How to learn Computer Science, using Computer Science

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Abstract: – Many different learning styles exist nowadays. In general, they contain a sequence of steps the student has to go through in order to get new knowledge. The truth, however, is that the teacher most often provides students with a problem, a dozen of facts considered to be an "absolute truth", his own solution to the problem and a subsequent assessment. Such, well known, learning pattern has a couple of shortcomings that many scientific papers are trying to solve. This paper aims to solve a general drawback of the standard learning approach, where the students accumulate knowledge while remembering set of definitions that subsequently do not know how to use, because they often do not understand them – how and why they were obtained. As an alternative approach, this paper defines a learning model where the teacher provides just a couple of "learning blocks" considered to be axiomatic set for a particular subject or a lesson, together with a number of problems that students have to solve. While solving each individual problem, the student himself reaches new definitions, which he or she then adds to his "dictionary" of "learning blocks". In other words, the students build new, more complex, "learning blocks" by their own, based on a few core "blocks" or other "blocks", which they already are built by their own. This learning model follows the philosophy that a theorem is composed by several axioms (core "learning blocks") and/or one or more other theorems (newly built "learning blocks"). To demonstrate the relevance of the presented model, a specific domain was chosen, where the model is applied – Computer Science. There, the students are provided with the opportunity to study Computer Science through Computer Science itself, having just a few key "learning blocks" initially.

Key-Words: - Learning block, Controlled self-study, Learning model, Computer Science, Algorithms, Self-generated analogies, Self-explanation

1 Introduction

The teacher goes through several basic steps to present a lesson to the students in the standard learning approach. He or she defines a problem, his or her own definitions of "tools" used to solve the problem, often solves the problem by himself or herself and, finally, evaluates by his or her own the decision to choose exactly the selected "tools". The last steps of the process is where the students are having an assessment on whether they understood what they have just learned. Since they remembered the "absolute truth" provided by the teacher, the students often used it by, almost, quoting it, but do not actually understand what they are writing. As a result, the students gain "knowledge" but not "skills" and "experience" to solve problems in different situations. [6] This leads to a major problem – lots of "knowledge" that cannot be applied. [7] "Thanks to some excellent classroom and cognitive research in recent decades, we know a great deal about how learning happens and how little of it happens in lectures". [10]

A brief introduction of what is "Computer Science" is made in section II, in order to present the domain used to evaluate and implement the learning model offered by this paper. The purpose of this presentation is to guide the reader to the nature of the study area, what are its peculiarities and potential problems. Such an implementation of the model is done in section IV, where is it used to present in a novel way of learning "Algorithms", as part of "Computer Science", and considered to be a basis for creating software applications.

The learning model presented in this paper is thoroughly explained in section III. It describes an approach of learning a lesson or a group of lessons trough arranging a set of small "pieces" in a complete "puzzle". What makes the approach interesting, however, is that just a small part of the "puzzle's pieces" are provided to the student. This pieces are

considered as the "core" of all the other pieces of the puzzle. The rest of the "pieces" are created by the student himself or herself. In other words, this model describes a "controlled self-study" process. The student should not remember all the definitions related to a subject or a lesson, following this process, but generate them by his own or her own. Thus he or she will understand how they have been created and, at the same time, he or she will gain an "experience". The "experience" is the key to increasing his or her "skills" and "knowledge".

The challenges before the model application in any different learning area are presented in section V. There are two major challenges that need to be analyzed and overcome – 1) definition of core "pieces" for a lesson and/or a discipline; 2) problems that will serve to generate new "learning blocks" by the student.

This novel way of learning is close to another learning model called "Learning by doing". There the students are being put in particular situations, which have to provoke them reaching their goals by solving a problem and thus gain knowledge and skills. What is different between this is approach and the model presented in this paper is that the paper provides a system for self-studding by incrementing the students knowledge and going from the single "price" to finishing the whole "puzzle" of learning in a particular domain.

