HOW TO GENERATE CLEVER QUESTIONS AND WHY

Jaromír Kukal, Pavel Kapoun, Jana Kapounová

ABSTRACT
Teaching/learning process can be improved by using clever questions. This idea is remarkably old. Since ancient Greek philosophers used questions while carrying on dialogues with students in order to make them clever. Generally speaking, human dialogues can cause wisdom to be shared, the questions being tools.
The subject of the paper is how to generate them automatically with ICT (Information and Communication Technology) support. Question categorization is necessary for teachers' inspiration, question collecting and new question generating. Answer analysis is based on matching answer symptoms in an inexact way. Methodology of clever question generating is illustrated by three examples from different science areas. ICT support is necessary for question and answer generating and collecting. Both database techniques and self-organized neural networks are available for system realization.

KEYWORDS
Knowledge efficiency, question categorization, self-learning, testing, ICT support

MOTTO

Why are you reading the following paper?

SOCRATIC DIALOGUE IN INSTRUCTION

The word "dialectics" is used in plenty of meanings, sometimes not interpreted in the proper sense of the word. The word itself is not to blame. The Greek word "dia-lektiké" means the art of carrying on a dialogue, i.e. the art of developing two views (however contrasting they may look), theses and their antitheses in order to reach the higher truth – synthesis.

When we hear the name of Socrates, we sometimes think of a very sharp debater who tried to rob his opponents of their views or even of their intellectual self-esteem via asking them a lot of malicious questions. On the other hand, Socrates does not seem to have been a man who boasted of his knowledge considering the others around to be fools, which can be proved by the words he is supposed to have uttered: The only thing I know is that I know nothing.

This, however, might be a very comfortable attitude to life because it enables you to find lots of "buts" everywhere, lots of excuses for your failures as well as a perfect alibi if you are too passive, since if you do not know anything, you are not able to do anything either.

What prevents many people from taking an action is the fact that they keep on waiting until they are theoretically in a perfect state to act and until the risk they take is almost minimal and any failure is absolutely out of. And seeking means a great deal of courage to face your own ignorance and faults. What is more, seeking means acting because experience is the best teacher, after all. He who seeks and acts is confronted to continuous dialogues with himself, somebody else or his surroundings.

From outside a dialogue appears to be a sequence of questions and answers, which is not true. In fact, it is a mutual search for the truth, which is – at the very beginning at least – just vaguely seen by debaters but while they are debating it appears in a new brighter light. The participants of the dialogue work together to achieve the new cognition mutually as well as individually. It is because each of them has to defend their conception and arguments; each of them tries to understand those of the other/s/. At the same time, however, they search for weak points in the mutual construction of truth, which is being built by either debater by means of counterarguments and clever questions. It is obvious that those who have taken part in building such a construction will remember and understand the "newly" discovered truth much better than those who have been shown the complete outline just for a while.

Confucius said: "The teacher leads – not draws – his disciples. He encourages them to go forwards, but does not rush them. He opens a way ahead of them, but he does not lead them to the destination." It is more useful for a learner at school as well to touch the new knowledge themselves than to read a formulated axiom in the textbook the meaning of which is clear only to its author and the teacher, not to the learner, though ("Why shall I learn it? What is it good for? Is it true because it is stated by the teacher?") Etc etc.

If we see the instruction as a dialogue between a teacher and a learner, then it is not only the teacher who knows more facts and the learner who only has to parrot them. Provided that the instruction is not only a teacher's monologue aiming at a learner, but a genuine dialogue between them, it is both the learner and the teacher who benefit from that: the learner does because – apart from facts – he learns to handle as well as classify them, and the teacher because the learner's "naive" questions make him be on intellectual guard, make him rethink the matters he has taken for granted for years and years. In fact, the matters are not always so obvious and it is sometimes good for a teacher to be challenged by a "cheeky" little boy's unexpected question expressing something like "The emperor is naked!"

On the whole, it is not too wise of the teacher to base his authority on the mere knowledge of a greater deal of facts. It is in particular the case of those subjects in which learners use their computers a lot because they are likely to apply the knowledge much better than the teacher. In addition, they may not expect their teacher to compete with them in this field, either. On the contrary, they will appreciate the fact (if not immediately, definitely a few years later) that their teacher did not let them stagnate in the position of "monkey see, monkey do". If the learner becomes an equal participant in the dialogue, he is able to create his own wider view of using modern technologies, which is much more effective than any other way. By the way, a dialogue is quite an enjoyable intellectual game if it is carried by the teacher and the learner, and might be called Schola ludus then.

