

The Use of ICT of Educational Purposes in the Independent Work of Students in the Study of the Basics of Programming by Future Software Engineers

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Abstract: The article describes the author's experience of using a number of information and communication technologies of education in the independent work of students in teaching the discipline "Fundamentals of Programming" to future specialists in software engineering. The content of studying the discipline "Fundamentals of Programming" and the number of hours allotted for its study in institutions of higher education in Ukraine is analyzed. When studying the discipline "Fundamentals of Programming" at the Zhytomyr Polytechnic State University, the study of the corresponding course on the platform of massive open online courses Sololearn is submitted for independent work, and use of other ICTs of educational purposes. A description of the possibilities of using this Massive Open Online Course (MOOC) in teaching the discipline "Fundamentals of Programming" for future specialists in software engineering is presented. In addition, using a pedagogical experiment, the effectiveness of using a number of information and communication technologies of education in the independent work of students in teaching the discipline "Fundamentals of Programming" to future software engineering specialists was tested. The results of the pedagogical experiment showed the effectiveness of using a number of information and communication technologies of education in the independent work of students in teaching the "Fundamentals of Programming" to future software engineering specialists.


1 INTRODUCTION


In the process of professional training of students of specialty 121 "Software Engineering", some professional disciplines are required to study, in particular, "Fundamentals of Programming", "Object-Oriented Programming", "Web Technologies", etc. All disciplines are studied in the manner prescribed by the educational professional program and provide for a cer-


tain "basic" level of knowledge for the preliminary study of the subject.


Analysis of the curricula of higher education in Ukraine (National University of Life and Environment Sciences of Ukraine, Zhytomyr Polytechnic State University, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Odesa Polytechnic National University) showed that the study of the discipline "Fundamentals of Programming" is given from 150 to 330 hours. Note that in some universities this discipline is divided into two Programming and Fundamentals of Software Engineering.


A sufficiently large number of hours predetermines the need to submit part of the material for independent study (usually from 30% to 60% of the


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material is submitted for independent study, and universities themselves operate on this). A variety of additional learning tools becomes useful here for both teachers and students (Seidametova et al., 2022; Vakaliuk et al., 2021; Kovalenko and Palamarchuk, 2018; Semerikov et al., 2020).

Massive Open Online Courses (MOOCs) has already gained popularity in the first quarter of the 21st century, so there are a lot of articles concentrated on that topic, even more, there are books, that are devoted to the disclosure of this topic from different angles. For example, we can see a demonstration of the historical perspective on various stages of development of these courses and how their value changed, depending on the stage (Waks, 2016), advises on optimizing the process of their implementation and use according to the type and stage of development of the information infrastructure of the educational institution advice on optimizing the process of their implementation and use respectively the type and stage of development of the information infrastructure of the educational institution (Mesquita and Peres, 2015) or just perspective of its evolution from a higher education point of view (Bennett and Kent, 2017).

Speaking about the latest research results, which undoubtedly appeared more due to the growing popularity of distance learning as a result of the pandemic, it is worth paying attention to Scopus as one of the most reliable sources of verified information. There are currently 48 articles available in this source that focus on this topic part of them are concentrating on the adaptation of the course to the general type and specifics of the country's study conditions or just on solving some specific problems universities are forced to face too, like overcrowded universities on the impossibility of organizing real-time face-to-face lessons (Naji et al., 2020). However, one of the most important and interesting aspects of the Massive Open Online Courses study is its use in teaching students a specific subject, for example, mathematics (Vagaeva et al., 2021), international relations (Kaempf and Finn, 2019), geography (Syvyi et al., 2020), physics (Huangqing and Yanping, 2021) or languages (Lebedeva, 2021). Still, we have to remember about digital barriers (Ling et al., 2020) that students might have while studying that way. Those barriers could make effect data results and lead to a distortion of information about the prospects for the development of the MOOC industry in education since every year students are better versed in digital technologies. The best way out of the situation is to test such courses on subjects that are studied by students of specialties related to information technology. A good example of such subjects could be computer net-

works (Vakaliuk et al., 2020) or software engineering.

A review of various MOOC platforms showed that they mostly contain theoretical material, test tasks; the possibility of communication between other participants, and, in the case of learning programming languages, a compiler is built in to train the acquired skills.

In the professional training of future software engineering specialists in the context of a pandemic and the Russian-Ukrainian war, a combination of traditional, distance, and blended learning opportunities, as well as the use of various additional tools, including massive open online courses, are becoming increasingly important, which allows increasing motivation and student interest.

2 LEARNING THE FUNDAMENTALS OF PROGRAMMING WITH MOOCs

The purpose of studying the discipline “Fundamentals of Programming” is to form students’ theoretical basis necessary for further work, obtaining theoretical knowledge and practical skills in the algorithmization of computational processes, the basic principles of software development in the C programming language.

The objectives of studying the academic discipline “Fundamentals of Programming” are:

- providing students with the necessary knowledge on the theory and practice of using algorithmic programming languages;
- to form an idea among students about the main stages of solving a computer problem;
- the sequence of actions, skills, and abilities to work with modern software, program debugging;
- providing students with basic knowledge and skills with basic algorithmic structures;
- mastering by students of basic knowledge and skills in working with arrays;
- mastering by students of different methods of sorting arrays;
- providing students with basic knowledge and skills for working with functions, as well as the ability to implement recursive functions;
- mastering students the ability to work with structures, string values, pointers;
- mastering by students the basic skills of working with repositories.

Let us give an indicative topic for studying this discipline (as an example, the program is given, according to which they study at the Zhytomyr Polytechnic State University).

Content module 1. Introduction to programming. Basic construction methods.

Topic 1. Introduction to programming. Basic concepts. The concept of a method. Ways of representing algorithms. The alphabet of the C programming language. Directives. Connecting libraries. Data types. Constants and variables. Declaring variables. Operations of the C programming language. Data input-output operators. Formatting specifiers. Arithmetic operations. Features of working with them. Increment, decrement. Math functions. Block diagram. Basic elements of flowcharts. Basic algorithmic constructions.

Topic 2. Branching. Comparison operations. Logical operations. Boolean expressions. Simple and compound logical expressions. The if branching statement. Ternary operation. Switch statement.

Topic 3. Introduction to the Git version control system. The concept of a repository. Existing version control systems. Introduction to the Git version control system.

Topic 4. Loops. The concept of a loop. Loops with while condition. Loops with “for” parameter. Break and continue. Loops with postcondition “do ... while”. The comma operation. Nested loops.