2 Computer Science

The Computer Science is a broad concept that includes many sub-areas including software architectures, computer architectures, computer networks, software development, operating systems, databases, and many more. Some of these sub-disciplines are included in the learning plans of most schools. This makes them interesting for a research, which has to develop a new, better, model of tutoring and gaining knowledge by the students.

According to Encyclopedia Britannica, „computer science is the study of computers, including their design (architecture) and their uses for computations, data processing, and systems control. The field of computer science includes engineering activities such as the design of computers and of the hardware and software that make up computer systems. It also encompasses theoretical, mathematical activities, such as the design and analysis of algorithms, performance studies of systems and their components by means of techniques like queueing theory, and the estimation of the reliability and availability of systems by probabilistic techniques. Computer science is generally considered a discipline separate from computer engineering, although the two disciplines overlap extensively in the area of computer architecture, which is the design and study of computer systems." [3]

3 Learning model – "controlled self-study"

Self-learning by solving problems is a scientific concept researched by many papers. First Thorndike started working on it with his learning experiments. [8] Subsequently, other scientists such as Kohler [5] and Tolman [9] contributed this topic. Its final coherent analysis was provided by A. Newell and H. A. Simon [1] with their framework for understanding how problem solving provides the relationship between learning and performance. Although this concept shows remarkable results, Anderson [2] explains in his publication that this concept will be more effective and with higher performance when a complex problem is divided to a set of small problems and then the small problems are solved one by one. Thus, it will be possible the concept to be applied in every discipline, for every problem and it will result a development of a cognitive knowledge. The learning model, presented it this papers, follows the same idea of solving complex problems by dividing them to a set of elementary problems. However, it is further developed by offering a comprehensive learning system. Moreover, it argues that in order to solve even small problems, the student must have a minimal knowledge provided.

Gaining knowledge based on personal experience has proven its efficiency. In this way, the student accumulates experience and skills, not just remembering information that has no value by its own. The opposite of this approach is highly embedded into the tutoring systems used by the educational institutions, where the knowledge is simply provided to students as an "absolute truth" and they are expect to memorize it.

Learning model presented in this paper follows a well-known sentence "Give a man a fish, and you feed him for a day. Teach a man to fish, and you feed him for a lifetime." In order to apply the offered model, however, the teacher has to provide the student with a set of basic knowledge – a core set of concepts that supports the student to gain new knowledge but his own. As a result, the student will be able to use this new knowledge, group it together and gain even more

knowledge. In other words, by aggregation of a couple of "learning pieces" (core and/or generated by himself or herself) the student will be able to create a new "learning piece".

The model, presented in this paper, contains two components – a group of axiomatic truths ("core blocks") stored "dictionary of knowledge" and a set of problems, solving which new truths (new "learning pieces") are reached and, in turn, added in the "dictionary of knowledge". In other words, the student increase his or her knowledge while he or she progress.

There are two participants in the learning model – a teacher and a student. Each of them has his roles and responsibilities. On one hand, the teacher should select only a set of basic elements for a particular topic, subject, or a discipline. Furthermore, the teacher has to develop appropriate problems, so the student to reach a new definition/knowledge ("learning piece"). On the other hand, the student has to solve the problems carefully by using either just the "core pieces" or the ones he or she gained by himself or herself. Finally, the teacher has to check the solution of every problem and provide a feedback to the student. Thus he or she will ensure the student that he or she reached the correct definition/knowledge. In other words, we can call this learning model "controlled self-study" as the student himself or herself generates new definitions/knowledge, but the teacher manages the process.

According to Wong, the method of "self-study" is effective because students without any background knowledge needed to solve a problem may use their analogue knowledge and experience in other topics or the same topic to solve it. [11] He calls this principle "self-generated analogies" in his study. Using this method of "self-explanation", the students are able to develop their knowledge with higher productivity.

The mathematical expression of the model, presented in this paper, looks like this:

(1) Pc_i- *set of "core pieces of knowledge"*
where "i" may vary from "1..r" and "r" gives the number of the last piece of the set of "core pieces of knowledge".

