CHILDREN'S COMPUTER CLUB AS AN EXAMPLE OF NON-FORMAL EDUCATIONAL SYSTEM IN THE FIELD OF INFORMATICS

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Abstract

The article represented describes theoretical and practical approaches to creation of non-formal educational systems called "St. Petersburg Children's Computer Club" (CCCP). The CCCP project is based on the theory of socio-cultural development, as well as activity theory. The main principle of the system is represented by a multilevel set of interconnected modular courses on informatics, which allows pupils to choose the direction of self-education according to their interests and abilities. Results of CCCP project (progress, students' achievements, etc) have been analyzed and have proven its productive use.

Key words: *non-formal educational systems, teaching informatics, computer club, vocational guidance, activity theory, development of abilities*

1. INTRODUCTION

Non-formal educational systems are usually created to solve some problems that formal system is not able to cope with. In spite of being created to solve specifics tasks, non-formal systems are often widely applied as they have a number of advantages. These include: variability and flexibility of programs, free choice of traditional teaching methods, opportunity for implementing innovations, possibility for organizing accelerated learning programs (International Institute for Educational Planning 2006).

Improving of non-formal educational structures is a typical process, particularly in fast-growing areas such as informatics, because official systems can't get accommodated fluently to constantly changing claims entered for the content, level and quality of teaching computer studies.

The project "St. Petersburg Children's Computer Club" (CCCP) appeared at the end of the 90-s as a regional non-formal educational structure to give schoolchildren of St. Petersburg access to a high quality supplementary education in computer studies. At that time the main theoretical basis for teaching informatics at school was the concept of academician A. Ershov, who believed that algorithmic and programmer skills were fundamental components of human activity and formation of these skills was the main goal of National Program in school informatics (Ershov, AP, Zwenigorodski, GA, Pervin, AYu & Yunerman, NA 1983). The concept based on the considering programming as the second literacy caused particular direction of school curriculum. At the same time there was an opposite viewpoint according to which user applications should be the main goal of school informatics.

State educational system failure in combining these two approaches in one educational program was caused by the lack of hours budgeting provided for informatics. In addition, there were some difficulties with methodological, technical support, and training of teachers. As a result, the educational needs of schoolchildren in informatics were not satisfied. Official school did little to solve problems such as students' leisure time organization, reduction of computer games influence etc. These problems caused a lot of worrying among the parents who wanted their children to have productive extra-curriculum activities and get a good vocational education.

The complicated situation described above is actual today. It explains large number of various non-formal educational systems in the field of informatics today. These systems are mainly social demand-oriented, therefore teachers are free to develop various educational programs adapting them to

particular circumstances (European Association of Institutions of Non-formal Education of Children and Youth 2005).

Non-formal educational systems are variously structured. Some of them, such as Computer technology center in the St. Petersburg City Palace of Youth Creativity, are parts of larger structures, while others are relatively autonomous computer clubs, courses, etc. These structures may have essential differences in educational programs, number of courses, as well as recommended training sequences. Nevertheless, each non-formal educational system in the field of informatics aims at providing students with knowledge and skills that enable them to become in-demand fellows of the society and business communities (Children's Help Net Foundation 2014).

Despite obvious and understandable formulation of the goal, the ways of achieving this goal are not always clear. There is little information about how to create structures of non-formal educational systems in the field of informatics. Therefore, we can assume that theoretical justification of such systems' creation does not exist and that the development is often based on some empirical data.

This approach sometimes leads to strange results. For example, a primary level of computers courses for children called 'Basic training' unexpectedly includes the study of robotics and applied mathematic (Higher Engineering School 2014). This basic training is designed for schoolchildren who could call themselves 'academicians', because the system of courses they attend has a strange title 'Academy'.

There are lots of such examples. Their existence confirms the importance of theoretical concept for developing non-formal educational systems in the field of informatics. This concept should be based on the use of objective laws of learning and development, i.e. on psychological pedagogics.

2. THE BASIC IDEAS

Wide diversity and variety of tasks set by non-formal educational systems in the field of informatics have resulted in appearing non-trivial ways of searching theoretical basis to solve those tasks. Various age ranges, interests, and levels of children, different parents' requirements led to the search of some common ideas that would serve as a basis of creating adequate educational structure. This search has resulted in outlining the following ideas:

- Choice and creativity freedom.

- Skills development.

