

Music as a material for scientific literacy: universality and diversity

Tsuyoshi HONDOU

Department of Physics
Tohoku University

Science education

from viewpoint of STS
(philosophy of science)

Importance of exchange ideas between sciences and humanities, Tohoku UNIV 2007

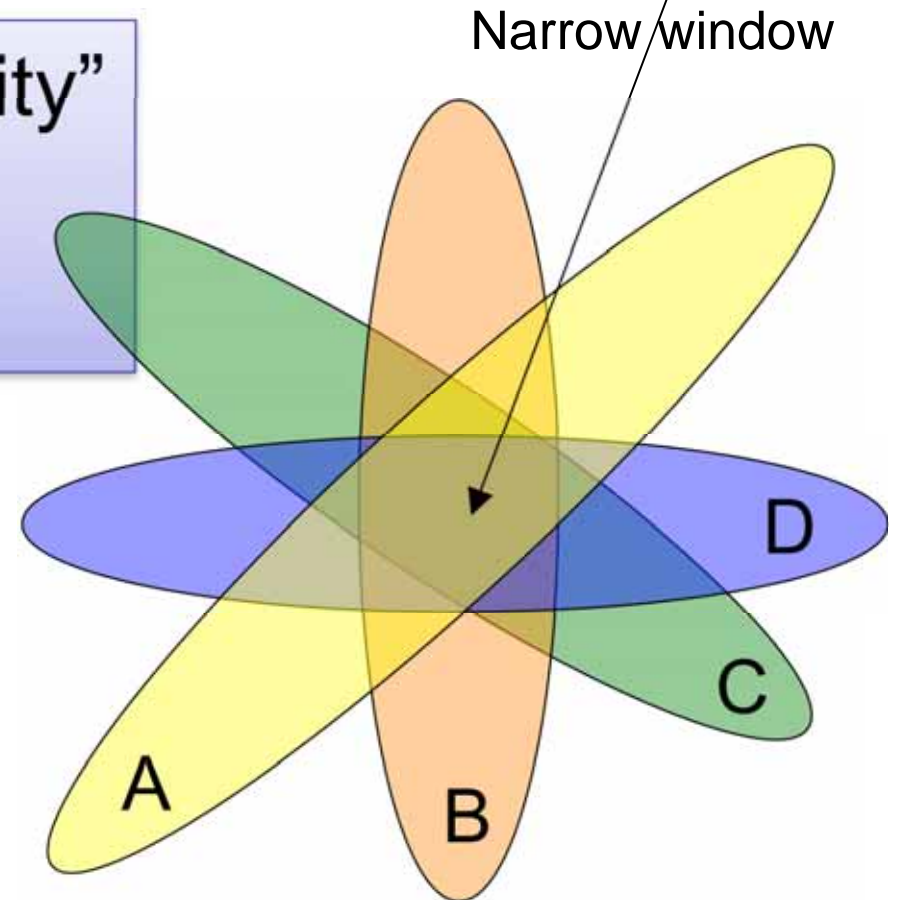
Content

- Status of public understanding of science
 - for citizen
 - for science under civilian-control
- Scientific literacy
- Music in laboratory course
 - as a material for scientific literacy

Some claim:

- Science is far from “Creativity”
- No space for diversity
 - » even students in science courses

Science toward: $A \cap B \cap C \cap D$?



“feel surrounded”

Diversity → Universality
Science cuts diversity?

At Hospital

- Evidence-Based Medicine (EBM)
Science —————> decision (choice of therapy)?
(determines?)

“feel surrounded”

*Misunderstanding of EBM
(for proper EBM
see Muir Gray's book →)*



Misunderstanding of science

promoting unnecessary confusion

Confusion between

- Scientific evidence (Which is bigger, moon or earth?)

– *with universality*

- scientific issue



or



- Value judgment (Which animal do you like better?)

– *diversity*

- **not** scientific issue



or



What's science?

in a social context,
target of science education

- Focus of PISA, survey of age 15 (OECD, 2006)
 - Competency: Identifying scientific issues
 - differentiating between scientific issues and issues that are *not related to science*

(http://pisa.ipn.uni-kiel.de/pisa2006/fr_reload_eng.html?naturwissenschaft_eng.html)

Sample item (PISA 2006)

“Catching the killer”

Which one of the following questions cannot be answered by scientific evidence?