(2) $P_j = \sum_{i=1}^{r} B_i . Pc_i$ *for a problem* P_j*- sum is provided virtually, meaning that the derived new peace of knowledge is made of building blocks containing a combination of the previous pieces of knowledge.*

(3) Bi – is integer coefficient, showing how many times (if at all) is used as building block the core piece of knowledge
j is equal to "r+1 .. n"(n>r), meaning that a new piece of knowledge, based on the core pieces of knowledge has been derived. n - gives the last piece of knowledge from the set.

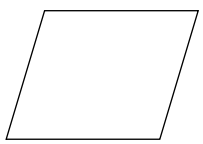
Remark: It's up to the user of the model to decide if the new piece of knowledge may gain the status of a "core piece of knowledge" – k, Initially k=r and it may vary from "r..n". If it gains such status, then k=k+1 and the new "core pieces of knowledge" is $Pc_k = P_j$ *and the new r=k, thus starting the building of the new pieces of knowledge, but with more "core pieces of knowledge".*

(4) P_j*- forms a set of "new pieces of knowledge".*
So at the end we have the full set of pieces of knowledge, which contains the initial set of "core pieces of knowledge" Pc_i *combined (,joined) with the derived set of new pieces of knowledge* P_j

4 Application of the model in study of Computer Science

The design of problem-solving algorithms is a major part of the Computer Science. It can be considered as the first step in creating more sophisticated software applications. For this reason, it is a good case study to apply the proposed model of self-study.

For basic elements of a simple algorithm, we can assume "initial values", "process", "decision", "go to" and "end values".



- **Initial values** – What is the initial state before solving the problem
- **End values** – What is the state after solving the problem

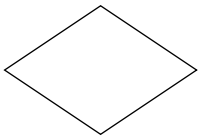
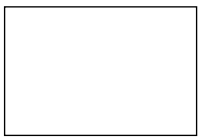
	• **Decision** – What decisions we have to make in order to solve the problem
	• **Process** – What action we have to make in a particular moment
	• **Go to** - Where we have to go after we have done some action. For example, we have made a decision or we have just taken the initial value, etc.

Table 1: Core learning pieces needed to study algorithms as part of Computer Science

The goal is to reach the element "repeatability/cycle".

The problem that is defined in order to reach the goal is:

Ivan has a basket of 10 apples, 9 of the apples are green and just 1 is red. He likes to eat only red apples. What Ivan should do to be sure that he will eat the red apple from his basket?

The problem should provoke the student to use the already defined basic elements and understand that in order to solve the problem he has to return to the decision step several times with every apple until he finds the right one.

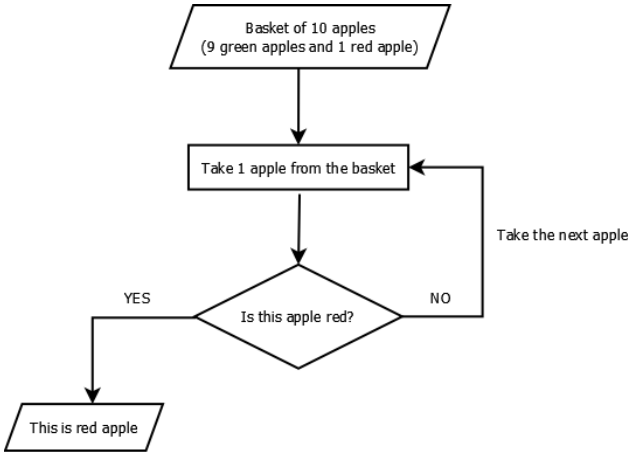


Fig. 1 Solving the problem

As it can be seen from above the example, the student has reached the definition of "repeatability/cycle" by solving the problem.

