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# Multivariate Analysis when Choosing the First Programming Language Studied in Universities

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**Abstract**—Since the key point of training IT specialists is based on the labor market demands and the compliance of the employer's requirements with the knowledge and skills of future programmers acquired during the training, the authors conducted a study of the Ukrainian IT labor market. To demonstrate the distinctive features of the domestic and foreign IT markets, a comparative rating of programming languages in the labor market in Ukraine and in other countries was made. A survey of IT students and experienced programmers was conducted as another factor of the study. Based on many years of the authors' teaching experience and the result of analyzing the opinions of interviewed programmers, the requirements for the first programming language studied in universities by IT-students were determined. According to these requirements, a system of numerical evaluation of practical criteria for the first language programming selection among the most demanded ones was worked out. A total rating for each language was created in order to identify the most suitable programming language for teaching the beginners.

**Keywords** — *programming language, introductory course, IT labor market, teaching programming, basics of programming.*

## I. INTRODUCTION

The development of technics and technology stimulates the growth of demand for some programming languages and at the same time reduces the use of others. Universities that train students in IT specialties are forced to adjust the curriculum for changes in the labor market. Constant changes in the ranking of programming languages challenge higher education institutions that train IT professionals forcing them to adjust flexible training programs to the requirements of the labor market. One of the most controversial is the question of which programming language should be used in teaching students the basics of programming. The correct choice of the first programming language affects the student's motivation to study, the effectiveness of mastering the skills of the basics of programming and the success of further education (in particular, the mastering of the courses "Algorithms and Data Structures" and "Object Oriented Programming").

## II. STATEMENT OF THE MAIN MATERIAL

### A. Analysis of publications

Many researchers pay attention to the problems that determine the choice of the first programming language in universities. In the article [1], an extensive list of criteria for the selection of a programming language for introductory courses was developed, but these criteria are rather theoretical. The authors themselves [1] note that further research should include clarification of the choice criteria, formalization of the selection process and application of this process in different conditions. In the work [2], when studying the choice of a language for an introduction to Programming course, it is proposed to consider such criteria while choosing popular programming languages: ease of use, availability of training materials, simple and clear programming environment, and cost of the compiler. Nevertheless, the author of this research does not make any recommendations on the choice of a specific programming language for teaching an introductory programming course for IT students. The publication [3] explores trends in an introductory programming course in Australian universities. In particular, the authors analyze the criteria of choosing programming languages for teaching. The pedagogical advantages of the language is the most significant argument. The criterion of demand in the labor market ranks second with a small margin [3]. Training in initial programming in universities in the UK is analyzed in the article [4]. The most common languages, according to their data, are Java, Python, and the C family of languages. Moreover, in the ranking of reasons for choosing Python, the leaders are pedagogical advantages, accessibility (price), platform independence, online help and compliance with the needs of employers. Java is mainly chosen for teaching object-oriented programming, due to compliance with the needs of the labor market, accessibility, availability of training materials, and popularity among students [4]. Publication [5] claims incorrect programming training in simpler languages and suggests teaching students how to interact with a computer and how to cope with all the surprises a machine can teach you, despite the presence of languages that can protect a programmer from many of these surprises [5]. Tony Jenkins, an expert in teaching the basics of programming, believes that it is necessary to teach students skills and languages that are in demand in the industry [6]. A detailed analysis of the

programming languages used in universities and industries in the USA is carried out in [7].