- Gradual specialization in the process of education.

- Vocational guidance of education.

The main aim of the educational system is to unite the ideas expressed above so that the process of creativity, realized and experienced emotionally by pupils at the initial stage of education, would motivate them to identify the field of interests in informatics as well as the following vocational development. The role of a computer in this process should be reduced to the tool of vocational and creative activity. But the realization of these ideas may face some obstacles due to the specifics of a computer as a tool used in the process of thinking.

In traditional theory of cultural-historical development sign systems along with the speech were considered as tools of thinking (Vygotsky 1962). A part of actions with sign systems in the process of development becomes interiorized and automated, for instance, mental calculations are firstly learnt involving the use of physical objects (counting sticks etc), after that, all arithmetic is gradually getting done mentally. Various automated calculations such as adding 2 to 3 are made much quicker in head than on a calculator. Doing simple arithmetic in head is a new intellectual ability which a person acquires in the process of development and which influences the prospective development of some other intellectual abilities such as numerical prediction of actions happening around, making decisions etc.

One may wonder what will happen if the computer makes all simple automated calculations instead of people. Obviously, it will influence the development of other mental processes which use these abilities for simple calculations in head. Transferring some intellectual activities to outer automated mechanisms may result in growing dependence of a person on outer automated operations, for instance, instead of searching for complex decisions mentally a designer will place an object in different parts of a screen in search of the most appropriate variant. As a result, relying excessively on computer possibilities a human being limits development some of his/her intellectual abilities.

In order to avoid negative consequences of studying informatics it is necessary to encourage pupils to separate themselves from interface as well as concrete computer technologies when solving tasks. The same requirement in the terminology of activity theory will be considered as a task solution with the help of actions having a high level of generalization (Galperin 1992).

A learning task as well as any problem is a necessary condition for development of learner's intellectual abilities if it corresponds to his/her zone of proximal development, i.e. it can be solved only in cooperation with a teacher (Vygotsky 1962). Difference in education level of students typical for non-formal educational systems leads to the elaboration of learning task systems with complexity diversity. Therefore, development of learning task complication principles is an essential part of designing educational system and provides its conceptual unity and adaptive capabilities as well.

The idea of gradual specialization in process of vocational training is well known in vocational education. The traditional model of gradual specialization consisting of 3 training levels: 1) primary, 2) basic, 3) advanced - was taken as a basis of CCCP educational system concept. Each level is characterized by the degree of specialization as well as special principles of learning task system development which result in forming generalized actions.

3. DEVELOPMENT OF CREATIVE ABILITIES AT THE PRIMARY LEVEL

Primary level of teaching informatics is intended to those who are unaware, partially aware or not completely aware of informatics possibilities. On average, it corresponds to the age range of 9-12 years old. As any person, appeared to be in an unknown place, a learner is in need of broad orientation. The broader this orientation is the better.

At the primary level learners get entry view of all types of tasks which are connected with a computer, methods of productive computer usage and principles of computer work. Pupils are taught to work with shells in computing and user environment, learn key functional elements of a computer, are introduced application software (text, 2D and 3D graphic editors, archivers, electronic spreadsheets, the Internet, communication, multimedia etc). In the process of education learners get fundamental notions needed for work on a computer: "interface", "command", "program", "configuration", "operating system" etc. As a result, they get knowledge and develop skills essential in any area of informatics.

The principle of concentrating attention on a task itself instead of means of its implementation is crucial at this level. Broad variety of learnt instrumental means suggests the same variety of tasks which use these means. This kind of variety is the most advantageous for creativity development. Therefore, learning task orientation which develops creative abilities is to be considered as the main target of the primary level.

The example illustrating possibilities of combining tasks on creativity with practice of drawing skills in graphic editor is given below. A learner is given an image and a task to make something up and draw it (Fig. 1). The main attention is paid on the task, different graphic possibilities of the tool serve as the means of solving the task given. Similar method can be used at learning wide range of instrumental means (up to work with operating system) and it helps develop tool skills as well as creativity (Lokalov 1999).
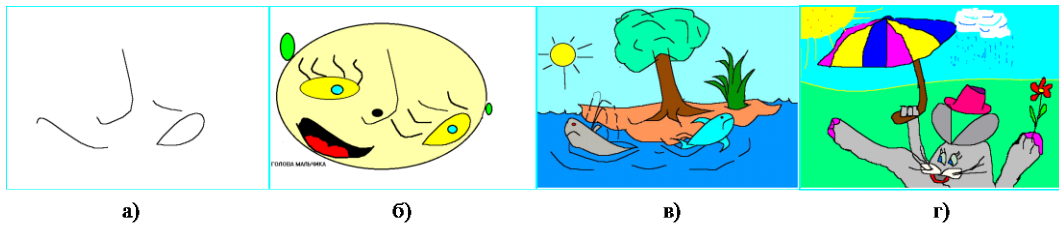
Fig. 1. Task "What does it mean?" To make up and draw as many variants as possible: a) – original image, b), c), d) - variants.