Content module 2. Arrays.

Topic 5. Setting up the program. Testing. Basic concepts. Setting. Error types. Test types.

Topic 6. Arrays. Array concept. One-dimensional arrays. Declaring and calling in one-dimensional arrays. Generation of pseudo-random numbers. Operations with one-dimensional arrays.

Topic 7. Sorting arrays. Sort by the exchange. Sorting by the selection method. Insertion sort. Shell sorting. Pyramid sort.

Topic 8. Multidimensional arrays. Declaring and accessing multidimensional arrays. Two-dimensional arrays. Operations with matrices.

Content module 3. Functions, pointers, structures.

Topic 9. Functions. The concept of a function. Function prototype. Passing parameters. Functions with a changing number of parameters. Passing an array to a function. Recursive functions.

Topic 10. Pointers. Local and global variables. Variable address. The concept of a pointer. Declaring a variable of pointer type. Basic operations on pointers. Features of the scanf function. Pointers and arrays.

Topic 11. Character variables. Working with

string and character variables. String functions.

Topic 12. Structure. The concept of structure. Arrays of structures. Programming with structures.

When studying the discipline “Fundamentals of Programming” at the Zhytomyr Polytechnic State University, students are recommended to study the materials of massive open online courses as part of their independent work. Students can take the course offered on the MOOC platform Sololearn (Sololearn, 2023). This course provides an opportunity to study individual theoretical blocks, and perform individual test tasks and certain final works.

Let us consider the possibility of using MOOC Sololearn when studying the course “Fundamentals of Programming” as part of additional independent work. The first thing to point out is that this course is in English, and since this platform does not provide for any actions of teachers or instructors, it is not possible to localize in another language.

This course involves studying the material and improving skills in the basics of programming in the following sections: basic concepts of the C programming language; conditional expressions and loops; functions, arrays, pointers; strings and function pointers; structures; memory management; file and error handling; preprocessor.

These topics fully cover the topics for study in the main course “Fundamentals of Programming” and are their logical addition. Another feature of this MOOC platform is that the courses are freely available and anyone can take them. Yes, not all features of the platform are freely available, but if you wish, you can purchase the full version for an in-depth study of the material. Another feature of this platform is that each course is provided with a separate address where you can enter the course without wasting time searching for the course.

When you log into your account at the address of a specific course (Sololearn, 2023), the user opens his profile of passing (studying) the course (figure 1).

Each section (study topic) in this MOOC includes theoretical information (figure 2), containing material for repeating what was learned in the classroom.

This MOOC can leave comments on all activities of each topic. Such a section is located in the upper right corner, by entering which a registered user at the stage of viewing theoretical material can communicate with other registered users through comments (figure 3).

However, it should be noted that not in all sections of the MOOC data, such an opportunity is open immediately. In addition to theoretical material, users are allowed to view examples of program execution and try to work with them on their own, making cer-

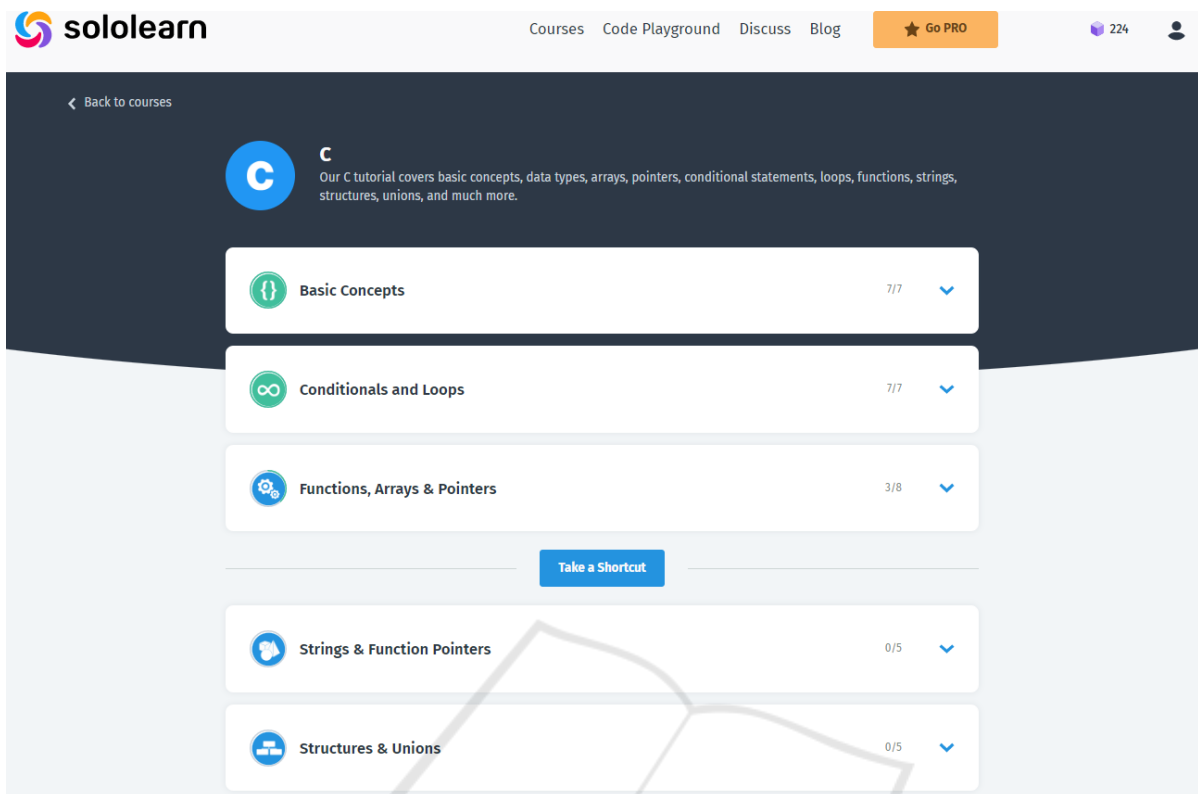


Figure 1: Personal account for studying the course.

tain changes (figure 4 and figure 5).

This platform MOOC also provides a task for testing knowledge of various forms, for example, choosing 1 answer from several proposed ones (figure 6) and entering your answer (figure 7). At the same time, it should be noted that the section of communication through comments in such tasks becomes available only after checking the answer. For each topic, up to 10 tasks of this type are given to consolidating knowledge.

