



# LEARNING AND TEACHING

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## **LEARNING AND TEACHING**

### **WHY LEARNING**

- Knowledge gives advantage to the individual who makes the effort (it is a worthwhile personal investment that cannot be lost, and lasts for ever).
- Knowledge gives advantage to society (it is a worthwhile social investment, to the extent of justifying compulsory education expenses)\*.
- Humans are curious; they love learning (it provides personal pleasure).
- Knowledge is not inherited, thus every generation has to learn from anew. An advantage from starting anew (assuming both, teachers and students, being intelligent and not simple machines as today computers), is that learning is more efficient every new generation.
- Why learning in the Internet era where all human knowledge is available on line? A simple answer may be that all musical notes are available on the piano keyboard, but the composer, a creator, is needed to make music from sounds.

### **What we learn**

- Skills for interaction with our environment: at childhood, we learn to walk, to talk, to read and write, to quantify (mathematics), and to recognise people and things in our environment.
- Skills to earn our living: at youth, we learn a trade to be employee or employer. Skills, i.e. abilities, always rely on some factual knowledge, but methods to solve problems (abilities) are worth more than memorised facts (experience).
- Subject matters for our pleasure and pride (during all our life): natural sciences, social sciences, arts, handicrafts (usually, one chooses complementary subjects to those for a living). Besides specific contents, we learn (or we should) generic intellectual skills like a logical reasoning for analysis and synthesis, to isolate key-points from the overwhelming negligible disturbances (that brings confidence

in one's power to solve problems, so important for a living), to have a critical personal thinking (to be a person, not just an individual), to be able to expose oneself with coherence and clarity, to consider other's point-of-view, etc.

- Why learning thermodynamics?: to understand heat engines, used for transportation or for electricity generation, that may produce 1000 megawatts per unit, ten millions times more than one-person's 100 watts of metabolism; to solve the energy crisis of using non-renewable fuels, to solve the environmental crisis due to combustion pollution, to solve energy balances for any consumer's heating, refrigeration, air conditioning, heat and waste recovery problem, or to solve thermal control problems of people, animals, vegetables and materials (from electronic boards in computing engineering to expansion gaps in civil engineering), to understand meteorology, oceanology, philosophy (the arrow of time, life and death, self-organisation).

### **How we learn (origin)**

- From parents, teachers and elders that, intentionally or not, transmit their knowledge. Teaching provides education, but learning is a pupil's task (as Piaget established in his theory of intellectual development).
- From peers (at home, at school, at work). We tend to imitate what we have been exposed to.
- From casual happenings and purposely excited events (experience and experiments). Feynman said: "Science doesn't teach anything; experience does".

### **How we learn (techniques)**

- Knowledge is built with some effort (there is not effortless learning, there are not pills for learning, and knowledge cannot simply be transferred from experts to newcomers). But be an optimist! Yes you can; try to relax and enjoy the effort; the reward is coming.
- Learning starts by realising our ignorance and mistakes; don't fear being wrong at the beginning. Learning occurs when someone wants to learn (not when someone wants to teach).
- Take an overview to find what it is about. Don't surrender if you don't understand; learning is an iterative process that takes time.
- Make tentative schemes, trying to relate main topics, to establish an order or classification of main topics, to write the main key-word.
- Make links between the new topics (chronological order, parent/childhood, belonging to a class). Also make links to your previous knowledge in this area or any other (associate dates, behaviour, techniques).
- Try to ask questions to yourself (do I remember the last item?, what if I change the input?, may I interpolate?) to check your memory and understanding (asking questions already demonstrates some knowledge).
- Try to teach what you think you have learnt, to check understanding and communication (nobody knows better than a professor that the best way to learn something is to teach it).
- Try to solve related problems, to check masterfulness. Remember Confucius proverb: I hear and I forget, I see and I remember, I do and I understand (experience is the best teacher).

## How I know that I have learnt

- I have a vocabulary of concepts and facts I can communicate (speak the same language).
- I distinguish between right and wrong statements (I can check and criticise).
- I know how things work, so I can forecast how they behave (I can solve conceptual problems)..
- I have skills to enforce in practice what I have learnt (I can solve practical problems).
- I can pass examinations, i.e., I am able to convince knowledgeable people, that I know the theory and the practice, by solving most of their questions. They give you qualifications according to your achievements, be it a simple pass (qualify) or a mark in a range. Passing an examination convinces you and the examiners that you have learnt; to convince just other people, an official accreditation can be exhibit instead of being subjected to another examination (i.e., a third-party trust).