It is crucial to focus on interests of learners when choosing range of tasks in order to provide high level of motivation. Therefore, topics of tasks should be connected with actual spheres of life and be performed in the form of a game.

Primary level is characterized with absence of specialization and specific principles of building a system of tasks gradually getting more complicated. As the main purpose of the level given is to develop general and specific creative abilities, it is convenient to use Guilford's model of intellect structure as the basic system of classification (Guilford & Hoepfner 1971).It represents a system of elementary intellectual abilities in three-dimensional space (contents, operations, products) and is usually depicted in form of a parallelepiped. Axis along which complications of intellectual processes occur can be indicated for this parallelepiped. Divergent abilities are sections of this parallelepiped (Fig. 2).
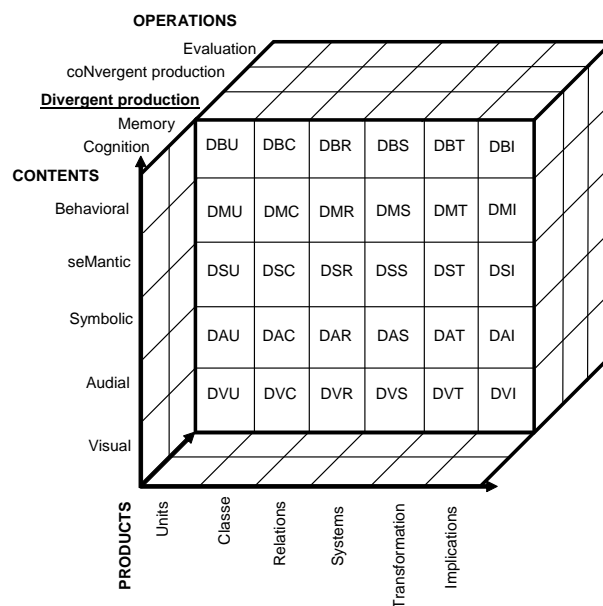

Fig. 2. Guilford's structure of intellectual abilities and divergent intellect abilities (in section).

Each task can be considered in association with several intellectual abilities needed for finding a solution. For instance, solving the task "What does it mean?" divergent abilities of building visual content systems are needed (DVS) in order to create various compositions, whereas divergent implications (DVI) are used to get different variants of the same picture.

The process of solving a task in form of multilevel intellectual activity is considered below (Fig.3a). Upper level shows aiming at a creative purpose (P_x), which activates divergent abilities (D_{xx}) responsible for creative search, which results in tool activity after finding a solution (T_x).
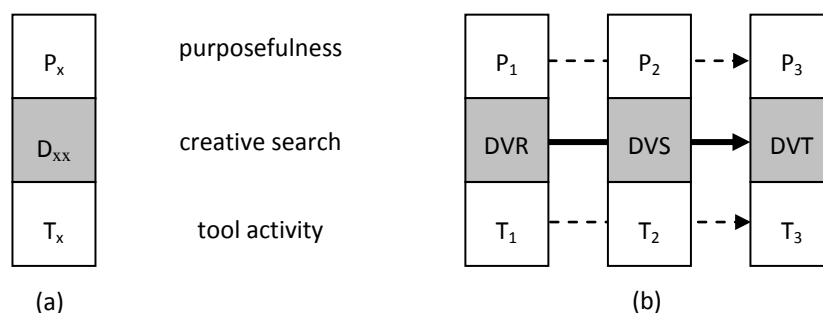
Fig. 3. Activity structure at solving tasks of primary level (a) and an example of building a task succession on the basis of gradually getting complicated products of divergent visual content abilities (b).