After passing the module, the user is presented with a final test (figure 8), which consists similarly of several questions (from 5 to 10), and according to the result, it is set whether the module was enrolled to him.

It should also be noted here that the next module will not be opened to the user until he completely completes the previous one (figure 1).

If we consider each topic offered in this MOOC, then in section 1 “Basic concepts” there is a repetition of the base of the C programming language, namely: data types, arithmetic operators, comments in the code, working with the console (input and output). In section 2 “Conditional statements and loops”, conditional statements were considered, such as: if, else, switch, three types of loops: for, while,

do... while. The section also included theory on logical operators, which are &&, which means “and”, and ||, which means “or”.

Section 3 “Functions, Arrays, and Pointers” provides material that is completely repetitive to the classroom material. As a result, in this section, there is only a repetition of the studied material, as well as the consolidation of the necessary skills for working with arrays, functions, and pointers.

Section 4 “Strings and Function Pointers” has a new topic that doesn’t overlap with the classroom material. This is the “Pointers to Functions” topic, which explains in detail how to declare and access functions using pointers. The next section is “Structures and Unions”. It should be noted here that again students were offered a new topic for study – this is the topic “Union”, in which students can learn about unions, which allow storing different types of data in the same place in memory, accessed through the dot operator located between the name of a variable and the name of a particular union member.

In Section 6 “Memory Management”, the following functions were considered for memory allocation on dynamic array memory (malloc, calloc), array expansion (realloc), and freeing (free). This material is not new to the student, since this topic completely

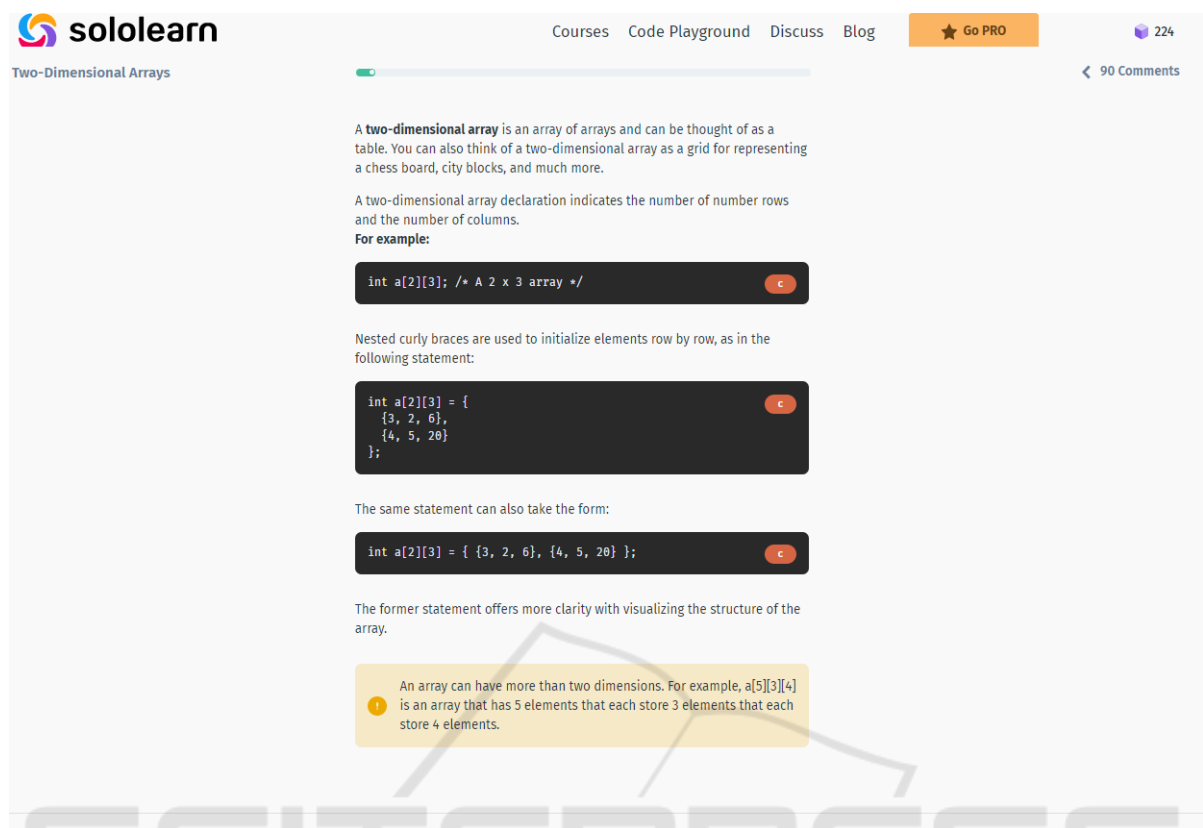


Figure 2: Theoretical material in the MOOC Sololearn.

overlaps with the topic for studying in the classroom, so students in this section only consolidated their knowledge and skills.

Section 7 “File and error handling” is the largest section in terms of the amount of new material that is submitted for independent processing. By studying the topics in this section, students can learn how files are handled in the C language, which is used for this function, what binary files are, and how to handle errors.

Section 8 “Preprocessor” contained some of the material that students studied in the classroom and some of the new. The topics covered in this section are preprocessor directives, conditional compilation directives, and preprocessor statements.

Note that the advantage of such MOOC is that all the material is structured, and for each topic, there is theoretical material, attempts to work with the program code, and knowledge testing.

The use of this MOOC for self-processing by students within the framework of the course “Fundamentals of Programming” contributes to the consolidation of the mastered theoretical material, since the course contains a repetition of the theory presented to students in lectures on this discipline, as well as the de-

velopment and improvement of skills in programming in the C language.

During the course, students can view the progress bar (figure 9), and after successful completion of the course, students receive a certificate (figure 10).

Note that the MOOC Sololearn is adaptive for various systems and, accordingly, devices, so the user has the opportunity to use it from any device.


The use of MOOCs in the educational process of higher education contributes to the assimilation of the material through one’s own practical experience, mostly independent. After all, students can get acquainted with additional theoretical information, view various examples with solutions in the C language, and at the same time they can also try to change a fragment of the program code using the knowledge gained; perform a separate task by writing code fragments in the answer, and, of course, take a test to test your knowledge.