What is more, a dialogue is an efficient tool for investigating knowledge, views and attitudes of the others. If the learner behaves only like his teacher's echo repeating what he has heard from him or learnt from textbooks, the teacher himself learns from it only what his learner's short-time memory is like, but nothing about an improvement in the learner's cognition process. A variety of clever questions can serve as a spotlight by means of which we can see the level of the learner's knowledge from various angles and thus we can gain a three-dimensional picture of his. Besides, clever questions are not only a tool for examining or getting feedback to show the teacher how effective his instruction is. In addition, Socratic dialogue teaches both the learner and the teacher to communicate, cooperate as well as think in a critical way and not to be satisfied with half replies. Mere "dry" facts might be forgotten sooner or later but the method of asking clever questions will be extremely useful later on, e.g. when the learner will have to face politicians" demagogy. Moreover, the facts themselves can be remembered better and longer if they are not isolated but structured and understood in the context. Understanding

the issue cannot be transferred from a textbook to somebody's brain automatically. It must be done by individual effort via e.g. asking or being asked clever questions.

Not only is the dialogue an efficient tool in search of the truth and subsequently its critical assessment, but also an efficient tool for stating a range of decisions or evaluating potential risks in any aspect. It also enables us to get into the spirit of the others in order to find out how they see the same things and thus to avoid an unpleasant situation which might be described by the saying "We are talking at cross purposes". During the teamwork it might lead to another unpleasant situation generally called "The left hand does not know what the right hand is doing."

Dialectics, i.e. the art of dialogue, was mastered by Plato. Later on – in modern times – it was successfully used by Galileo Galilei. It is a bit ignored by contemporary authors. It is really a pity because the dialogue – apart from many other advantages – can make the truth more personal, it can make the truth something you are involved in, not only something given from outside, since you have been made to find it by yourself, have doubts about it or even defend it. Our contribution on asking clever questions, which is one of dialectical skills, wants to be just a small one to the revival of dialogue.

While teaching via Socratic dialogue, it is necessary to set and keep the standard of questions to ask:

- The question should fit in the context of the topic being covered.
- It should show an innovative non-traditional view of the topic.
- It should activate rational thinking of those participating in dialogue.

Such questions cannot be made without previous education or experience. And for that reason, in particular, it is necessary to create an open – but not empty – database of clever questions.

For didactic reasons, let us illustrate clever questions a little, choosing a few graded examples from mathematics, physics and chemistry.

CLEVER QUESTIONS AND ITS ROLE

Definition

Any question to the given subject is called a clever one if it enriches the subject, the question respondent, its reader or author at least.

Remark

According to the above mentioned definition, the clever question is easy to recognize, possible to ask, difficult to answer, but unfortunately it is rather difficult - whether randomly or systematically – to generate a clever question associated with the given subject.

While recognizing a clever question, any student as a respondent is disappointed because the question is difficult. The style of question can be a good motivation for question reading, understanding and answering. The alternative way of asking is very difficult to prepare. Supposing the existence of N clever questions to the given subject or related subjects, we can use the inductive approach. If samples of clever questions are available, probability of generating new clever questions is growing provided their potential author has some knowledge of the given subject, imagination, fresh mind and motivation.

CLEVER QUESTIONS EXAMPLES

Maths

Function sign(x) provides +1 for positive x, -1 for negative x and sign(0)=0.

Questions:

Write formula for real solution number of the quadratic equation $x*x+p*x+q=0$, where p, q are real parameters. Is it possible?

- Write formula for solution number of the linear equation $a*x+b=0$, where a, b are real parameters. Is it possible?
- Is it possible to rewrite the formulas without sign function?
- Create your own problem for sign function application. Are you able to?

Physics

The Cat Committee for Physical Units and Standards decides to define:

- Time unit: 1 MIAOU as average time period of standard angry cat cry.
- Length unit: 1 CATFOOT as the length of a standard angry cat.
- Mass unit: 1 CHOCO as the minimum amount of chocolate ensuring the transit from the standard angry cat state to the standard lazy cat state.
- Temperature unit: 1 SHOCK as the nose temperature difference between the standard angry cat state and the standard lazy cat state.
- Absolute zero temperature is set to be T=0 SHOCK.

Unit conversions:

- 1 MIAOU=2.5 sec
- 1 CATFOOT=0.03 m
- 1 CHOCO=0.071 kg
- 1 SHOCK=5.27 K

Questions:

- What is the definition of the current cat temperature?
- Determine the velocity of cat crying in the open atmosphere. What is the result?
- Calculate the density of whipped cream, milk, beer and water. Are you able to estimate them?
- Calculate the gravitation constant in the cat favorite town. What is the name of the town?
- The obsolete mercury barometer gives the result of 764 mm. What is the atmospheric pressure?
- General gravity constant, light velocity in vacuum, general gas constant, Boltzman constant, Avogadro constant and permitivity of vacuum are useful physical constants. Which of the selected physical constants have not been defined yet?
- Give a modern re-definition of 1 MIAOU and 1 CATFOOT. Isn't it fantastic?