Some authors suggest specific programming languages for initial study and propose the arguments of their choice. For example, according to the teachers of Riga Technical University [8], Java should be the first language. They refer to their approach to introductory programming training and its basic elements. Recently, there have been many supporters of starting programming from the Python scripting programming language [6, 9-11]. John M. Zelle in 1999 argued for the choice of the Python language with such criteria: simplicity of syntax and semantics; high level and flexibility of the language, which allows students to quickly and easily experiment with alternative design options; support for modern design approaches, including abstraction, encapsulation, and object-oriented methods; availability on various platforms [9]. Philip Guo calls Python the most popular language course on programming in American universities [10]. M. Lvov and V. Kruglyk when comparing Python with the Pascal language prefer Python as the first programming language [11, 12]. P. Merzlikin describes the successful use of the Python language for students [13]. L. Kubliy reasonably insists that Pascal should be the first programming language [14]. L. Grishko considers it appropriate to start learning to program from two languages: Pascal and C [15]. D. Krpan and I. Bilobrk tested three programming languages (QBasic, C, and Python) in order to assess which would be the best as an introductory programming language for students. Although the students graded C as being the most difficult programming language before the actual solving of the assignments, 70,97% of them later stated that it was easier to solve the assignments in C [16]. American programmer Vardan Grigoryan justified the need to start learning to program with C++ [17].

The analysis of publications has revealed various subjective approaches in the search for an answer to the question: which language is the best to start learning to program. This question is debatable and attracts a lot of attention of teachers and experienced programmers in many countries. Contradictory opinions are expressed. Foreign authors have carried out many studies. However, they take into account regional trends and traditions and do not consider the specific features of Ukraine. Some Ukrainian teachers advocate the introduction of the experience of their American colleagues, without recognizing, in particular, the specifics of the Ukrainian labor market. In addition, when developing criteria for choosing the first programming language for first-year students, the formalization of the selection process and the practical aspects of applying these criteria in different conditions are not considered.

### B. Aim and tasks of the research

The purpose of this work is a multivariate analysis of popular programming languages, taking into account the distinctive features of the IT labor market in Ukraine compared to other countries. When forming a system of numerical evaluation of practical criteria, it is advisable to form a rating of compliance of the most popular programming languages with the requirements for the first language to be studied. It will allow choosing an optimal programming language for use in the courses "Basics of Programming" or "Algorithmization and Programming" for students of IT specialties in Ukrainian universities.

### C. Analysis of programming languages that are most popular at the IT market

#### 1) Analysis of the IT labor market in Ukraine

The key position of training IT professionals is the demand of the labor market and compliance of the knowledge and skills of future programmers acquired during training with employers' requirements. Thus, the authors conducted an investigation of the Ukrainian IT labor market. Statistical analysis of the search queries results on sites rabota.ua and work.ua allowed forming a rating of programming languages popular in the IT market (Fig. 1). The JavaScript and PHP languages used in web programming take the first two positions. Expanding the capabilities of the JavaScript language in recent years has increased the scope of its use and significantly increased its popularity. The third place is taken by the Java language, which is used, in particular, for programming Android applications and for server applications in large corporations. The fourth position is assigned to Python which areas of use are web development, machine learning and writing scripts for automation. The C# language, which is the main competitor of Java in practical applications, takes the fifth position with a small margin. C++ is the last in the top. Many editors and high-speed servers are created in this language. Besides, C++ keeps primacy in the gaming industry.

