UDC 004.9:501

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COMPUTER SCIENCE AS THE MASTER KEY FOR TRANSDISCIPLINARY EDUCATION: FROM ONE'S PRACTICAL TEACHING EXPERIENCE

Abstract – Having their long-term professional experience in teaching of Computer Science, Physics and Mathematics, and also based on their productive collaboration as co-heads of some research projects of students, the authors discuss their own positive experience of training of competitive graduates of specialized secondary school. The authors also express their own opinion about transdisciplinary approach in education.

Keywords: transdisciplinary education model, Comp. Science & Programming, transdisciplinary methodology of learning, intellectual competitions, Skills Developmens.

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КЛЮЧЕВАЯ РОЛЬ ИНФОРМАТИКИ ДЛЯ ТРАНСДИСЦИПЛИНАРНОГО ПОДХОДА В СИСТЕМЕ ОБРАЗОВАНИЯ: ИЗ РЕАЛЬНОГО ОПЫТА ПРЕПОДАВАНИЯ

На основе своего многолетнего опыта преподавания информатики, физики и математики, а также на основе успешной совместной работы в профильных классах средней школы, авторы высказывают свое суждение о трансдисциплинарном подходе в образовании, и в частности, о своем позитивном опыте воспитания конкурентноспособного выпускника средней школы.

Ключевые слова: трансдисциплинарная модель образования, информатика и программирование, интеллектуальные соревнования, трансдисциплинарная методология обучения.

Introduction

The classical model of education, which was aimed to obtain a large amount of skills due to teaching at the university and then to be gradually improved one's professional skill "later" because of subsequent trainings, began to collapse. One of the reasons of this is acceleration of needs for new skills, which must *constantly* and *frequently* be updated and improved. The modern manufacturing processes require more mental work from a person because simple routine works are being automated with amazing rates.

Education in general allows us to receive knowledge as well important life skills. Mr Ralph J. Cordiner, former chairman of General Electric Corporation, expressed the attitude of top business management towards education as follows: "Business is interested in competency, not diplomas. More and more we depend on books, files, and machines to store information. If we can do only what a machine can do, we're useless. How well educated a person is, is measured by how well his mind is developed. In brief, by how well he thinks. Anything that improves our thinking ability is our education." [1, p. 271].

Technical progress is implacable, and it requires corresponding changes in the education system. Of course, it is necessary to reform the educational system here, in Ukraine. The authors of the work would like to present their opinion on the development of domestic specialized secondary schools.

Working in Ukrainian educational system, we understand its place and role in our society. Currently secondary School is a basic element of the sociological chain, which is inherent for the market economy and the chain looks like this: "*graduates of specialized secondary school → university graduates with the same specialization → the job market requirements*". According to this imperative, this tandem "specialized secondary school + university" is essential to optimize current school education in order to formation of secondary school graduates which will be able to compete in the labor market, especially after receiving by them of higher professional education.

The authors have been working for many years in the Ukrainian IT education sector – one of them as a highly qualified teacher of Comp. Science of the specialized secondary school, the other – as an associate professor of IT Dept. of a Telecommunication academy: both are familiar with the general and internal problems of domestic education.

Especially keenly one can feel the need for changes in domestic specialized schools: it is enough to mention at least one of the problems arising at the stage of creating of specialized classes – imperfection of rules and gears of student selection procedures in these classes. Only about 30% of graduates of our specialized school[4] continue their studies at universities for the selected profile of studying. And the fact raises some questions about the training effectiveness for pupils of graduation classes. And we must, of course, mention the important and vital fact: for quality training of school pupils of senior IT-classes it is so needed to have necessary knowledge and skills of university teachers! And in this regard, we share the view expressed by [2] concerning to necessity to pass through

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[4] accordingly to the long-term monitoring data on secondary specialized school №49 of Odessa City.

the State External independent Testing in Computer Science for senior school pupils. Problems in post-secondary education are the result of many problems in secondary education.

Problems in specialized secondary school are the basis of many general or specific problems in higher education institutions. Of course, any university (in principle) can correct the *status quo*, but only in part, because it acts as a part of the existing education system and it is its hostage. The natural reaction to the short efficiency of the specialized school was the desire to solve this problem through the cooperation of secondary and tertiary education.