The use of such a MOOC provides 100% coverage of the topics provided by the training program for studying the discipline “Fundamentals of Programming”. Note that MOOC is not the main one in the study of the course “Fundamentals of Programming”. It is only an auxiliary tool for consolidating knowl-


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 **SARAVANAKUMAR S K**
 for example `a[5][3][4]`. all the elements are zero. i.e { { { 0,0,0,0 } {0,0,0,0} {0,0,0,0} } {0,0,0,0} {0,0,0,0} } {0,0,0,0} {0,0,0,0} } {0,0,0,0} {0,0,0,0} } {0,0,0,0} {0,0,0,0} } {0,0,0,0} {0,0,0,0} } {0,0,0,0} {0,0,0,0} }

 **Vagner dos Santos**
 Suppose your code has an array like this `int a[10][30][100]`; An analogy to understand it is: There are 10 libraries Each library has 30 shelves Each shelf has 100 books. So if you print the content of `a[2][8][42]` as the indexing starts at zero, you will get the content of the book number 43, of the ninth shelf, in the third library. Hope that helps =)

 **ABARNA P**
 Matrix addition using 2d array...

```
#include<stdio.h>
#include<conio.h> int main() { int m, n, i, j, first[10][10], second[10][10], sum[10][10]; clrscr(); printf("Enter the number of rows and columns of matrix\n"); scanf("%d%d", &m, &n); printf("Enter the elements of first matrix\n"); for (i= 0; i < m; i++) { for (j = 0; j < n; j++) scanf("%d", &first[i][j]); } printf("Enter the elements of second matrix\n"); for (i = 0; i < m; i++) for (j = 0; j <
```

edge and skills during lectures and practical exercises.

In particular, to study the basics of programming, students are also offered the following MOOC for independent study:

1. C programming (<https://moocfi.github.io/courses/2016/aalto-c/en/>)
2. Learn the Basics of C Programming Language (<https://www.edunix.com/courses/Software-Development/Learn-the-Basics-of-C-Programming-Language>)
3. Programming Fundamentals (<https://www.coursera.org/learn/programming-fundamentals?specialization=c-programming>)
4. Writing, Running, and Fixing Code in C (<https://www.coursera.org/learn/writing-running-fixing-code?specialization=c-programming>)
5. Pointers, Arrays, and Recursion (<https://www.coursera.org/learn/pointers-arrays-recursion?specialization=c-programming>)
6. Interacting with the System and Managing Memory (<https://www.coursera.org/learn/interacting-system-managing-memory?specialization=c-programming>)
7. Learn C (<https://www.learn-c.org/>)

The listed MOOC are offered for additional study of the basics of programming, their content covers the topics of studying the course “Fundamentals of Programming”. However, to fully study the course, for example, on the MOOC Coursera, you need to complete 4 courses.

Note that within the framework of studying the discipline “Fundamentals of Programming”, students have the right to choose any similar course that fully covers the study of the topics of this discipline, of course, by the decision of the teachers.

It should be noted that in order to motivate students to use additional means, including MOOC, the Zhytomyr Polytechnic State University decided to count certificates of certain courses as separate components of the study of the subject (as part of the study of individual topics). To enroll as a separate topic or within the subject is decided by teachers who teach the basics of programming to collective solutions. In addition, at the discretion of the teachers, the completion of such courses is counted as a separate part of the number of points for the overall rating. This helps to motivate students to successfully complete the full course.

It should be noted that most of the proposed MOOCs are in English, which, along with mastering certain programming knowledge, helps to im-

Figure 3: The ability to communicate through comments in the MOOC Sololearn.

Accessing Two-Dimensional Arrays

To access an element of a two-dimensional array, both the row index and column index are required.

For example, the following statements display the value of an element and then assign a new value:

```
int a[2][3] = {
    {3, 2, 6},
    {4, 5, 20}
};
printf("Element 3 in row 2 is %d\n", a[1][2]); /* 20 */
a[1][2] = 25;
printf("Element 3 in row 2 is %d\n", a[1][2]); /* 25 */
*/
```

Try it Yourself

Just as a **for** loop is used to iterate through a one-dimensional array, nested **for** loops are used to traverse a two-dimensional array:

```
int a[2][3] = {
    {3, 2, 6},
    {4, 5, 20}
};
int k, j;
/* display array contents */
for (k = 0; k < 2; k++) {
    for (j = 0; j < 3; j++) {
        printf(" %d", a[k][j]);
    }
    printf("\n");
}
```

Try it Yourself

Back

Continue

Figure 4: Ability to work with program code in Sololearn.

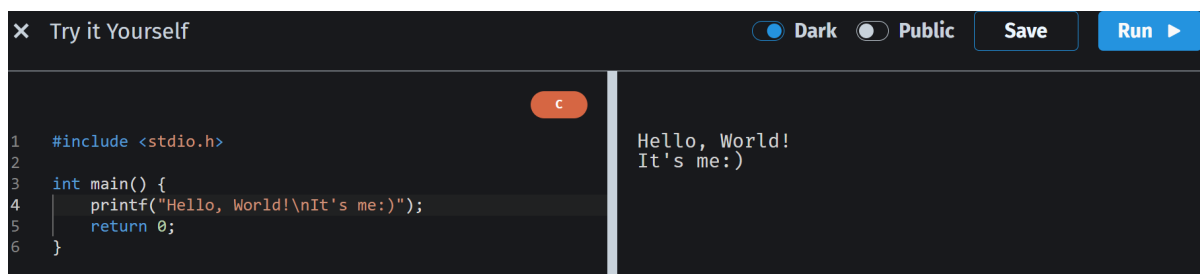


Figure 5: Working with program code in Sololearn.

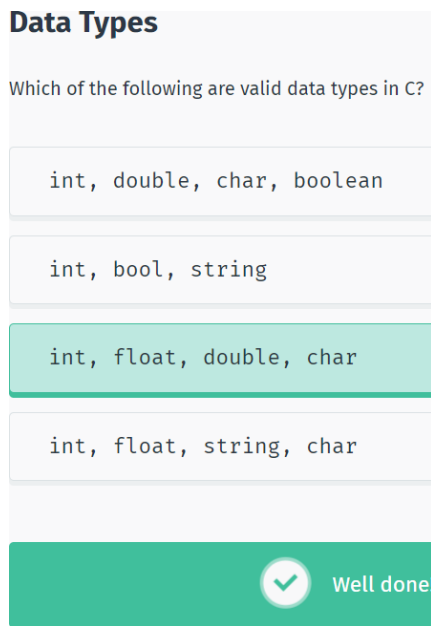


Figure 6: Choice of 1 correct answer.

prove the level of foreign language proficiency, which is a mandatory requirement for future programmers, testers and project managers when applying for a job.