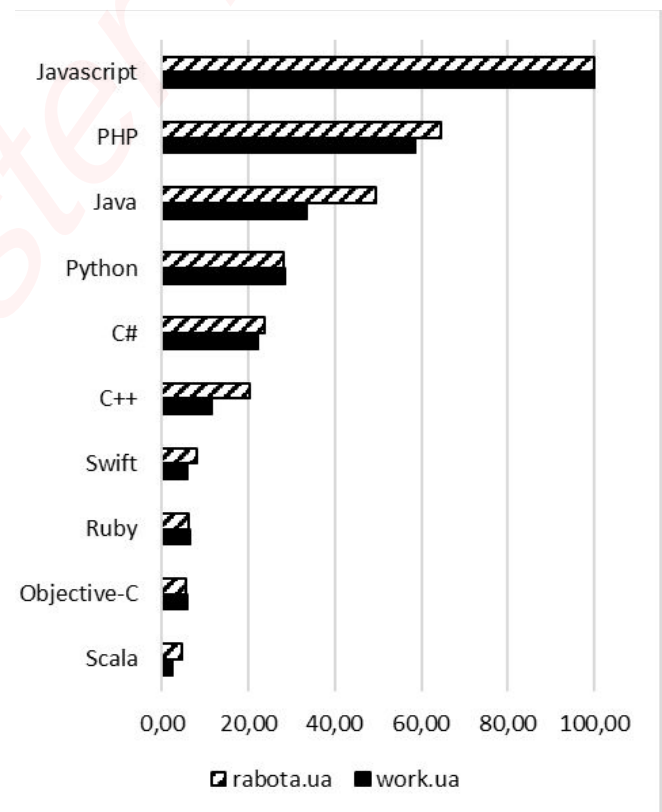


Fig. 1. Rating of demand for programming languages in Ukraine (the diagram is based on data from rabota.ua and work.ua)

#### 2) Analysis of the foreign IT labor market

The second stage of the study was the analysis of the foreign IT labor market. In [18], significant differences were revealed in the demand for programming languages as compared with the Ukrainian IT labor market. The undisputed leader abroad is Java, second place is taken by JavaScript. Python, C++, and C# take from the third to fifth

places, changing among themselves in various ratings [19, 20]. PHP is in the seventh or eighth position.

To demonstrate the distinctive features of the domestic and foreign IT markets, a comparative rating of programming languages on the labor market in Ukraine (according to *rabota.ua* website) and in other countries (according to *indeed.com* and *dice.com* websites) was formed (Table I) [18-20].

TABLE I. COMPARATIVE RATING OF PROGRAMMING LANGUAGES IN THE LABOR MARKET IN UKRAINE AND IN OTHER COUNTRIES

Language	indeed.com	dice.com	rabota.ua
Java	100,00	100,00	49,53
JavaScript	92,31	68,01	100,00
C#	51,48	39,87	23,82
Python	44,76	53,64	28,13
C++	32,68	43,55	20,46
C	30,88		6,73
PHP	18,92	12,04	64,60
Ruby	16,81	14,58	6,33
Objective-C	6,59	35,43	5,52
Swift	5,75	4,57	8,08

Distinction in the requirements for knowledge of programming languages in this rating indicates the heterogeneity of the tasks. Since the Ukrainian labor market has significant differences from the foreign one, it is unreasonable to fully adopt the experience of universities in other countries. It is advisable to regularly monitor changes in the demand for programming languages in Ukraine and study the need to adjust curricula.

#### D. Programmer's survey

##### 1) Survey of students of IT specialties

As another indicator of the presented multivariate research, a survey of students-future programmers was conducted. It revealed that 58% of respondents began to learn to program after leaving school. 48% of responders met the programming for the first time in the university. At the same time, more than 30% of schoolchildren were engaged in programming independently at home, and therefore their knowledge is rather fragmentary. Thus, the task of the university is to introduce first-year students with the basic fundamental concepts and programming constructions, as well as to develop skills in writing syntactically literate code using the gained knowledge. However, it is not expected that the first programming language should become the main one in the future professional activity of students. Such a conclusion was made after a survey of experienced programmers conducted as part of our research.

##### 2) Survey of programmers

According to this survey, less than 20% of respondents use the first programming language they studied for work, while 68% believe that the first language gave them basic knowledge, making it easier to learn the syntactic features of other programming languages. Therefore, in their opinion, the first language should have all the fundamental constructive functionality, regardless of the scope of possible application.

#### E. Compilation of programming language compliance with requirements for the first language to learn

Based on many years of experience of the authors of the research and the result of analyzing the opinions of interviewed experienced programmers, the requirements for the first programming language studied in universities by students of IT specialties were formed. They are:

- high language position in the ranking of demand in the IT job market; this provides good motivation for students to study it;

- a convenient and intuitive online compiler or free development environment;

- availability in the programming language of all the basic constructs used in modern programming languages;

- the simplicity and clarity of the syntax of these constructs;

- maximum compatibility with other programming languages, including similar syntax, that will be used in subsequent courses and professional activities.