Search of principle of task complexity is search of the whole process complexity. As an example, on Fig. 3b there is the principle of building a task succession which results in getting more complicated divergent product (visual relations, systems and transformations). Also, Fig. 3b demonstrates an opportunity to build a task succession on the basis of purpose P_x (P_1, P_2, P_3) and tool T_x (T_1, T_2, T_3) component complexities.

Complexity of tool activity can be increased due to complexity of tool manipulations (for instance, a chain of five operations is more difficult that a chain of two operations). It also can be increased due to complexity of information performed mentally by learners which finally results in converting this information with the help of tools. Graphic editors operate with visual information (V), text editors and spreadsheets operate with symbolical information (S). Work with commands of operating system and programming is done along with the processing carried out by semantic information. (M). On the ground of the succession given above a number of entry-courses can be developed with a special accent on development of such abilities as DV_x, DS_x and DM_x.

Primary level which develops divergent intellectual abilities is an important stage on the way of further vocational development as with the help of orientation activity it contributes to creation of the complete image of informatics.

4. DEVELOPMENT OF PROJECT COMPETENCE AT THE BASIC LEVEL

As a rule, after broadening their minds on entry-courses learners are ready and eager for specialization in one of directions of informatics. Some students enter the second level with definite interests in this field and desire to improve their knowledge comparing to school education. These interests are the basis for choosing the second level courses.

A list of courses given to the learners of the second level is influenced by two factors. At first, this list reflects the main directions of computer technologies and programming. Secondly, it reflects pupils' and their parents' understanding of which directions are important and interesting. Today this list includes 2D and 3D graphics and animation, programming and web development.

Choosing a direction is, first of all, an act of specialization connected with the choice made for studying some subject domain with its objects characterized by concrete structural, functional and technological features. At the primary level a learner acquires diverse experience, whereas at the basic level this process transforms into arrangement and systematization of this experience in accordance with some subject domain. This process has intellectual-age prerequisites.

The approximate age for entering second level courses is 12 years old. This age was not chosen accidentally. According to socio-cultural theory of L.S. Vygotsky (Vygotsky 1962) it is the age when

systematic conception thought starts to develop. Learners are able to identify new concepts which serve as basis for process of thinking when solving tasks.

Conception thinking allows student to solve tasks at higher level of conscious awareness and voluntariness. Also, it helps them concentrate on general principles of task solving, abstract their minds from concrete tool realizations. Development of this type of thinking at the basic level oriented on definite subject domain is most likely connected with development of project skills (project competence).

Detailed structure of a learner's activity at solving problems including project development is given below (Fig. 4). This structure is genetically connected with the structure of solving a creative task (Fig. 3), therefore, there are some similarities as well as some differences.
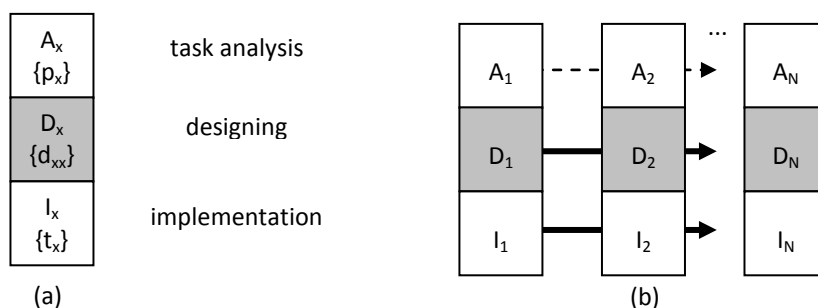

Fig. 4. Structure of activity at solving a problem on basic level courses (a) and a scheme of task complexity succession (b).

The process of solving a creative task on primary courses can aim at getting hardly conscious purpose P_x, whereas the project task of the second level involves its gradual conscious awareness in process of analysis of requirements to the structure and functional characteristics of a supposed result (A_x). In other words, a student learns to predict the result of his/her work as well as to understand why this result is needed.

For instance, working on a cartoon on a given topic "Design and animation" a learner should think over the following questions: the reason of making a cartoon, its main idea, the main audience, how long it will last, how it will be taken etc. A teacher should lead a learner to conscious awareness of the requirements to his/her future design and connections between the requirements mentioned and project stages and its implementation. The restrictions identified may include a number of creative purposes $\{p_x\}$ applying to some original qualities of a future project, for instance.