We also note that once a year, before the start of a new academic year, it is necessary to check the available new MOOC for a qualitative update of the proposed list.

Students are encouraged to master these materials on their own as an additional source of study of a particular subject.

These courses were chosen in accordance with the subject “Fundamentals of Programming”, as well as in accordance with the competencies that students have at the end of the course. The experience of teachers working with international software companies will also play a role in choosing a course.

The work of students with MOOC provides:

- study of theoretical material on a particular subject;
- implementation of scientific projects using acquired knowledge and skills;
- implementation of joint projects with their further presentation and defense in front of a group of students.

In addition, other teaching aids should be used for independent work of students. In particular, to get acquainted with theoretical information, we offer for use a number of electronic textbooks on the basics of programming in the C language:

1. <https://metanit.com/cpp/c/1.1.php>

2. <https://www.codesdope.com/c-lets-start/> (figure 11)

3. <https://www.codingeek.com/c-programming-tutorials/> (figure 12)

4. <https://www.codingeek.com/tutorials/c-programming/beginning-with-c-programming-language/>

5. <https://www.geeksforgeeks.org/c-programming-language/>

It should be noted here that all but the first two resources are in English. These electronic manuals are clearly structured, freely available, and offered to a wide range of users. The second service is quite popular because it contains not only theoretical information but also specific examples for each topic.

Such online resources allow not only to get acquainted with theoretical material, but also to communicate with each other through comments on relevant topics. Often, the authors of such resources support feedback and provide users with comprehensive answers.

Teachers offer students for preliminary acquaintance with theoretical material and subsequent discussion of problematic issues of individual topics in the classroom. In addition, at the discretion of the teacher, the material can be taken out for independent study by students, and then the presentation of the material at lectures by the students themselves in front of their fellow students for additional points.

In addition, students are encouraged to use freely available videos, in particular, the free online programming course in C for beginners (<https://www.youtube.com/playlist?list=PL76809ED684A081F3>). This course is logically divided into lessons, where the author offers his own vision of learning the C programming language. So, for independent work, and familiarization with the material, this is a fairly useful resource that clearly shows all the possibilities of the C programming language.

The listed means contribute to the consolidation of theoretical knowledge on the basics of programming, as well as self-learning and self-development.

In addition, to consolidate practical programming skills, the authors offer a number of available tests to test knowledge and programming skills:

1. C Programming Online Test https://www.tutorialspoint.com/cprogramming/cprogramming_online_test.htm

2. C Programming Test <https://www.indiabix.com/online-test/c-programming-test/>

3. C Online Test <https://www.testdome.com/tests/c-online-test/62>

The free Function

Fill in the blanks to allocate memory and then free the memory allocated by malloc().

```
int * ptr = malloc(10);
free(ptr);
```

Recursive Functions

Fill in the blanks to define a recursive function for calculating the factorial of n:

```
int fact(int n) {
    if (n == 1) return 1;
    return n * fact(n - 1);
}
```

✓ Well done!

✓ Well done!

Figure 7: Entering your answer.

Which choice indicates a single-line comment?

##single line comment

**single line comment

//single line comment

Fill in the blanks to print the numbers 0 through 5 using the do-while loop:

```
int c = 0;
do {
    printf("%d", c);
    c ++;
} while (c <= 5);
```

✓ Well done!

✓ Well done!

Figure 8: Module test.



Certification

We are happy to present your certificate to you for completing this course.

Claim Certificate

Figure 9: Course completion scale.

4. C Quiz | C Online Test <https://www.javatpoint.com/c-quiz> (figure 13)
 5. C Online Test <http://www.pskills.org/c.jsp> (figure 14)
 6. Online C Programming Test – Free MCQ’s to test your C Skills <https://data-flair.training/blogs/online-c-programming-test/>
 7. C Online Quiz Test <https://codescracker.com/exam/showtest.php?subid=2> (figure 15)
 8. C Programming Online Test <https://www.jobstron.com/c-programming-online-test>
- It should be noted here that some of the tests are



Figure 10: Certificate.

generalized for the entire course C (1, 3 – hereinafter, respectively, the number of the means for testing), and the other part is a set of tests on topics (2, 4, 5, 6, 7, 8). Note that these tests are divided into topics in different ways. Some services offer detailed breakdowns into topics (2, 4, 5, 6), while others are superficial and cover only selected topics.

Here it should be noted that, again, the decision of teachers, to pass tests covering most topics, may be accompanied by additional motivation in the form of additional points instead of lost ones (for late delivery, for example, laboratory work).

In addition to all of the above for independent work, students are offered a parallel study of various programming languages. To do this, students are offered the same resources, only with an emphasis on a different programming language. Also, dual education started this year at the Zhytomyr Polytechnic State University. Its essence lies in the fact that in the course of studying the basics of programming in the 1st semester, students can study object-oriented programming in courses from ISM Ukraine. As a result of taking these courses, students were asked to have an interview on theoretical material with the course teacher and subject teachers at the university, and as a result, receive an appropriate grade in the next subject. This contributes to the development of the self-organization of students, the organization of their employment, and usually the use of various additional means for self-study.

It should be noted that the list of proposed ICTs for teaching the basics of programming was formed by the authors as a result of their many years of experience (Vakaliuk et al., 2020, 2021) and other their works, as well as preliminary scientific research on the selection of appropriate learning tools. Therefore, the each teacher can choose the range of information and communication technologies for teaching independently. In particular, as you know, now there

Table 1: Comparative distribution of students from the CG and the EG by the level of educational achievements in the fundamentals of programming at the beginning and end of the pedagogical experiment.

Level of academic achievement	Before		After	
	CG	EG	CG	EG
Beginner (1-59)	10	10	9	5
Average (60-73)	25	27	21	10
Sufficient (74-89)	21	19	24	33
High (90-100)	9	8	11	16
Total	65	64	65	64

are many games and simulators for learning programming languages. The only drawback in our case is that there are no such tools specifically for learning the C language. However, if the basics of programming in some higher education institutions are studied on the example of another programming language, the use of such games contributes to even greater interest and motivation of students.

In addition, another tool for effective independent work of students we see Gitlab, which on the basis of the Zhytomyr Polytechnic State University is used not only in classroom work, but also in extracurricular activities. Thus, in cooperation with ISM Ukraine, on the basis of this institution of higher education began to implement the so-called program “Code Review”, in which employees of IT companies provide their recommendations to students to successfully improve their own laboratory work. All this is done within the framework of using the Gitlab service for successful communication of all members of the educational process.