One's understanding of this problem has led to closer and fruitful cooperation between Odessa National Academy of Telecommunications named after A.S.Popov (A.S.Popov ONAT) and the specialized secondary School #49 of the City of Odessa (Odessa School #49) within the respective pedagogical experiment. So, in 2012, in Odessa City it was established the initiative group of local educators of Odessa School #49 and A.S.Popov ONAT in order to provide adequate levels both in certain knowledge and competency of current secondary school graduates' – "to be good enough" as a student of the academy. Another words, we would like to balance out the educational levels of school graduates and university entrants. The authors were the active participants of the mentioned educational project for some years till February of 2017 [3].

Since then, we were carrying out diverse works aimed at improving the quality of education at the School:

i) new special learning course in Computer Science has been created (it was designed in order to change the content of education for pupils of the IT-specialized classes of the School);

ii) conducting lessons in Programming for secondary school students by the ONAT lecturer;

iii) training and preparing of school pupils for different intellectual competitions (mainly in "hard" disciplines such as programming and physics) for some years;

iv) during the period of 2013-2015 there were held seminars (workshops) to improve the skills of school teachers of informatics.

Transdisciplinarity in Teaching as a variant of solution of current Educational problems

Surely any reforms (i.e. real changes, in the sense of "substantial improvements") of current educational system should be significant and consistent. We believe that one of the main shortcomings of school education system at the present stage is receiving of fragmentary knowledge by pupils and their inability to apply this knowledge outside of the formal tasks. Therefore, it is necessary to put into practice of specialized school education the modern concept of transdisciplinary approach [4-6]. It allows to break down certain known "barriers" between usual school subjects, which are still being taught strictly separately we have here, in Ukraine, and only a weak interaction between them one can observe at best. They have long been using the principle of transdisciplinarity in senior classes of secondary School in advanced countries of the world for a long time and this practice is fairly successful [7], the main result of this system of learning is correspondence of the knowledge level of school-leavers to needs, which a modern university puts to its entrants.

It is well known fact that the researches according to the principle of "*on the junction of different sciences*" are very fruitful. In our opinion, exactly Computer Science – because of its own "integrating" properties it has contributed to gathering around itself a lot of branches of knowledge – it helped to implement in secondary school as well in tertiary school the modern concept of transdisciplinary learning [8, 9].

Since the main task of secondary school is to create the basis for any modern profession [2], that without involvement of university professors in teaching of students of specialized secondary schools it will be very difficult to provide the necessary level of knowledge and skills.

Due to its own "toolkits" and methods, Computer Science makes it possible to solve research problems for almost unlimited number of scientific fields. Most of really interesting and practically important tasks are transdisciplinary essentially since they step over the boundaries between disciplines. Fig. 1 illustrates the main directions of students' research works from our practice.

These transdisciplinary tasks are clear even for high school students, and they are ready to find their decision of the given tasks actively and with desire. Therefore it is very important to show both the scientific and competence levels of the teacher, which becomes a worthy leader for his students. The teacher should himself to show his ability to explore by personal example, as well the ability to bring the begun work to a successful finish.

It is an old truth, that the most important principle of motivation is "*The Goal can be achieved*!". From this idea it does come the pupil's confidence in his teacher and, vice versa, the teacher's faith in his pupil. As a result, the pupil begins to believe in himself, his own power.

Students usually come to the feeling of self-reliance through the ability to reach that brought up in them for years, as well through their own skills that were taught and that were cultured by their teachers.

All the pupils are curious and full of desire for learning! An educator aims to take into account the interests of given pupil, as well to take into account the psychological qualities of his personality, and at a certain stage the teacher "as a manager" can advise or even assign him to the selected topic of research. Another words, in this case the teacher may "connect" a specific problem with a specific person (pupil-the-researcher). Surely, the teacher-supervisor faces the mass of different tasks, among which there is the psychological one that directed to his pupil – the teacher's ambition, his desire to cultivate a pupil's aspiration to solve the problems he has met. In this way the pupil becomes a real explorer! The purpose of the teacher is to direct the student's cognitive energy on the better

pathway: to gain his interest to certain researches and to inspire his creative skills in order to fulfill the work.
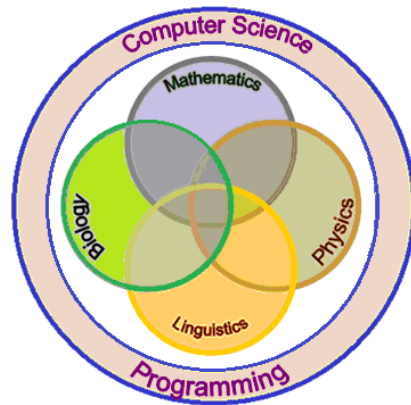
Fig. 1: Computer Science as the Master key for Transdisciplinary Education
(it illustrates the main directions of students' research works from our practice in 2015-2016)