The project is a formalization of development purpose and formulated with the help of subject domain terminology. Divergent processes $\{d_{xx}\}$, which played the main role in solving creative tasks, are integral parts here providing search of original solutions in the process of designing (D_x), for instance, creative search of an expressive image of a character.

Depending on a course there are various project subjects such as: visual form in 2D and 3D graphics; temporal dynamic structure in animation; structure of program modules' interaction and programming algorithm; informational structure and algorithms of users' interaction in web projecting. Pupils don't work on real project documentation but, nevertheless, they implement their ideas in sketches, schemes, algorithms, storyboard (Fig. 5).
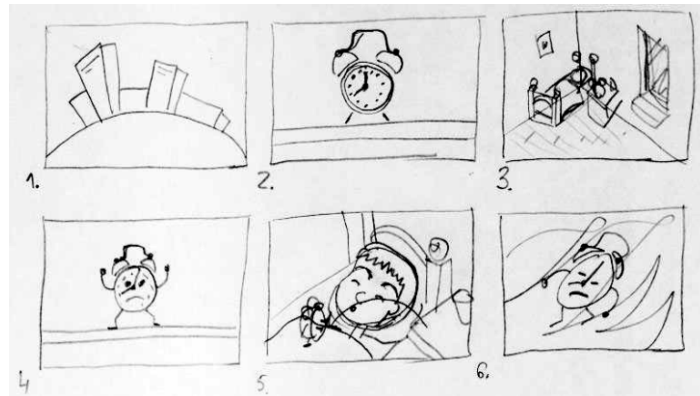
Fig. 5. An example of storyboard cartoon project.

Complexity of problems' chain at this level is oriented on projected object structure (D_1, D_2, .., D_N), which leads to complexity of corresponding technological operations succession (I_1, I_2, .., I_N).

Technological process is described by general terms of subject domain, not by tool means, i.e. it is tool-free. It is possible to point out that at the second level learners study general technology. It is a precondition for comprehension of the importance of choosing an appropriate tool and best possible technological chain $\{t_x\}$ as well as easy switching from one tool to another one.

5. VOCATIONAL AND TECHNOLOGICAL COMPETENCY DEVELOPMENT AT THE ADVANCED LEVEL

Two levels studied above have given a basis advanced training in informatics connected with vocational specialization can be built on. It is most actual for learners who are not satisfied with their school computer studies. Developed divergent abilities and project competencies serve as crucial conditions for forming vocational actions. It is easy to prove.

According to Galperin's theory (Galperin 1992), each action consists of orientation and executive parts. The first one is responsible for preparation and correct fulfillment of actions under concrete conditions. It means that oriented part is needed to accommodate an action to different conditions (such as time limits, level of tool possibilities etc.). The better action accommodation is the wider its orientation basis. Therefore, educational process should be oriented on development of this part. It is obvious that a vocational action is characterized with wide orientation basis.

Orientation part includes four main components:

a) purpose image and following motivation peculiarities;

b) distinguishing essential for a future action components of a situation;

c) action planning;

d) action regulation on each phase of carrying-out.

It is necessary to point out that learning task solution of first two levels puts development of these components ahead in direction of orientation basis development. High motivation and possibilities of various voluntary regulations (a, d) were peculiar to creative tasks whereas distinguishing essential components and planning (b, c) - to project competencies. Besides, generalized idea of technological process provides fast adaptation to new tools used for task solving. Thus, first two levels of non-formal system in informatics encourage students to acquire qualities of vocational actions in process of education.

At the advanced level a learner is not only to learnt how to do something, but to organize the whole process of elaboration, how to make the process fast and productive, what technology to choose, how

to find a compromise in controversial situations etc. For instance, how to make elaboration productive when given technological decisions widely used for web sites and programs development help reduce time for development but make the quality worse.

The complexity of learning tasks at the third level is determined by the level of various requirements to them. It is possible to point out at least three criteria of this kind of complexity: degree of action conscious awareness, overall performance and level of requirements to the result quality. At the end of task complexity succession there should appear leaning tasks similar to professional ones.

As pupils don't work on commercial orders, motivation on the third level is based on participation in contests, opportunity to enter the University or just realization of creative ambitions, making a portfolio.

6. PRACTICAL IMPLEMENTATION AND RESULTS

An example of practical implementation of three-level non-formal educational system in informatics with the help of which lessons in CCCP were organized (Children's Computer Club of St. Petersburg 2014) is given below. It uses modular approach in order to provide freedom in educational direction.