To test the effectiveness of the implementation of a number of information and communication technologies of education in the independent work of students in the study of the discipline “Fundamentals of Programming”, a pedagogical experiment was conducted based on the Zhytomyr Polytechnic State University, which consisted in comparing the learning outcomes according to the traditional method of teaching the basics of programming and the author’s using a number of information and communication technologies of education in the independent work of students.

For this, the applicants for the education of 1 year of study were divided into the EG and the CG (experimental and control groups, respectively). In the CG, training was carried out according to the traditional method, and in the EG – using a number of information and communication technologies of education in the independent work of students.

Statistical data of the EG and CG before and after the experiment are presented in table 1 and figure 16.

To test the statistical equivalence (to the exper-

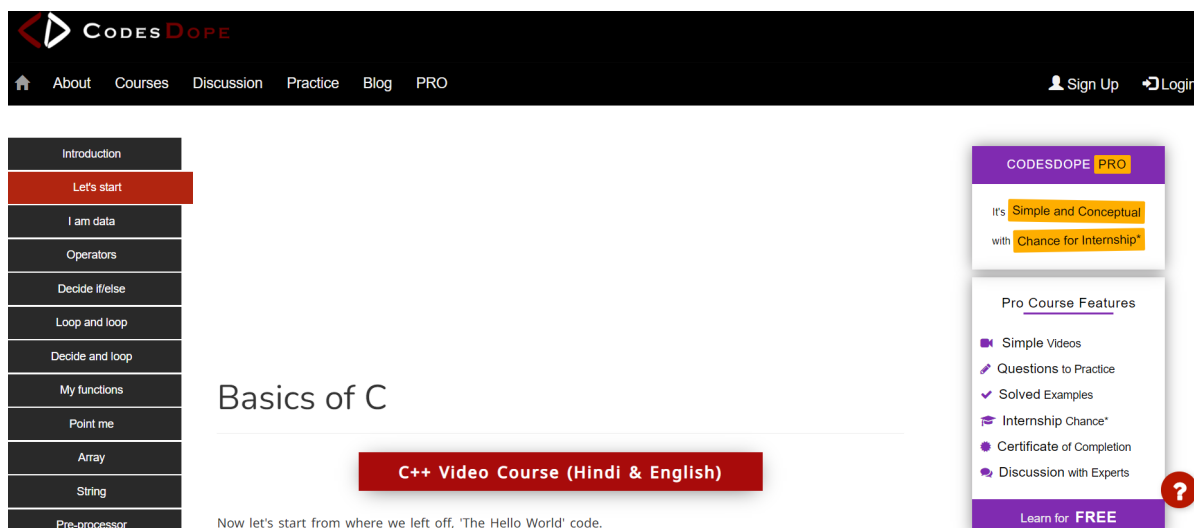


Figure 11: <https://www.codesdope.com/c-lets-start/>

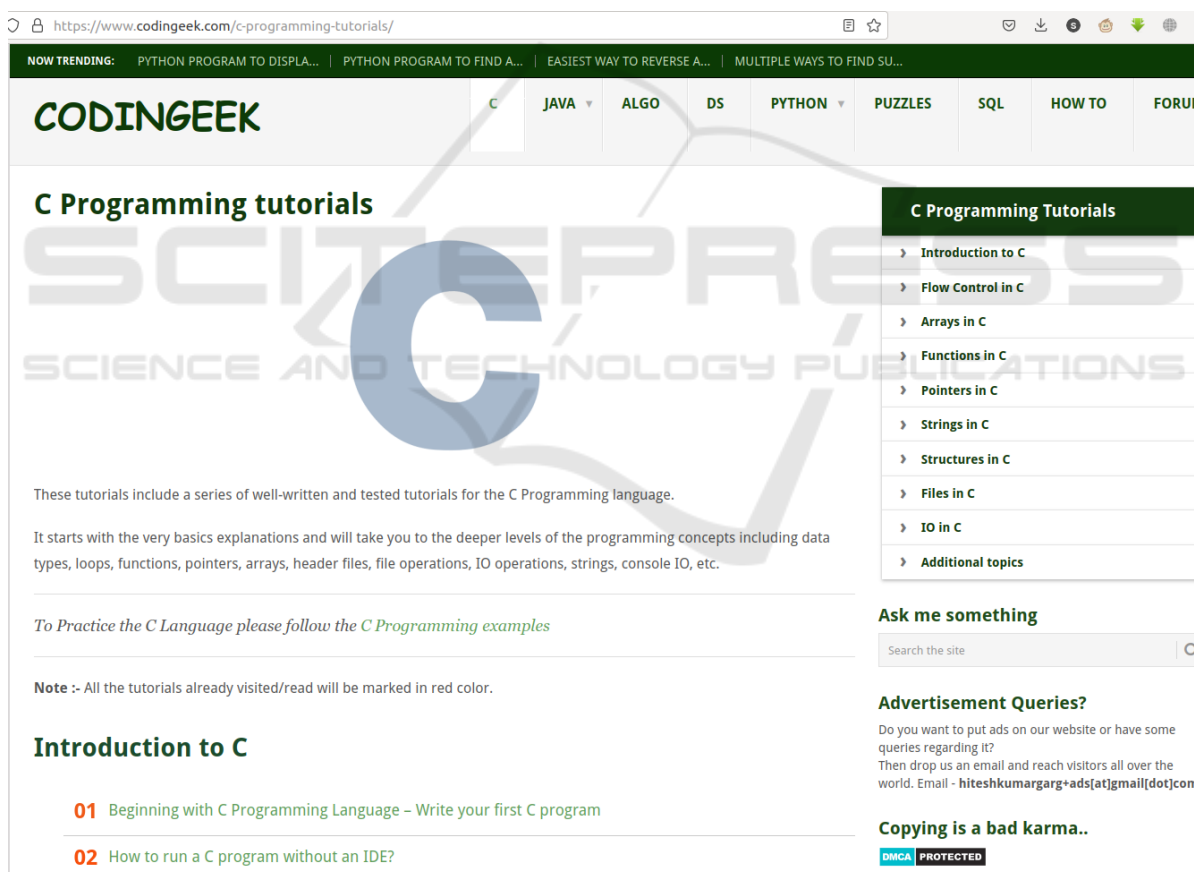


Figure 12: <https://www.codinggeek.com/c-programming-tutorials/>

iment) and statistical non-equivalence (after the experiment), the Pearson test was applied, the result of which was found:

- at the beginning of the pedagogical experiment, it

was found that $\chi_{emp}^2 = 0.36, \chi_{emp}^2 < \chi_{0.05}^2$, therefore, the samples do not have statistically significant differences, and this means that the composition of students in the EG and CG is approxi-

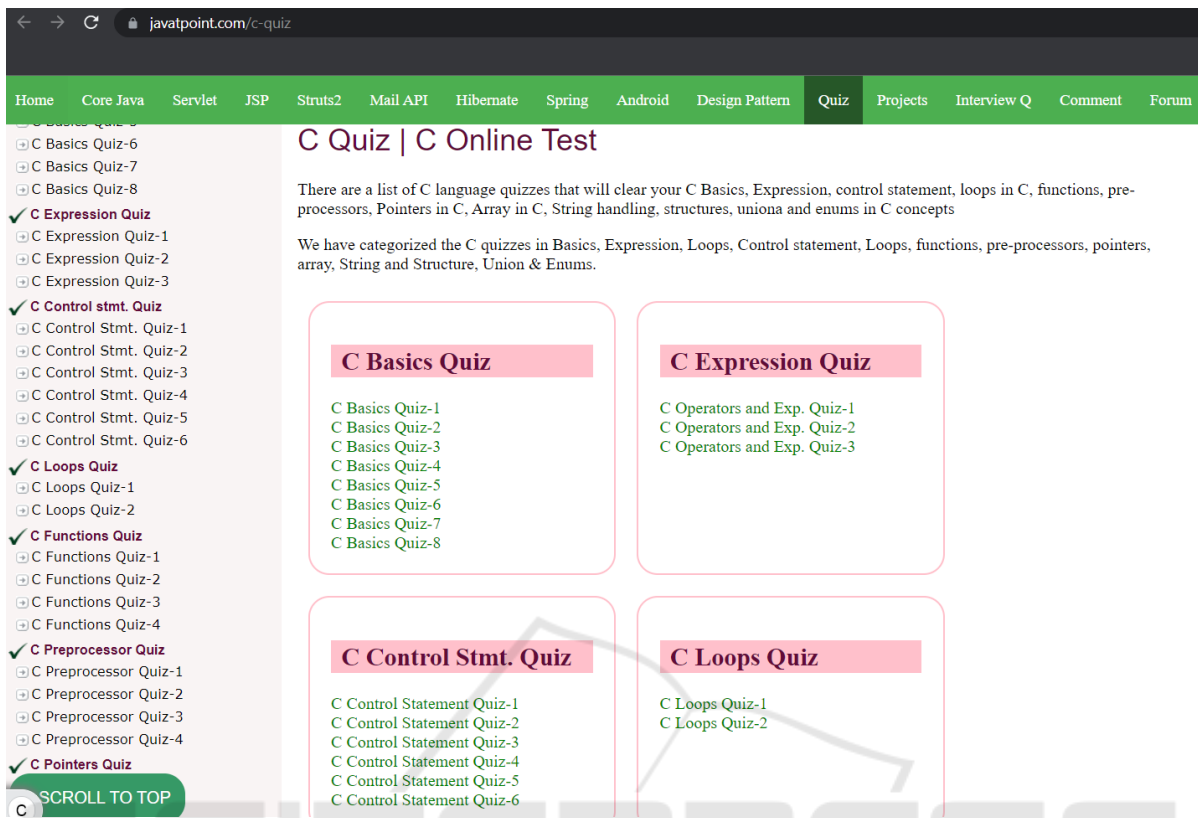


Figure 13: C Quiz | C Online Test.

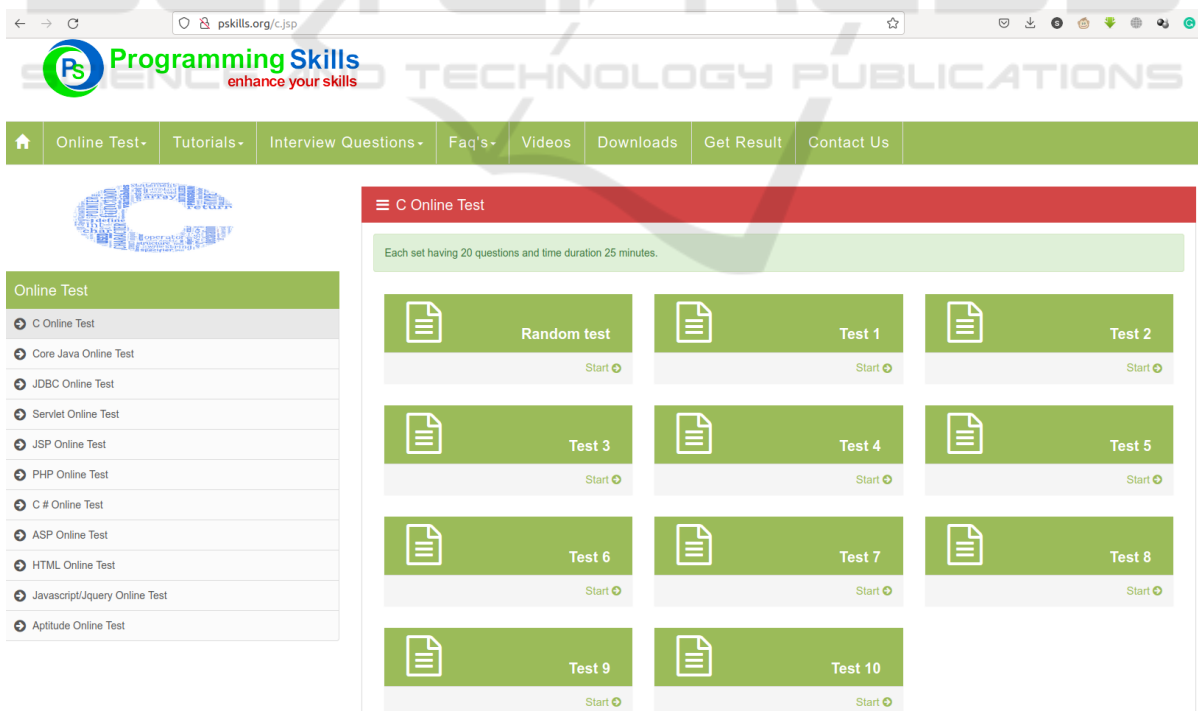


Figure 14: C Online Quiz Test.