- A) What was the medical or physiological cause of the victim's death?
- B) Why was the victim stabbed many times?
- C) Is taking cheek scrapings a safe way to collect DNA samples?
- D) Do all identical twins have exactly the same DNA profile?

*) stab: 突き刺す scraping: こすること

(<http://pisa.ipn.uni-kiel.de/pisa2006/>)

Scientific literacy

competency of scientific knowledge in a social context

How to teach?

- Knowledge about science

Cf. Knowledge of science (traditional course)

- We have taught: What science can.

- » unbalanced/misleading

- what science cannot?

- Limits of validity of sciences

- Educational materials << Theoretical knowledge/concept

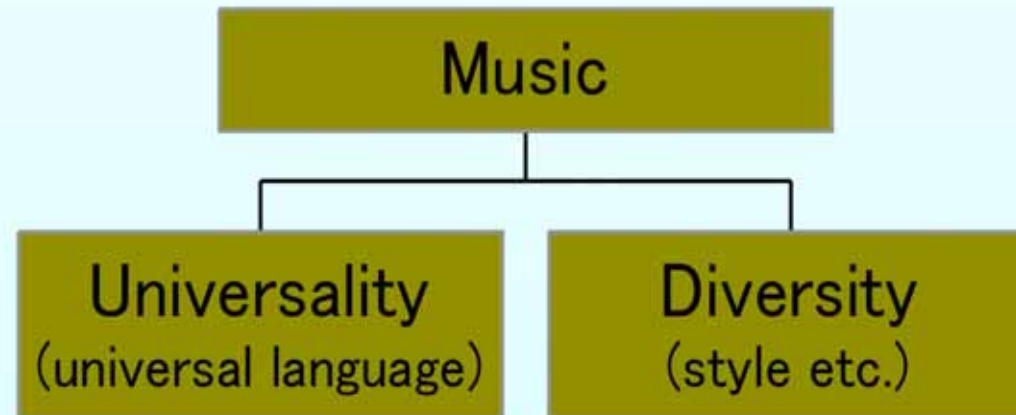
Ref.) Solomon J. *THE SCIENCE IN A SOCIAL CONTEXT*

(*How Can Be Sure?*) Association for Science Education (U.K.), 1983.

Ogborn, J. et al, *Advancing Physics*, Institute of Physics, 2001.

Music

Ideal material for scientific literacy

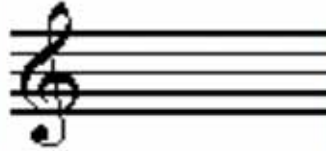


New laboratory course for freshmen in Tohoku Univ. (2004~)
1,800 students/year both in arts and sciences

Question

Why?

- musical scale
 - discrete (quantized)
 - applicable worldwide (score)
- Do, Mi, Sol: principle chord (special set of notes)



<diversity>

We have different musical scales:

- Just temperament (natural scale)
- Equal temperament (artificial scale)
 - One *may* ask “Which musical scale is better?”