Module is an independent structure and therefore is characterized by its purpose and objectives. It allows us to consider a course as a module. In order to combine it with other modules in week curriculum as well as extra-curriculum activities not connected with non-formal educational system it was decided to conduct classes once a week during 32 studying weeks. Duration of one lesson is 3 academic hours which makes 96 hours of the whole module course.

The main criterion of enrolling students is their interest and self-esteem. When studying a student can change the course. Enrollment peculiarities, dynamic structure of a group result in age and level diversity within the group. The following ways help deal with these difficulties: 1) flexibility of curriculum, 2) individual work of a teacher or an assistant with learners, 3) individual-oriented tutorials.

On Fig. 6 there is an actual structure of CCCP courses (2014). Due to fast development of information science this structure has been changed several times and might be changed in the future due to the same reason. Major changes usually take place at the third level as there are courses closely connected with actual level of informatics' technological development.
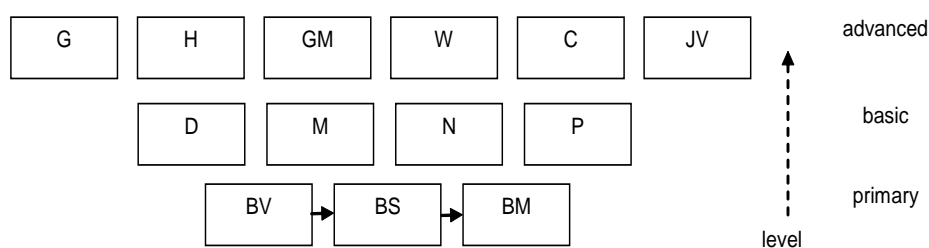

Fig. 6. Structure of three-level modular system.

Today CCCP system includes the following courses. At the primary level: BV – introduction in computer graphics; BS – introduction in MS Office and the Internet; BM – introduction in computer software and hardware. At the basic level: D – design and animation basics; M – 3D model basics; N – web-design basics; P – programming basics. At the advanced level: G – graphic design; H – a human and characters modeling; GM – games and interactive 3D model development; W – web-programming; C – C programming language application development; JV – Java application development.

Structure and programs of courses given above are flexible. Each course includes basic set of topics reflecting main course content and variable part to adapt to the concrete group. First of all, variable part is used to compensate a possible gap between an actual group and basic plan. Besides, depending on course level specific purposes may appear.

It is important to encourage learners to get new knowledge, broaden their minds. Variable part of entry-courses includes the following topic: 1) work with operating system, 2) file system, 3) file archivers, 4) office software suites, 5) 2D and 3D graphic applications, 6) the Internet, 7) command line. Content of these topics may vary due to the concrete situations or be used for revision, drilling or mind-broadening. At the primary level due to developing task complexity the following order of a course is preferable: BV-BS-BM. At other levels no order is significant.

Variable part of basic courses includes introduction to a number of tools and students should learn to use the most appropriate ones. For instance, M course includes 3DS MAX as the main tools and has alternative programs such as Blender or SketchUp.

Variable part of advanced courses can be dedicated to problems of operational design development, its technological effectiveness. For instance, variable part of W course may include learning such technology concepts as Joomla or Drupal.

It is difficult to estimate effectiveness of whole system as each learner has his/her own way and objectives. Though, with the help of some facts and numbers it is possible to demonstrate that proposed system meets needs of learners in additional education on informatics, encourages their creativity and vocational development.

CCCP system provides learners with opportunities to choose appropriate course, succession of courses and their duration. Average annual number of students is 300-400. Distribution of learners' number due to their study level is approximately equal (Fig. 7). It shows that at least some groups of learners may satisfy their educational needs.
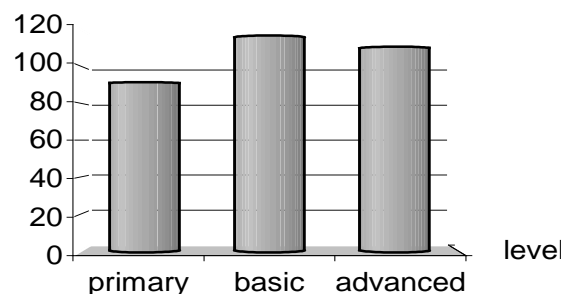

Fig.7. Distribution of learners' number due to their study level (2013/2014).