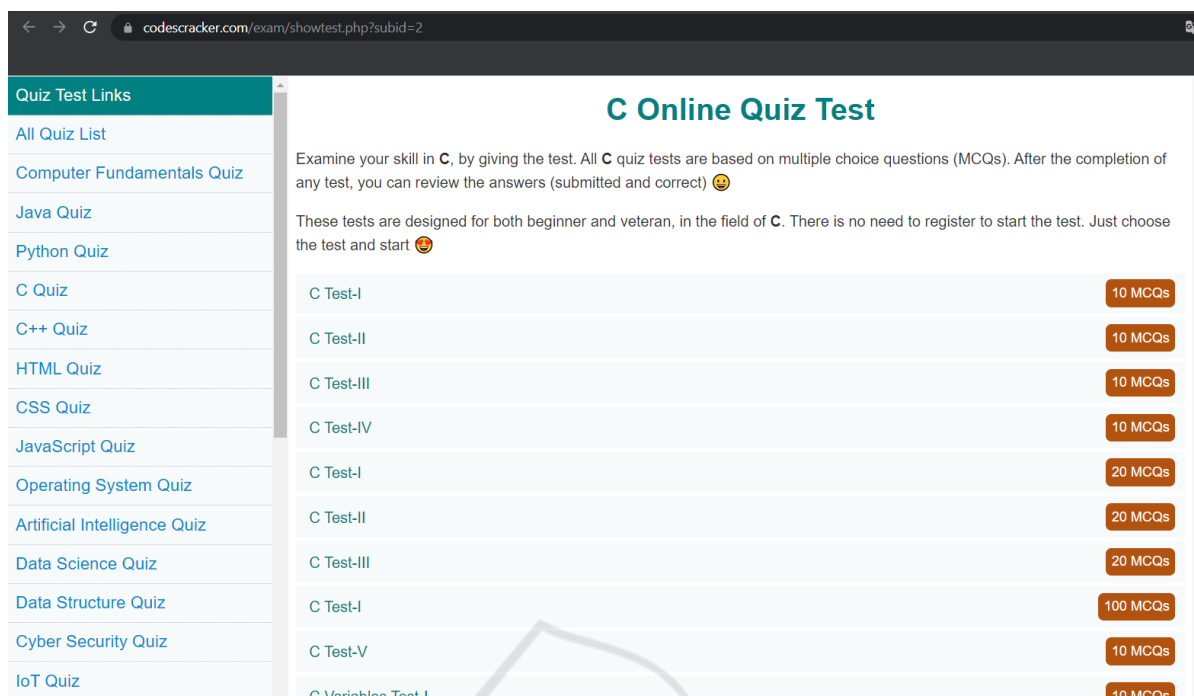


Figure 15: C Online Quiz Test.

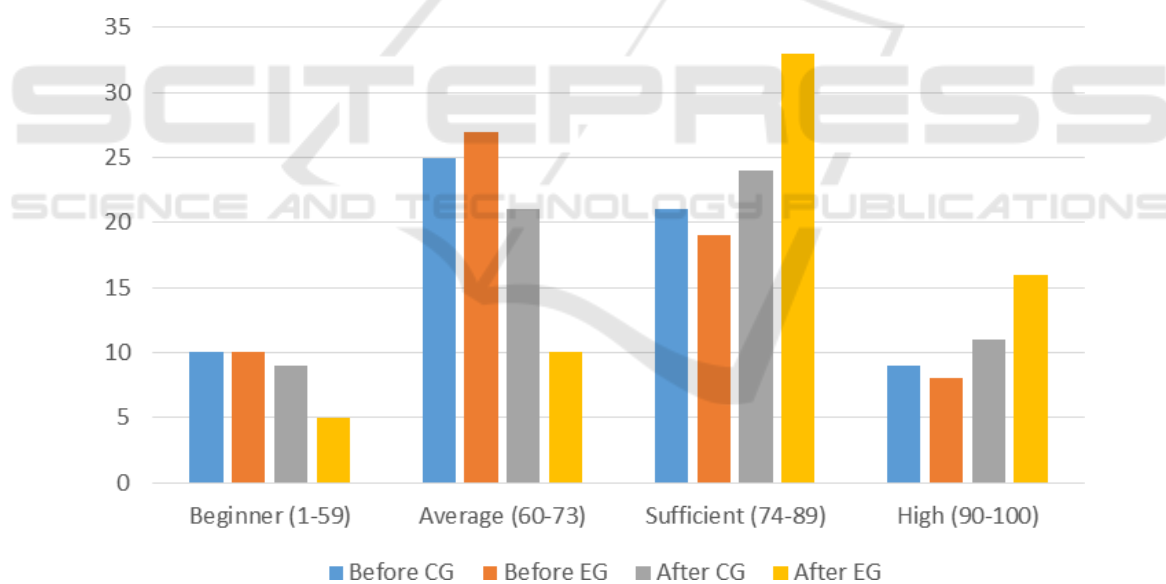


Figure 16: Comparative distribution of students in CG and EG according to the level of academic achievements in the fundamentals of programming at the beginning and end of the pedagogical experiment.

mately equivalent;

- at the end of the pedagogical experiment, it was found that $\chi_{emp}^2 = 8.48, \chi_{emp}^2 > \chi_{0.01}^2$ and this indicates that the samples have statistically significant differences at this stage.

Since the statistical data testify to the positive dynamics of a sufficient and high level of educational achievements in the experimental group at the end

of the pedagogical experiment, which is confirmed experimentally, we can conclude that the experimental methodological system of teaching “Fundamentals of Programming” using a number of information and communication technologies of education in the independent work of students is more effective than the traditional one.

3 CONCLUSIONS

When teaching the basics of programming to future software engineers, changes should be made to the curriculum of the discipline with the addition of a number of information and communication technologies of education for independent work. As the conducted pedagogical experiment showed, the use of a number of information and communication technologies of education in the independent work of students in teaching the basics of programming to future bachelors in software engineering helps to increase the level of student's educational achievements. In addition, as the students themselves point out, the use of various tools in the educational process contributes to their self-development, motivation, and interest, and helps to consolidate the acquired knowledge and skills. As for the prospects for further research, the authors see them in the search and development of new qualitatively new learning tools for the basics of programming.

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