According to these requirements, we evaluated each of the six programming languages most in demand among employers (Fig. 1), as well as the C language, which is currently common in Ukrainian universities in teaching students the basics of programming. The introductory course does not study object-oriented programming. However, some predefined classes can be used if it is necessary. In particular, the C++ language is considered just as the base C language with streaming I/O and string class, as well as file streams.

All considered languages satisfy the requirement of a convenient online compiler or free development environment. Position in the rating of demand was assessed on a 10-point scale. For the other three requirements for each of the languages, each of the main constructions (input-output, conditions, cycles, one-dimensional and two-dimensional arrays, pointers, strings, structures, file streams) traditionally studied in the course “Algorithmization and Programming” was evaluated on a 4-point scale (from 0 to 3), and then summed up the scores of each language for each of the requirements. The results of the calculations are presented in Table II.

TABLE II. CONFORMITY RATING OF PROGRAMMING LANGUAGES TO REQUIREMENTS FOR THE FIRST LANGUAGE TO LEARN

№	Language	Rating of demand	Availability of all necessary constructions	Simplicity and clearness of syntax	Compatibility with other programming languages	Total rating
1	C++	2	27	27	29	<b>88</b>
2	C#	2	24	23	26	<b>78</b>
3	C	2	23	23	24	<b>75</b>
4	Java	4	21	20	23	<b>71</b>
5	JavaScript	10	16	16	15	<b>57</b>
6	PHP	6	17	17	15	<b>55</b>
7	Python	3	17	17	13	<b>53</b>

As shown by the overall rating formed as a result of the research, the C++ programming language is the most suitable for teaching novice programmers. A high degree of similarity of its syntax with other popular programming languages is one of the advantages of this language. The same language can be used when studying the course "Algorithms and Data Structures", which will make it easier for students to learn.

C# language is in the second position and loses due to more cumbersome input/output, the need for at least minimal knowledge of classes and the absence of the concept of pointers, familiarity with which implies an initial programming course. At the same time, this language can be studied in the "Object-Oriented Programming" course, since the difficulty of switching to it after learning the basics of C++ programming is minimal.

The C language, occupying the third position, loses due to the low score of the simplicity and clarity of input/output and work with strings. For example, to enter a value of the integer variable x, you need to write the following command: `scanf("%d", &x);`. For a student who is just learning how to program, it is quite difficult to understand what %d and & means. In addition, novice students poorly perceive the impossibility of using traditional equality operator when testing strings.

The Java language requires basic knowledge of classes. In addition, it does not have pointers and structures (struct in C syntax), which reduces its scores when choosing the first programming language for study.

The rating of JavaScript and PHP languages shows that it is inappropriate to start learning to program with these languages for several reasons. First, before starting to get acquainted with them, the student must already have basic knowledge of HTML. Secondly, these languages do not support structures.

The Python language, which quickly rises in the rating of demand, loses to other considered programming languages with a significantly different syntax, which can be a hindrance when learning other programming languages. At the first glance lack of curly brackets, block-bounding instructions, no semicolons after commands, no parentheses when writing conditions seem to be a simplification. However, in fact, it does not form a clear understanding of the nested program structures for students and increases the risk of logical errors for beginners. The absence of semicolons may interfere with the study of other languages in which they are used.

In our opinion, teachers' ideas about the simplicity of Python and the complexity of the C language are subjective and are not supported by the opinion of students after the end of the introductory course.

### III. CONCLUSIONS

Although in practice, the choice of a programming language for an introductory course is often a compromise that depends on economic, political, and pedagogical factors, multifactorial research with an analysis of the requirements of the IT labor market has allowed:

– to identify the distinctive features of the IT labor market in Ukraine in comparison to other countries;

– to develop and formalize the criteria for choosing the first programming language for the first-year students of IT specialties;

– based on the specified criteria, to calculate the rating of compliance of the most requested programming languages with the requirements for the first language being studied;

– to establish that the C++ programming language is currently the most suitable for learning newcomers in Ukraine.

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