We believe that one can achieve positive results in learning activities of pupils in classroom as well as "after-school-hours" when working with small groups of pupils: we have an opportunity to replace common "frontal" methods of learning with individual work with students in order to implement student-centered approach in learning. Our own experience shows that the successful modern teacher should be a consultant, a leader and even a manager, since he has to be not only the "master of training", rather also "a master of managing of learning". From time to time the teacher himself has "to sit at the school desk" for mastering new technologies in education, so it is better way to open "new horizons" not only for his students but also for himself. And by combining of traditional and innovative teaching methods he can teach present-day students "in a modern way".

"Work, a Talent, a Victory"

In our opinion this short, but capacious phrase is really a good illustration of one of the very difficult, but perhaps the most interesting types of teacher's work – his work with the eager and hard-working pupils during extracurricular time, namely when they working upon research projects.

We know from our own experience that the combined work of a teacher and of his pupil is able to bring good results. A talent itself is not always a guarantee of success: the personal qualities such as dedication, hard working and intellectual curiosity are still determinative.

Naturally, a teacher should provide the evolutionary process of learning in the traditional trend "*from the simple to the complicated*". Relying on this principle, a teacher can and should form the pupil's logic, as well his critical thinking skills and algorithmic thinking. As usual, at this stage pupils make their first steps in mastering of basic algorithms. But some current tasks require combining of classical basic algorithms and heuristic approach for their solution.

In our scholastic practice, each research problem we have to solve was broken into necessary number of stages of its solution, – we call them "passages" (i.e. exercises), each of which in its essence is a step towards achieving our goal. As their individual progress in learning, including personal activity and success, the pupils were distributed among some current research problems respectively to their interests and abilities. After about a year of training, when they had prepared the intended knowledge base and have mastered the basics of different related disciplines and basic programming algorithms, they were offered a more knowledge-based formulation of the problem. We consider these steps as bringing them to the scientific view of the chosen problem.

As for pupils, their individual receptivity of certain topics and their interest for the chosen problems were the important criteria for selecting by pupils "their" certain research areas. For example, when working with a group of pupils in 2016 the two main areas of research were selected – *linguistic* one and *bionic* one (see Figure 1). And in both cases, one had to achieve the specific level to create computer programs of practical importance.

We believe that the value of such way of teaching – "quasi-individual" one – was also in the fact that both groups of pupils were not isolated from each other, and they could see the whole process of mutual learning. It was trainings both for general and special knowledge, as well as computer technology skills to use the knowledge. These were the time periods rather of the unique life experiences for the pupils, in which they became complicit and sympathetic to one another, partly because they could see the cognitive evolution of each.

The effectiveness of educational work carried out for some years, as ever, is proved by practice: one of the indicators of the effectiveness of the work is the achievements of pupils in intellectual competitions of different levels (see the summary *Table 1* of the achievements of our team). Of course, anyone teacher would like to teach the pupils that are capable and creative, and moreover, that are able to understand "on the fly" educational material of any kind. We would like to note that the pupils who were trained by us and prepared to the intellectual competitions of various levels (from the regional one to the international one – *see the Table 1*) and who had won diplomas and prizes, – they were NOT so called *A-students* in its conventional meaning. Thus, the pupils were *interested* in the proper subject and were *NOT afraid to work* a lot!

Table 1

The results of pupils' participation in Domestic as well International competitions of different levels in various academic disciplines Academic years: 2013-2017 (the School #49 of Odessa)

