perspective. Rather than being a different statistical method, Bayesian is a different statistical philosophy, a different perspective on the interpretation of the world. This way of thinking that changes and constantly revises one's ideas based on evidence can help students break through their intuition and provide a richer and more interesting way of interpreting the way things work. Some excellent references are Colin Lowson and Peter Urbach [11] *Scientific Reasoning, the Bayesian Approach*. Lê Nguyễn Hoàng [9], *The equation of knowledge: from Bayes' rule to a unified philosophy of science*.

- 2) Module on art and physics: selected study and discussion on the connections of various art forms such as painting, sculpture, music, literature, and architecture and modern physics, for example, the artistic underpinnings of several revolutionary theories in modern physics, the overwhelming artistic beauty of discoveries in physics [5], and the amazing correlation between the two fields. Reference can be made for example to Leonard Shlain [19], *Art and Physics, Parallel Visions in Space, Time and Light*.
- 3) Module on the relationship between music and nature: selected study and exploration of the inner harmony between music [7, 17], the working of the universe and the related philosophical issues of science, from Pythagoras to Newton, Bach, Beethoven, Einstein, Schoenberg up to Grass, Cage, etc., discussing the intertwined and intricate interconnections between science, philosophy, and music. Jamie James [12], *The Music of the Spheres* is a good reference in this respect.
- 4) Module on the historical development of science and philosophical concepts: the selected study of the origins of science and the nature of thinking, as well as the hidden beauty and artistry of science. Critical reading and discussion of historical events and philosophical themes related to the impact of the history of science on worldviews, from Aristotle to Newton and on, in particular, the impact of modern scientific developments on worldviews. References such as Richard Dewitt [6], *Worldviews and Introduction to the History and Philosophy of Science* and Sean Carroll [3], *The Big Picture: on the Origins of Life, Meaning and the Universe Itself* are excellent and informative.
- 5) Module on history and development of Artificial Intelligence, and challenges for humanity: A selection of the study on the intrinsic connections between literature and art, the human mind, neuroscience, current cognitive systems and artificial intelligence, etc.. Open discussions can be made on the development and future of Artificial Intelligence in the context of literature, philosophy, and computer science. References can be George Zarkadakis [22], *In Our Own Image: Savior or Destroyer? The History and Future of Artificial Intelligence*, Jo Marchant [14], *The Human Cosmos: A Secret History of the Stars*.

In general, we hope the discussion and study of the above modules can guide and inspire students to explore the questions such as the following:

- 1) How does Bayesian thought define the relationship between subjectivity and objectivity? How does it reflect artistry and science in its simple formula?
- 2) How do art and science being closely and profoundly interconnected embody beauty?
- 3) What is the relationship between music and science? How do they influence and promote each other?
- 4) The world is ever-changing, and it is still changing moment by moment in our understanding of it. Space-time can be curved, there may be a lot of dark matter in the universe. Does the accumulation of knowledge and foresight based on Bayesian thinking allow us to see further and inspire us to explore completely new and unknown territories?
- 5) What is scientific thought? What constitutes the characteristics of scientific thought? What does it ultimately teach us? Are there limits to scientific thought?

- 6) To what extent does civilization influence our understanding of Artificial Intelligence? Can computers acquire self-awareness?
- 7) What are some of the ideas in the literature you have researched that you think are narrow and biased? How has what you have learned profoundly influenced your original thinking mode and even your worldview?

4 A GP Simulation Example to Illustrate the Artistry and Scientific Logic of Bayesian Thinking

Gaussian processes (GPs) are a powerful Bayesian machine learning statistical algorithm and probabilistic approach frequently used in a wide variety of areas during recent years. A GP is a probability distribution over functions that use multivariate normal modeling techniques to model unknown functions and to flexibly solve (in a Bayesian way) problems such as regression and classification non-parametrically. As richly illustrated in the literature, GPs provide excellent advantages over classical non-Bayesian statistical methods for their reliable estimate of uncertainties, among which, Carl E. Rasmussen and Christopher K. I. Williams (Rasmussen, 2006) [18] is a classical and comprehensive reference for both theoretical and practical aspects of GPs. We use Gaussian process regression (GPR) to briefly illustrate its power and inner beauty. The basic structure of GPR is as follows: Let f denote a function that is unknown which maps inputs \mathbf{x} to outputs y : $f: \mathbf{x} := X \rightarrow Y$. In Gaussian process regression, we assume the output y of a function f at input \mathbf{x} can be written as