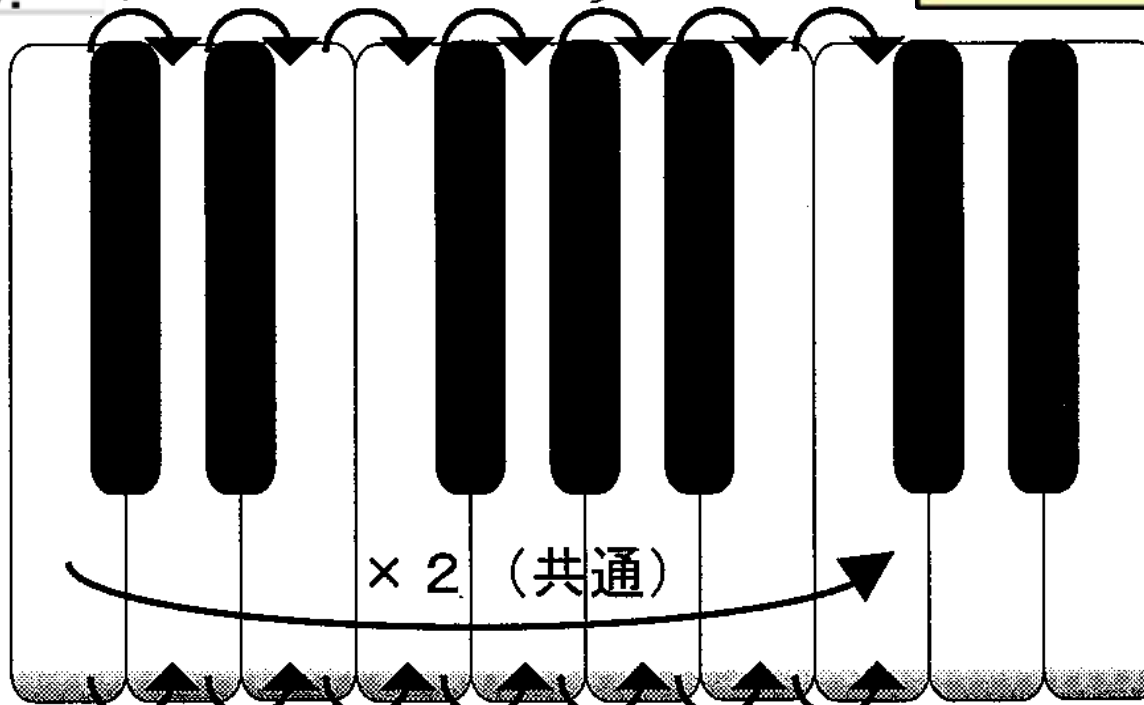
Diversity of musical scales

Rational

freq. ratio:

$$\frac{9}{8} \quad \frac{10}{9} \quad \frac{16}{15} \quad \frac{9}{8} \quad \frac{10}{9} \quad \frac{9}{8} \quad \frac{16}{15}$$

Just temperament



Irrational

freq. ratio:

$$2^{\frac{2}{12}} \quad 2^{\frac{2}{12}} \quad 2^{\frac{1}{12}} \quad 2^{\frac{2}{12}} \quad 2^{\frac{2}{12}} \quad 2^{\frac{2}{12}} \quad 2^{\frac{1}{12}}$$

Equal temperament

Experiment to answer the Question



- Discover **natural laws**
by five senses (with a guitar only)



Mode selection by flageolet (harmonics)



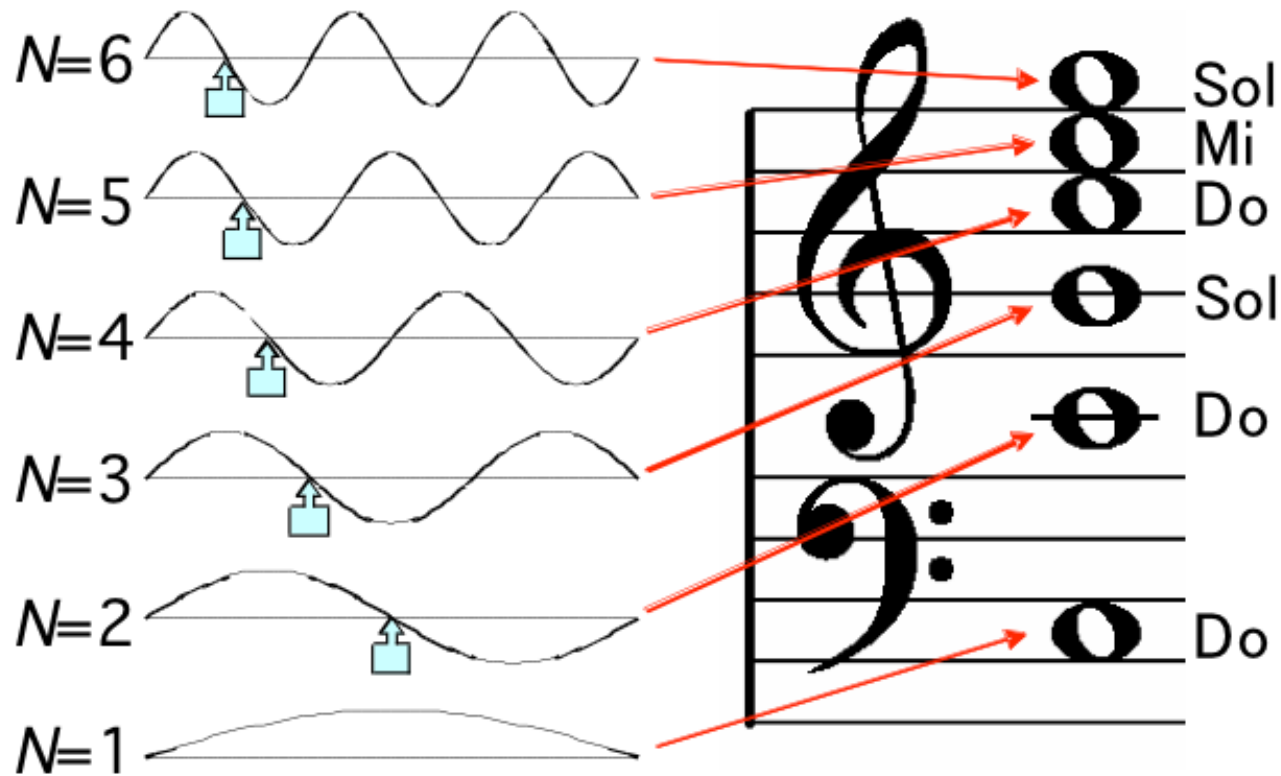
- making node in string oscillation by softly touching a string