## WHY TEACHING

- Education, i.e. intentionally transmitted knowledge (factual and formal) is more efficient than wandering alone. In primitive societies the parents were in charge of teaching the offspring, but soon they were helped by professional teachers (chosen by the family or by the public administration). A possible weakness may arise in this process of 'professionalism' because of the teacher's need to procure a livelihood, which may bias his attention from teaching-to-learn to keep-the-customer-satisfied (make the pupil happy to avoid complaints, teach to pass a test or external examination, and so on).
- To educate is to help find answers (to form, more than to inform), not to give answers (to inform). Socrates put it vividly, advocating his mother's method of helping people to find what is inside (she was a midwife), rather than his father's way of giving shape (he was a stone-cutter). This is the inquiry or Socratic method of teaching.
- The purpose of teaching has to be in consonance with the goals of learning, and teachers must try to convey assets to the individuals who make the effort (however, university education should point higher and above mere occupational training).
- Teaching feeds teachers back and forces them to be reflexive: '*docendo discimus*' (or '*si vis discere, doce*' from Cicero (106–43 BC)).

## How to teach

- Make it easy. Teaching is not to feed up the pupils but to help them in their own learning effort.
- Make it appealing. Learning demands an effort that is more profitable if the student cooperates willingly. Avoid artificial barriers, create the right environment (material), and build upon previous knowledge (it fosters pupil's confidence).
- Make it interactive. Don't just throw information one way. Promote participation; create the right mood (personal); pose challenging questions that make learning interesting. Don't make it radical and absolute; all knowledge is approximate and relative to a moment or context. Learn from student responses (e.g. the story of the barometer).
- Make it profitable. Show the usefulness of having learnt; propose exercises that reinforce the student's self-assurance (well-chosen examples fix up ideas most efficiently).

- Oral teaching (as practised since the most ancient times) is the best for small groups due to feedback, although it requires spatial and temporal coincidence. Need to use a common (oral) language (Greek, Latin, English,...). A person's knowledge base is resident in a highly volatile (human) memory, but the search engine is expert and can be enhanced by feedback, thus the quality of teaching depends on the actual mood of participants: the teacher and the audience.
- Written teaching (engraved in tablets as since 3000 B.C., printed in paper or digitally stored in a physical support: punched cards, magnetic tapes or optical discs) has the advantage of conservation, transportation and use on demand (without spatial or temporal coincidence of teacher and pupil). Need to use a common written language (using ideograms, an alphabet, digitisation). Since the invention of printer types (Guttenberg, 1440) it has been easy to make many originals. Since the invention of digitisation (late 20th century) it is easy to make perfect copies at a negligible cost.

### **What to teach**

- Time available is the first and basic constraint; previous knowledge (to build upon it) is another variable that conditions how to select the syllabus.
- Teach what you think may be most important to them. Teach clearly the relevance of the subject (for the student and for society, not for the teacher).
- Teach that the learned way to tackle any real problem is by first sorting out the most relevant points and making good choices on available solutions (that is how we act both professionally and in our normal life). All resources are finite (time, materials, money) and we all need some education on how to make the best with a limited budget.
- Concepts and theories should be given highest priority, since abstract generalisation of knowledge is more powerful than simple data. The implied generalisation makes established theories valid for the whole life-span of the individual. Their universality promotes new applications (creativity).
- Practical rules and guidelines that has been found useful, but that are not yet described in a general theory, must also be taught: life and profession must be exercised in our life time, with our without proper knowledge.
- Teach how to make use of ready-available resources, starting with our own mind (which is always at hand): encourage mental arithmetic and geometry. Promote back-of-the-envelope physical estimations (powerful computers connected with huge libraries are nowadays in our pockets most of the time, but drawing on the soil with a stick or your finger is an ageless human skill).

### **How I know that I have taught**

- My students have been exposed to the subject (it is very difficult to quantify the effect).
- My students are familiar with the vocabulary and concepts (may be checked by a test).
- My students have understood the subject matter and can transmit it (may be checked by an exam).
- My students are able to solve problems proportionate to the level I assume (i.e. they can extrapolate their knowledge to new situations), which can be checked by posing new problems and examining how they solve them (or just how they try to).

## EVALUATION

- What to evaluate? Evaluate the effort spent on the teaching and learning process (the investment) or the useful achievements (the profit). It may depend on the level and purpose: beginners should be encouraged and their effort rewarded even if not successful, to stabilise good habits, whereas scholars and professionals should be evaluated by their output and not so much by their investment. In any case, the efficiency, profit divided by investment, should be maximised.
- How to evaluate? Evaluation of achievements may be difficult if performed by the same teachers. Objective qualifications should rely on a sound examination and a thoughtful weight of the difficulty of the questions, their number and variety, and the time and other resources allocated, but some degree of subjective valuation cannot be avoided except for trivial tests.

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\*As a wise man said ""Human history more and more becomes a race between education and catastrophe." H. G. Wells, (1866-1946), English novelist, journalist, sociologist, historian and teacher, famous for his science fiction novels *The Time Machine* (1895), *The Invisible Man* (1897), and *The War Of The Worlds* (1898).