Chemistry

Every organic compound consisting of carbon, hydrogen, oxygen or nitrogen should be prepared step by step from air, water or graphite using adequate physical conditions or catalyst. But the way can be too long or inefficient. It is a kind of brutal synthesis.

Questions:

- Try to prepare any poisonous organic substance with minimal number of brutal steps. Isn't it funny?
- Try to prepare any sweet organic substance with minimal number of brutal steps. Is it possible to eat?
- Socrates was made to commit suicide by the alcaloide called coniin. Is it possible to synthesize it in less than twenty brutal steps?
- How many brutal steps are necessary to human DNA synthesis?

- Having C 12 and C 13 graphite, try to prepare acetic acid with C13 in carboxyle by brutal synthesis?
- How many brutal steps are necessary for total synthesis of 2-methyl-indole?
- Compare the complexity and the efficiency of brutal synthesis with natural organic compound isolation purification and with ordinary synthesis.

CLEVER QUESTIONS AND ICT

It is very tempting to create a system of generating and asking clever questions by means of ICT. These technologies make interactive searching as well as updating questions possible, along with a distant approach to this source of information. In principle, not only is it the passive consumption of information, but also it is an active ICT dialogue, which uses select rules and cross-references.

The first step towards creating an ICT system is to decide upon the principle of categorizing information, which enables the information to be approached from various angles. It is rewarding to categorize questions not only according to their difficulty and subject, but also according to their type and style. The type of question means a way of assessing knowledge and mostly evokes rational thinking processes of the asked person and forces him to think precisely. Whereas the style of question affects extra-rational and emotional parts of our consciousness more and forces debaters to leave being in a rut and find a brand new view of subject of learning and their own knowledge.

A dialogue should not be carried on without differently strong and inspiring emotions, which gets either debater much involved and makes them be on intellectual guard. Balance between rational and emotional elements of the question enables asking questions through ICT as well as a dialogue with a real person to support better understanding and cognition, which might lead to wisdom.

From the technical point of view, it is necessary to respect rules of ICT and database systems and so to decompose the whole system into a few tables:

- subject of question
- type of question
- style of question
- author of question
- question
- answer with question.

Decomposing the system will be rewarded by its easy update and the possibility to see the required information in every aspect:

- according to subject
- according to author
- according to type of question
- according to style of question
- according to subject and author
- according to subject and type
- according to subject and style
- according to type and style.

It is not suitable to use triplets or quadruplets of particular requirements since the system does not have to contain questions like this.

It is not, of course, prohibited to formulate clever questions concerning ICT subject. It is also possible to store and edit clever questions inside the database system and use ICT techniques for visualization, presentation and keeping them un/fresh. The better approach to clever question processing via ICT and database system is the subject of this chapter. The ER-Entity Relation model of the proposed database system is described on the Fig.1. The system is designed to facilitate question and answer analysis related to the subject of learning, the question of author individuality, the type of question and the style of question. The system like this can help every author to focus on his basic aim. There is a short sample of 5NF table content:

Table SUBJECT consists of learning subjects:

MAT Linear equation	PHY Electronics
MAT Quadratic equation	CHE Organic synthesis
PHY SI Units	CHE Radioisotopes

Table TYPE consists of question types:

DIRECT	SYNTHETIC
INDIRECT	ANALYTIC
DIFFERENTIAL	DEDUCTIVE
COMPARATIVE	INDUCTIVE
CROSS-REFERENTIAL	INDUCTIVE
COMPOUND	

Table STYLE consists of question styles:

STRONG	CRAZY
CLASSIC	UNEXPECTED
LIGHT	EXTRAORDINARY
FREE	

Tables AUTHOR, QUESTION and ANSWER are trivial ones.

The database of clever questions is currently developing and is filled with sample questions from mathematics, physics, chemistry and ICT. Its authors believe that specific questions will be a good inspiration for future creators of some other questions covering some other topics, no matter what field of human knowledge it may be. We would like to make it accessible on the Internet – after evaluating the functional qualities of the local question database – including the possibility of distant, non-interactive modification.

Jaromír KUKAL
Institute of Chemical Technology
Technická 5, 166 28 PRAHA
Czech Republic
e-mail:
Jaromir.Kukal@vscht.cz

Pavel KAPOUN
Technical University of Ostrava
17. listopadu, 708 33 OSTRAVA
Czech Republic
Pavel.Kapoun@vsb.cz

Jana KAPOUNOVÁ
University of Ostrava
Dvořákova 7, 701 00 OSTRAVA
Czech Republic
Jana.Kapounova@osu.cz