Students realize by their experient:

Evidence (Scientific fact)

Musical scale ← higher harmonics
Just temperament originated from natural law.



 : Finger (flageolet tech.)

Answer

<universality>

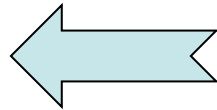
Why?

- musical scale
 - discrete (quantized)
 - by harmonics
 - applicable worldwide (score)
 - since natural laws are independent of time and space
- Do, Mi, Sol: principle chord (special set of notes)
 - also by harmonics (natural law)
 - Do, Mi, Sol: 4th, 5th and 6th harmonics
 - Do, Re, Mi: 8th, 9th and 10th harmonics



score

Universality in culture



Universality of natural law

OK

How to save “diversity” in relation to science?

Science for diversity

Which scale do you choose?

Evidences from experiments	Harmony (chord) without beat tone	freedom of change in key (e.g. C Major → F Major)
Just temperament	○ merit	✗ demerit
Equal temperament	✗ demerit	○ merit

Choice (diversity)

- Equal temperament
 - Piano
 - Guitar
 - Organ (in principle)
- Just temperament
 - Chorus (a cappella)
 - String ensemble (in principle)
 - Brass ensemble (in principle)
 - Most primitive music

What science can (Scientific matter)

- show evidences
 - merits & demerits of the two musical scales
 - Natural scale (just temperament)
 - Artificial scale (equal temperament)
 - to help decision-making
 - with individual value judgment (diversity)
 - help to understand the diversity of culture
 - why “equal temperament” was introduced in Europe
 - » Comparative culture

What science cannot (out of scientific matter)

- Which musical scale is better:
 - Just temperament (natural scale)
 - Equal temperament (artificial scale)
- Diversity of choice (decision)
 - Depending on value judgment
 - 1st order approx.
- Thus: No conflict
 - science and diversity
 - Limits of validity of science ← knowledge about science
 - Competency: **Indispensable to deal with environmental problems**
 - **Precautional principle**: global warming, electromagnetic smog. etc.

Response

- Students' response:
 - 51% strong interest
 - 6% have little interest
 - Most students realize what we expect

(students in humanities, 2008)

By educational efforts (advantages)

- context-based learning
- integration between the humanities and science
- simple but sensuous design

Improving

- to be suitable for students with diverse cultural background and interest

Summary & the next

Through the simple experiment of music:

Students

– learn

- what is “evidence-based decision”
- through the choice of musical scale
- “knowledge about science”
 - identifying scientific issues
 - limits of validity of sciences

• **remove their misunderstanding about science**

- no conflict between science and diversity

• What’s creativity in music?

– Ask Ms. Suzuki