Despite the fact that learners can take several courses in a row or at the same time, they often chose consistent education (one course a year). Less than 6% of learners take two courses a week. It is significant that approximately 70% of learners take the next course (this number may decrease due to graduation). Fig. 8 demonstrates distribution of learners according to number of courses passes. The distribution given shoes that majority of learners satisfy their educational needs having passed three courses.
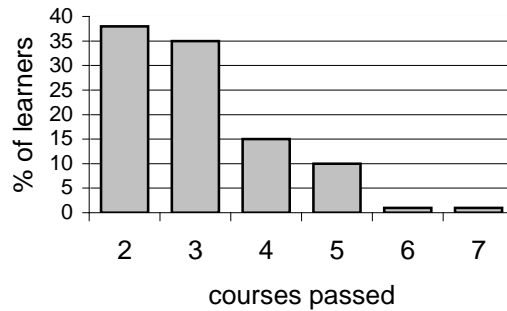
Fig. 8. Distribution of learners according to number of passed courses.

Analysis of courses' sequence chosen by learners is of special interest. It gives information about knowledge structure which learners tried to get and process of their vocational orientation. It is possible to divide all these sequences into four spheres:

1. Graphics (any sequences which include D or M at the second level and H or G at the third one).

2. Programming (any sequences which include P at the second level and C or JV at the third one).

3. Web-development (any sequences which include P and/or N at the second level and W at the third one).

4. 3D game development (any sequences which include P and/or M at the second level and GM at the third one).

5. Undecided learners (including various combinations of 1), 2) and 3)).

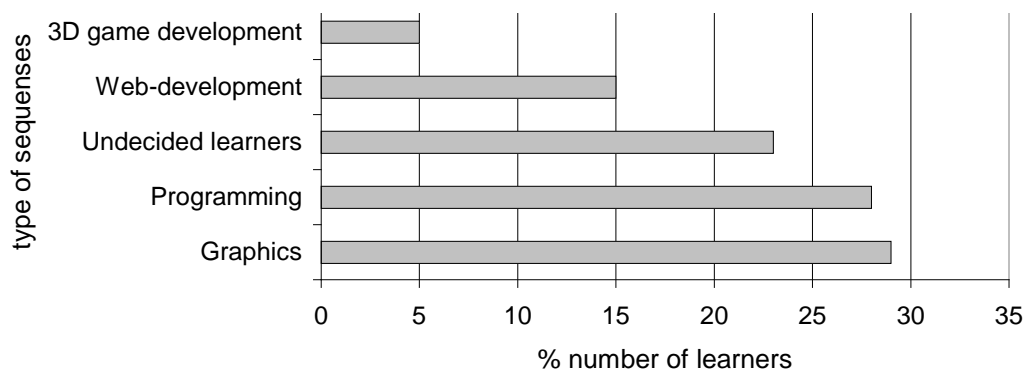As a result, we get the following figure describing specialization of learners (Fig. 9).

Fig. 9. Specialization of learners.

This distribution shows that around 80% of learners specialize in any sphere advancing in education levels. Sphere distribution proves implementation of free choice. Learners who are considered to be undecided (about 20%) often try to cover material widely. As a rule, they start from the first level and pass more than three levels broadening their minds in different spheres.

As it has already been said, creative development starts with development of creative abilities at the primary level. Effectiveness of developing tasks implementation in education process has already been proven (Lokalov 1999, pp 103-105). Vocation-oriented level of advanced courses is stimulated by organizing and holding creative contests on computer graphics and programming as well as orientation on preparing for entering High school.

Holding various exhibitions and contests of children computer art in CCCP started in 1999. At that time the first festival for schoolchildren of St. Petersburg "Computer and Art" was organized and included exhibition of 2D and 3D graphics, contests, computer animations. Since then the contest has been held regularly. Participation in these kinds of exhibitions and contests is an important part of educational process.

One of the club traditions is continuity of generations. 70% of teachers currently working with pupils used to be learners of these courses.

The fact that CCCP non-formal educational system has existed for more than 10 years and been in demand for all this time proves viability of theoretical and practical approaches studied in the work represented. The approach studied above represents one way of reaching a compromise between freedom and systematic character in education. Theoretical principles and practical experience in development of similar systems represented in the article are useful for realization of analogical projects.

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