ALGORITHMIC OPERATIONS OF TRAINING PROBLEMS AND STUDENT CREATIVITY

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Abstract. Training exercises in the classroom, reciting classes and laboratory may be divided in two independent fractions. The first one includes standard operations. The second one includes creating of new ideas. This part produces students' creativity. That is why this fraction is treated as the main part of training strategy. To be effective this fraction of operations needs to exclude actions not connected with the theoretical idea of the training exercise. The operations included in the standard fraction form the students' competence background or basic KSAO: knowledge, skills, abilities and other. The basic KSAO are studied. It was found the most significant KSAO of this type help the students to begin and to finish his or her training exercise. One can say that the standard basic KSAO build the frame of problem solving. If these KSAO became algorithmic the students can pay all his or her attention on different creative operations. Some problems of algorithmic actions in everyday life are discussed, too. It is known that complex tools and instruments are forced to have their complex description. That is why it is necessary to teach special experts which are competent in creation of user's manuals easy to understand.

Keywords: algorithm, hierarchy, education strategy, computer assistance, creative action, user's guide.

Introduction

Learning is to acquire the so called KSA, i.e., knowledge, skills and abilities. To support new knowledge and create different practical skills each student has to repeat some basic operations for many times. These operations are used in the set of various educational problems. The sequence of the operations one needs for problem solving is reflected in his or her brain. There are known two main conditions to store this sequence in the constant memory of the individual. The first one is multiple repetition of the standard operation sequence. The second one is connected with power of operational affectation on the individual's brain. If the sequence is reflected in the deep levels of brain all actions of the individual can be repeated without serious efforts. Usually one denotes such sequence as algorithmic. The development of a large number of algorithmic actions transforms them in the skills of a very high professional level [1]. However, if all actions of the individual would be strictly algorithmic, the activities will lose creativity. That is why the teacher or instructor has to find the best balance between the algorithmic and creative parts of students' time expenditures in the classroom and laboratory.

Theory

It is well known that the Universe has a hierarchical structure [2]. All its parts or substructures are hierarchical, too [3]. As the result the human perception of the surrounded world is hierarchical [4]. Three main levels of practical skills of trained specialist are known. They are located in the form of steps of the hierarchy [1; 5] (Fig 1).

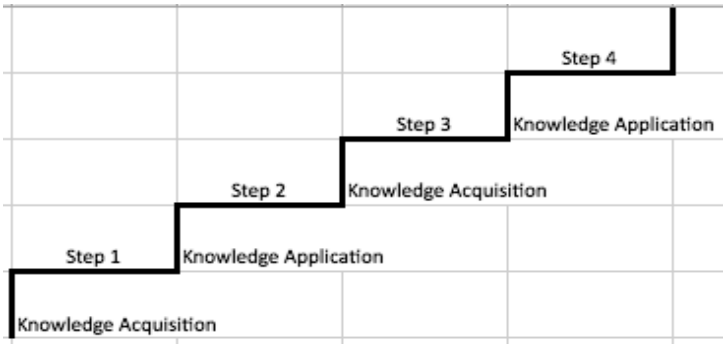

Fig. 1. **Knowledge acquisition- knowledge application staircase [5]**

From general considerations it is possible to say that the lower steps of this staircase consist of algorithmic actions. The upper step has to be built from variable operations. On the lower hierarchy levels all actions of the individual have to be strictly specified [2; 6]. This conclusion was at first published by E.A.Sedov [7]. This book unfortunately was never translated from Russian. It was also shown in this book that the number of different objects on each level of the hierarchy decreases on the way from level to level. Recently these ideas are widely used in the Social and Biological studies [8]. The most interesting result of all set of these pieces is the statement of the required degree of algorithmic actions on different upper levels of the hierarchy. Yet, so far nobody has studied it in relation to the typical classroom problems.