The teacher should check the student's solution and confirm if that it is correct, providing him or her a feedback. Then the teacher should explain the student that this is a "cycle" and give him a definition of a "cycle" as it is written in the paper. According to Schank, this kind of feedback will be effective even if the student fails to solve the problem, as by feedback and pointing the error by the teacher the student will create new knowledge. [7]

The result of this exercise is that the student has reached a new knowledge ("learning piece") that he has added in his "dictionary of learning pieces", using just "core learning pieces". Moreover, he or she has acquired both an "experience" and a "skill", which may use solving further problems.

This example could be extended by defining a problem, solving which will result a new definition – "recursion".

5 Challenges before the model's application

There are two major challenges before the model's application into different study areas that need to be overcome – 1) Definition of core "pieces" for a lesson and/or a discipline; 2) Problems that will serve to generate new "learning blocks" by the student.

"Core learning pieces" should be determined by the teacher, carefully selected in order to optimize the number of such basic pieces. The simpler the set of axiomatic "operators", the easier it will be for the

student to use them. The aim is not to provide as much information as possible to the student, as the standard learning model does, because then it will be difficult for the student to find out which part to use. Instead, the student should be provided with the opportunity to gather new definitions by solving problems on his own or her own. The teacher with a perfect knowledge of the subject matter can overcome this challenge. In this case, it will not be a problem for him or her to get the just the essence – "If you are not able to explain something in easy words, you just do not understand it" (common sentence in software development area).

Perfectly acquainted with the taught subject is the overcome to another challenge in front of the teacher – designing the problems in such a way that they force the student find and create a new element in his "puzzle" with knowledge. In addition to properly defining problems, the teacher must be careful about their proper organization and consistency. There should be no problem, which the student cannot solve with the current set of "learning pieces". Here one must think of proper verification of the derived by the student's pieces of knowledge. Whenever possible, it would be most appropriate for any subsequent problem to be wholly or partly related to the solution of the previous one.

Very important condition for the correct integration of the learning model into a specific science area is the availability of a solution validation and the provision of feedback from the teacher to the student. This will make sure that the student acquires correct knowledge and does not make a wrong interpretation.

6 Conclusion

The existence of different learning styles does not overcome the major problem for most the students – they accumulate a lot of knowledge without understanding its essence and accepting it as an "absolute truth". This does not allow students to easy applying the gained knowledge in solving problems. Moreover, the students suffer from lack of "experience" and "skills".

The model of "controlled self-study", presented in this paper, provides a new approach to the students for knowledge gathering and skills development. It describes a novel way of learning where the "puzzle" of knowledge in a particular topic or lesson is formed by the student himself or herself. The students solves various problems using just "core pieces" defined by the teacher, and hence generates new knowledge and skills – new "pieces" of the "puzzle".

Although, this learning model look particularly close to the needs of pragmatist and activist, according to Honey & Mumford's learning styles, it could implement each of these learning styles. [4] Firstly, the teacher may implement different learning style when he or she change the set of problems that have to be solved by the student. Thus, a personalized profile may be integrated for every kind of learning style. Secondly, the student himself may implement his preferred learning style while solving any problem.

Computer Science is an important part both from the schools' learning plans and the students' everyday live. This makes them interesting for a research, which has to develop a new, better, model of tutoring and gaining knowledge by the students.

The implementation of the model has been demonstrated in learning Computer Science through the Computer Science itself. The student is provoked creates and learn new definitions using only a small portion of simple "pieces". Going through the problem, one after another, the student starts gathering more and more sophisticated definitions related to the subject.

The main challenges before the model's application into different study areas that need to be overcome – 1) Definition of core "pieces" for a lesson and/or a discipline; 2) Problems that will serve to generate new "learning blocks" by the student. These challenges, however, may be overcome with a good knowledge of taught matter and a good organization of the learning process.

The future work of this research could be design and development of a software that integrates the presented model in an accessible to students and teachers manner. Another direction for further work is the design of the so-called "smart system" that can "learned" by itself while solving predefined problems and completing its set of "learning pieces".

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