$$y = f(\mathbf{x}) + \varepsilon \quad (1)$$

With $\varepsilon \sim N(0, \sigma_\varepsilon^2)$ the noise term assumption. If without the assumption of the noise term, (1) simply changes to:

$$y = f(\mathbf{x}) \quad (2)$$

$f(\mathbf{x})$ defines a Gaussian process:

$$f(\mathbf{x}) \sim GP(m(\mathbf{x}), k(\mathbf{x}, \mathbf{x}')) \quad (3)$$

The mean function $m(\mathbf{x})$ defines the expected function value at input \mathbf{x} :

$$m(\mathbf{x}) = E[f(\mathbf{x})] \quad (4)$$

The covariance function $k(\mathbf{x}, \mathbf{x}')$ called the kernel of the Gaussian process, describes the dependence between the function values at different input points \mathbf{x} and \mathbf{x}' . One common choice of a kernel is the radial basis function kernel, which is defined as [8]:

$$k(\mathbf{x}, \mathbf{x}') = \sigma_f^2 \exp\left(-\frac{\|\mathbf{x} - \mathbf{x}'\|^2}{2\lambda^2}\right) \quad (5)$$

σ_f^2, λ^2 as hyper-parameters. Under the Bayesian framework, once a mean function and kernel are chosen, the Gaussian process prior function and likelihood defined, we

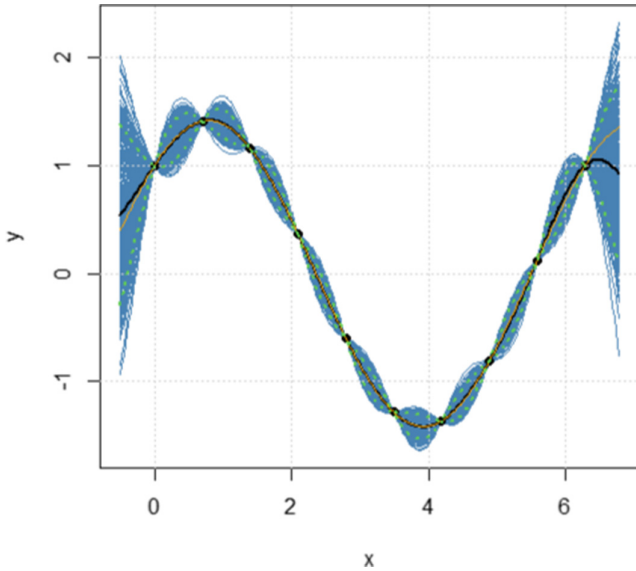


Fig. 2. GPR without noise assumption, 500 random samples of posterior mean function [Photo credit: Original]

can derive the posterior Gaussian process function from the prior and likelihood and thus make predictions (technical details omitted here). Parameters and hyper-parameters estimation in the modeling process is essential and there are different methods to solve the optimization problems.

A GPR using simulation is illustrated as follows using R software [24]. For simplicity, we set in Eq. (5) $\sigma_f^2 = 1$, $\lambda^2 = 1/2$, which is thus related to the Euclidean distance, and in this case, covariance structure has the property $k(x, x) = 1$. While in practice, we try to find optimal model parameter values to maximize the constructed objective function for parameters. Assume we have 10 observed data points which are generated from the function: $y = \sin(x) + \cos(x)$ within the interested region of $[-0.5, 2\pi + 0.5]$. The outcome of conducting Gaussian processes regression is illustrated in Fig. 2 without noise and Fig. 3 with noise assumption respectively. In both figures, the true function is shown by the orange line, observed data drawn in black points. 500 random samples of posterior mean functions are plotted in blue lines, and each random sample function values take 300 point-wise posterior prediction calculations. Two green dotted lines show the resulting 90% confidence bands.