Algorithmic education in the classroom and reciting hall

Let us focus our attention on the three upper levels of the training hierarchy only. On the higher level the graduated individual uses the professional skills in creative work. In the most part of real situations one of the same problems can be solved by a different set of actions. That is why on the second top level the individual must consciously choose the most suitable and convenient algorithmic program from the set of the standard sequence of actions. Traditional university educational strategies develop algorithmic actions of a simple level - calculations, preparing brief reviews, for example. Yet, the senior and pre-graduated students are involved in a more complex situation. The new education strategy has to be used in some of these complex situations. The student's creativity in these cases must be focused on new ideas which include searching for the necessary data, estimation of experimental errors and independent preparing of brief reports which describe the main results of the investigations. At this educational period the student must create his or her own sequence of active professional activity. For instance, the student has to generate his or her most convenient algorithmic sequence of several standard actions. In the simplest case starting his or her experimental work the student in every case must find an answer the following questions.

- Which of the quantities measured was the main source of the experimental error?
- Does it make sense to use more sensitive measuring tools stopwatch if all experimental conditions remain unchanged?
- What should the experimental conditions be in order to ensure that the results are independent of external conditions?
- Is it possible to change the method of investigations?
- What appropriate methods of investigation of the same problem are known?
- What factors affect the obtained experiment results?

The main sets of knowledge which is necessary to create correct sequence of actions is well known. The main of them are as follows.

- To be familiar with the instrumental technique of real-world behaviours;
- To be familiar with modern methods of describing real situations;
- To have good experience in making judgements in formulating conclusions about real-world problems;
- To understand which skills are the necessary skills in building and assembling parts and products or whole systems;
- To create abilities to choose the necessary materials and equipment;
- To be familiar with developing new system specifications;
- To create methodologies of meeting the client requirements;
- To generate abilities of choosing the optimal tools for answers on environment challenges.

We can suppose that the average quantity of information stored on the upper level of the action hierarchy is no more than 20 % from information stored below on the same level [9].

Computer assistance and algorithmic education

It is hardly possible to keep effective self-control control after each step of the real educational strategy. That is why computer assistance is a powerful tool which is the part of the educational strategy and standard professional work of graduated individuals. Both the senior students and the

graduated individuals have to be fluent in the Internet search of all the necessary information, methods of computer composition and decomposition of different technology processes, creating different documents in paper form. An educated professional must be familiar with the use of the Internet and local data bases. These skills must be tailored with a traditional set of professional skills. In the actual situation a very small part of the individuals think about these problems. Several skills, which are included in instructional algorithms regardless of their level, are developed in the courses of a particular subject matter e.g. mathematics, physics, chemistry, and so on. Yet, other skills have essentially an interdisciplinary nature. Not explicitly taught, such skills emerge as a part of a professional repertoire through active participation in a master/apprentice type of learning environment.

A high qualified instructor has to build the sequence of serious problems which are useful to be solved in the classroom. These sequences are created under continuous instructor's guidance. Yet there is known another way to customize the sequence of the required the habits of the individual. This way is the so called computer enriched instruction (CEI). The CEI fundamental merit is multiple choices of challenges. The student carries his or her one-to-one instruction. The instrumental circuit can be arbitrary built for each individual. All quantities and other conditions are accidental. Imitation computer experiment applies different strategies. The first strategy exactly repeats on the screen all instrumental tools known for the traditional experiment. This strategy is widely spread for distance education and self-guided training. The other strategy is based on arbitrary building of the instrumental circuit from any standard set of details. It is beneficial for a large repertoire of possible circuits. Training in virtual circuits building and breaking, understanding some basic laws of instrumental techniques is an additional advantage of this strategy. The third strategy at last acquaints the student with a situation that cannot be realised in the laboratory room. This strategy is more effective in compound with all-class verbal discussions in the reciting room. The main goal of this strategy is to help the student be familiar with situations he or she will meet in post-university practice.

A floppy disk with all instructions and data can be written on single floppy. It is possible to connect all computers in the classroom to single hard disk. After this strategy different disciplines can be studied in the single classroom full of computers. Variability of the available material is a serious advantage of these strategies. This strategy permits to manage a large number of students easy. Yet, the possibility of regular students-instructor discussions is still limited. The visual and simulation capabilities of computer assisted teaching materials and inherent flexibility in their use attach an additional advantage to computer simulation experiments.