Level of Competitions, year	Academic Discipline	Rating (Position)	Pupil's Name	Grade	Adviser Teacher	Scientific Adviser
Regional,MAS*-**2013**	Internet-technology & Web-design	3	VyacheslavEpancha	10-Б	N. Yevtushenko	Dr. A.Chepok
Regional,MAS*-**2013**	Programming Technologies	3	Mykyta Khmelenko	9-А	N. Yevtushenko	Dr. A.Chepok
Regional,MAS*-**2014**	Internet-technology & Web-design	2	VyacheslavEpancha	11-Б	N. Yevtushenko	Dr. A.Chepok
Regional, contest of Inventors and Innovators (**2015**)	Computer Science	1	Mykyta Khmelenko	11-А	N. Yevtushenko	Dr. A.Chepok
National, contest of Inventors and Innovators (**2015**)	Computer Science	2	Mykyta Khmelenko	11-А	N. Yevtushenko	Dr. A.Chepok
Regional,Conference (**2016**)	Inventive Activity, Energy, Environment	1	Olga Oreshko,Liza Blizyns'ka	11-Б,9-Б	N. Yevtushenko	Dr. A.Chepok
Regional,MAS-**2016**	Computer Science, ProgrammingTechnologies	2	Liza Blizyns'ka	9-Б	N. Yevtushenko	Dr. A.Chepok
National, «EcoSoft» (**2016**)	Information Technology	3	Olga Oreshko,Liza Blizyns'ka	11-Б,9-Б	N. Yevtushenko	Dr. A.Chepok
International, the 20th Belarussian open Republican Contest (**2016**)	Physics	3	Olexii Gordienko	11-Б	N. Yevtushenko	Prof. I.Trotsyshyn,Dr. A.Chepok
	Computer Science	Encouraging Diploma	Liza Blizyns'ka	9-Б	N. Yevtushenko	Dr. A.Chepok
Regional,Conference (**2016**)	Inventive Activity, Energy, Environment	1	Kalyuzhny Leonid,Leonova Olexandra	11-В,11-В	N. Yevtushenko	Dr. A.Chepok
Regional,Conference (**2016**)	Inventive Activity, Energy, Environment	1	IvanichenkoOlexandr	9-В	N. Yevtushenko	Dr. A.Chepok
Municipal,MAS*-**2016**	Information Technology	1	IvanichenkoOlexandr	9-В	N. Yevtushenko	Dr. A.Chepok
Municipal,Olympiad in Comp.Sci. (**2017**)	Computer Science	1	Kalyuzhny Leonid	11-В	N. Yevtushenko	Dr. A.Chepok
Regional, Olympiad in Comp. Sci. (**2017**)	Computer Science	3	Kalyuzhny Leonid	11-В	N. Yevtushenko	Dr. A.Chepok
National, «EcoSoft» (**2017**)	Programming	Diploma of the Finalist	StolyarenkoSaidullah	11-В	N. Yevtushenko	Dr. A.Chepok
National, «EcoSoft» (**2017**)	Programming	Diploma of the Finalist	YevtushenkoBogdan	9-В	N. Yevtushenko	Dr. A.Chepok
National, «EcoSoft» (**2017**)	Programming	Diploma of the Finalist	IvanichenkoOlexandr	9-В	N. Yevtushenko	Dr. A.Chepok
National, «EcoSoft» (**2017**)	Programming	3	Kalyuzhny Leonid	11-В	N. Yevtushenko	Dr. A.Chepok
National, «EcoSoft» (**2017**)	Programming	3	Leonova Olexandra	11-В	N. Yevtushenko	Dr. A.Chepok
International, the 21st Belarussian open Republican Contest (**2017**)	Biology	3	IvanichenkoOlexandr	9-В	N. Yevtushenko	Dr. A.Chepok
International, the 21st Belarussian open Republican Contest (**2017**)	Computer Science	Encouraging Diploma	Kalyuzhny Leonid	11-В	N. Yevtushenko	Dr. A.Chepok

* MAS = the Minor Academy of Science (the Ukrainian national institution for pupils-researchers)

Summary

All the presented here by authors is taken from their practical educational experience, which gives the right to the following conclusions:

1. Reforming of specialized secondary School should be aimed on the university criteria. Another words, the specialized secondary schools must go in tandem with the tertiary schools in content of teaching as well as in form of teaching.

2. Preparation of competitive secondary school graduates should be started in specialized secondary schools.

3. Implementation of the transdisciplinary approach to teaching is one of the essential ways for realization of required changes in the content of education and methods of teaching in specialized secondary School.

4. Computer Science is a key discipline which can help to solve many problems of modern Education.

5. It is through the immersion of pupils into research and knowledge-intensive projects one can form among the young generation the understanding and perception of the integrity and diversity of the surrounding world, and thereby it will permit to avoid the problem of fragmentation of knowledge.

6. Any teacher must constantly upgrade his knowledge and skills, and be willing and able to do it.

7. Within the simple vital formula "Work, a Talent, a Victory" one can see an old and genuine principle of human success.

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