As shown above, even to solve regression problems as simple as illustrated here, the difference in statistical algorithm between Gaussian process regression and classical OLS regression modeling is essential such that can be taken as a kind of paradigm shift. GPR is a reliable solution to make predictions with uncertainty using posterior distributions. In the above two figures, we clearly observe the football-shaped uncertainty evaluation, reasonable confidence bands estimation, and their obvious difference within and outside of the observed data. And in particular, the appropriate choice of the kernel or covariance function, which makes use of the succinct idea of finding the similarities

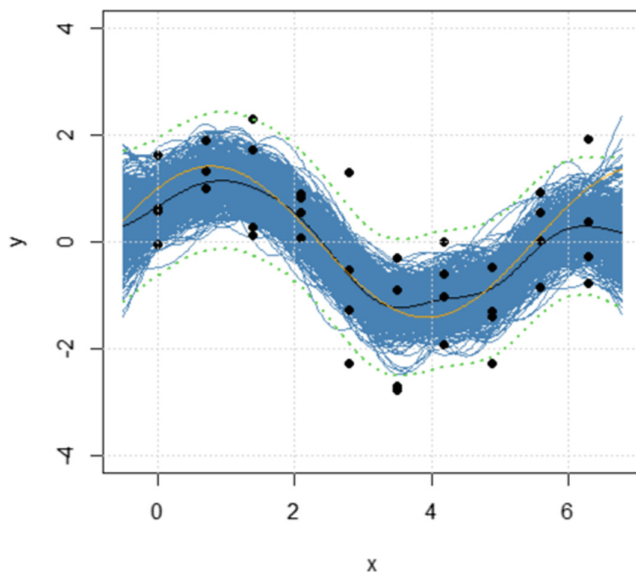


Fig. 3. GPR with noise assumption, 500 random samples of posterior mean function [Photo credit: Original]

between data points, is one of the key factors in proper GPR modeling. The underlying logic of GPR is Bayesian, while it still utilizes a simple Gaussian assumption, the distribution of which is generally regarded as the king of all distributions. The complex and chaotic phenomena we may be faced with in practice and the underlying rational logical explanation meanwhile often lead us to some philosophical rethinking of the order of nature and mysteries of science. Bayesian theorem (like many other succinct theorems) and its widespread use in more and more fields of science and technology make it no longer just a set of mathematical theories, but more like a treasure box that may lead to profound changes in the way of our thinking, giving birth to many innovative solutions to many puzzling problems. As for the Bayesian theorem, it is so simple yet so powerful that it elegantly combines art beauty with science logic in its own way.

5 Teaching and Learning Suggestions

The core of reasoning lies in the constant questioning of the assumptions and results of previous generations, but this questioning presupposes a deep knowledge and understanding of previous achievements and their values. Through the reading and study of literature, students are cultivated to think critically and independently, to question the absolute authority of existing knowledge, to observe carefully, to discuss, and to propose new ideas, which is actually an interesting process of rethinking the world based on Bayesian thinking. The following suggestions are proposed which are important, especially in the current technology-driven modern age rich in learning resources: (1). Encourage students to read in width and depth. The ability to have a whole block of time to read a complete work, rather than spending time on fragmented reading is extremely

important. Deep reading will guide students to enter into a holographic picture of what they are reading and thinking, and the sense of enrichment and inner satisfaction obtained is completely impossible for fragmented reading. (2). Encourage students to take advantage of the various learning forms such as MOOC, which is excellent for them to explore high-quality courses according to their own interests. In addition, group discussions with supplementing video materials will enrich the teaching format and content.

6 Conclusions

In GEB, painting, music, and mathematical theorems are wonderfully interwoven to form a glorious golden band. The unique spiritual presence and perspective of Escher's artist's paintings, the balance, harmony and infinite beauty of Bach's fugues, and Gödel's theorems have changed the way of mathematical development, touching the deep structure of the human mind, which in turn has deeply penetrated into music, art, biology, computers and Artificial Intelligence. From the ancient Greek sculptors, and Arabic polymaths to Einstein who imagined space-time as a giant mollusk, artists have time and again anticipated imaginative insights and given rise to discoveries in science, and scientists have explored science with artistry. The historical evolution of the combination of humanities, arts, and sciences has not only advanced the process of human civilization in general, but also is a history of the development of profound and imaginative human thought. Offering such courses in colleges and universities is exquisite food for teachers and students, therefore an elevation of the height of thought.

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