The whole list of advantages on this strategy application is well known. At the same time one can detect a principal obstacle, too. Absence of handling and practical interaction with measuring instruments is this obstacle. If someone desires to learn to drive he or she never restricts his or her training in the theoretical and imitation area. The applicant needs several times practical driving under the expert control. A student also needs to develop practical skills and abilities to have real achievements in experimental techniques. In order to get success the teachers are forced to match both the traditional and PC-imitation laboratory strategies. The ordinary scenario of aggregation of two education strategies is introducing both strategies in turn. Practical parallel exercises in two types of classrooms are also possible. An alternative approach is improvement of the instructional strategy with the help of special combined exercises. The main expected result of this strategy is creating educational and practical algorithmic sequences of a very high level. The expenditures of educational time for achieving good results in this way are practical, the same as in traditional instructional strategies.

The main advantage of all strategies that are discussed above is the formation of several algorithmic sets of actions. Their use allows the students concentrate on the creative activity. This can be considered a major benefit of algorithmic actions.

Algorithmic actions in everyday life

A great variety of algorithmic actions accompanies all individuals in their everyday life. Different simple calculations, driving, a number of hygienic procedures and much more are based on different standard action sequences. Therefore, their use in the instructional strategies is not something exclusive. During the last decades many new sets of algorithmic actions were implemented in the

control and management of complex electronic devices such as cell phones, new cameras, iPads and many others. An average user has no ideas about processing of these tools. That is why he or she has to use the user guidelines. The most part of user oriented descriptions base on the step by step recommendations. The sequences of these simple actions are frequently very long. More than over, no clear explanations are spread in these user's manuals. The algorithmic actions in education strategies are usually clear and simple enough. Implementing of algorithmic procedures in education is an excellent field for the training of their use in much more complex cases. In addition to this the study of algorithmic use in education allows to highlight the main problems of creating new effective algorithms for everyday household and industrial equipment.

Some new ideas about reflection of the general laws of algorithmic procedures in education strategies

Our preliminary analysis of algorithmic actions in human everyday life permits us to formulate a number of requirements of educational strategies improvement. The first one of these requirements is implementing of some general laws of developing a complex technique with algorithmic programs. It is known from the general description of technologies that the main way of their development is to create a set of simple and a set of very complex processes. The processes of the average level of complexity gradually disappear. It is the so called *The law of wash-out of the middle* [10]. This law affects the set of algorithmic programs which one can meet in his or her life. That is why this law and the general conclusions from it are necessary to be included in the education text-books and exercises. The second useful requirement is connected with creating of convenient and clear guidebook instructions [11]. Careful examination of several packs of different user addressed instructions allows understanding that it is necessary to create educational strategies for special training of future experts oriented on writing such documents. These experts have to be familiar not with technique and programming only. It is not less important for them to know the basic principles of the consumer psychology and advertising ideas. The more algorithmic programs are used in any tool, the more important it is to create its excellent descriptions.

Conclusion

Algorithmic operation tailored with computer assistance transforms the traditional instructional strategies in more effective ones. These strategies foster the students' activity and generate new KSA. The advantages of implementing computer assisted strategies in educational schedule are excellently known. Nevertheless, there are some negative behaviours of the widely spread algorithmic education. The lost individual's independence and practice to avoid complex problems, and waiting for different hints, are traditional disadvantages of excessive implementing of algorithmic technologies. Our point is that these disadvantages are not critical. The second result of our study is that a new type of experts is demanded in the market of complex equipment. One forecasts that in all real situations algorithmic programs will be engaged more actively then earlier. All algorithmic programs help students extend creativity of their studies at the university and in their future practical work. The decisive advantage of the widely spread of algorithmic programs is the formation of creative mindset and creating useful habits in everyday practice of educated professionals.

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