

# The use of WEB-oriented technologies in the process of WEB-programming teaching for technical universities students

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**Abstract.** The realities of the XXI century — informatization, digital transformation, high technologies, WEB-technologies in particular — put Ukraine state in front of global challenges of creating a digital state. It is the implementation of a number of digital projects which form the digital space of the state, in particular those coordinated by the Ministry of Digital Transformation of Ukraine.

The development of a significant number of applications requires the state to constantly update them, maintain them working, which requires qualified programmers. The task of technical universities is to train competitive specialists in the IT field.

This study analyzes the results of a survey of students of NTUU “Kyiv Polytechnic Institute. Igor Sikorsky”, the purpose of which was to find out what integrated development environments and programming languages senior students independently choose when developing programs within the educational and professional programs of the faculty, and which correlate with software used by programmers in the implementation of large IT-enterprises, in particular WEB-programming languages.

The results of the study showed as well that the rating of programming languages and the use of integrated development environments meet modern requirements for software development. 76.7% of graduates, while being students, are already employed in IT companies as full-time employees. The high percentage of employment suggests that graduate students of the Faculty of Informatics and Computer Engineering of Igor Sikorsky NTUU KPI are competitive in the modern IT labor market.

**Keywords:** programming language, integrated development environment, IT graduates competitiveness.

# 1 Introduction

Until recently, the labor market in IT was very attractive for novice professionals from all points of view: low entry threshold, high salaries, the opportunity to work in the largest companies. Over the past few years, the number of juniors has significantly exceeded demand, and the quality of programming skills leaves much to be desired. The current crisis has exacerbated the situation, and at present it will take much more effort to become a truly in-demand programmer.

In today's world of informatization, computerization and digitalization of education, it is very important to increase the level of training of future bachelors in IT specialties, which in turn depends on the level of competencies they acquire during and after graduation [1, p. 140].

Every applicant entering a higher education institution wants to be sure that after graduation he will be competitive as well as have a guarantee to be employed. Higher education institutions, together with the ICT Industry Competitiveness Council and leading companies in the field, are implementing the European Educational Initiatives project, which aims to provide everyone willing with quality modern education in the field of information technology.

Nowadays, educational programs are completely revised and modernized, individual learning trajectories are introduced, which allow for a better study of IT disciplines.

# 2 Research methods

A number of methods were used in the scope of this article: surveys, questionnaires, interviews with students, methods of comparative analysis and statistical data processing.

For achieving the goal of this study the authors used the following methods of systematic and comparative analysis of:

- sociological scientific, pedagogical, psychological sources;
- special literature to clarify the features of the advantages and disadvantages of Web-based learning tools in the training of IT specialists in technical universities;
- programming software languages use before training and, accordingly, during training at a technical university;
- integrated development environments use in program development during university studies;

- programming languages choice while independently studying and self-improving by students of IT specialties, bachelors of computer science in particular.
- the use of programming languages and integrated development environments for third and fourth year undergraduate students in real projects.

In addition, undergraduate students' recommendations on software selection for strengthening the content component of academic disciplines were studied.

### 3 Research results

The urgency of the question on WEB-programming specialists training is confirmed by the fact that Ukraine has set a course to create a digital state, namely the implementation of a number of digital projects, including those, coordinated by the Ministry of Digital Transformation of Ukraine, that form the state digital space [2].

Such projects include: “Action Application (Diya)”, “Electronic Services”, “e-Residence”, “Action City”, “Digital Education”, “Digitalization of Education”, “Business”, “Children Protection on the Internet”, “European Integration” etc. which include a number of subprojects, for example: residence registration, property rights registration, e-entrepreneur, e-baby, digital tax number, online registration, submission of applications to higher education institutions, etc.

The development of such a significant number of applications requires the state to constantly update them, maintain them in working order, forming a need for qualified programmers, which, in its turn, requires competitive graduate students availability. The IT industry in its dynamics, with the development of cross-platform technologies in particular, appears to be quite large and it requires from graduates not only the knowledge of modern approaches, methods, methodologies (Agile) and software development technologies, but also the teamwork skill, modern strategies and technologies abilities, and in particular WEB-technologies and tools of collective software development [3, p. 76].

Both study and application of WEB-technologies are directly related to Web-oriented learning technologies. By Web-oriented learning technologies we mean forms, methods and Web-oriented learning tools [4, p. 108]. The approaches to the organization of student Web-oriented education are carried out on an international level, in such projects as Erasmus +

“Curriculum for Blended Learning” and “Blended learning courses for teacher educators between Asia and Europe” [5, p. 609].

While considering the complex approach to the organization of education , which combines traditional (30%), distance (50%) and project (20%) learning, using cloud-oriented and WEB-oriented technologies [5, p. 609], we can see that higher education institutions put great effort to studying the questions of control and assessment of students’ learning activity results, as well as the principles of formative assessment and the levels of cognitive, emotional and motor goals that should comprehensively cover the educational and information space are highlighted; as well as peculiarities of assessment tasks formation in distance learning organization [6, p. 734].

One of the components of Web-oriented learning technologies is WEB-programming, which, in its turn, is described in the explanatory dictionary as a developing section of programming which focuses on the development of dynamic WEB-applications, in the creation of which WEB-programming languages are used [7]. While looking into WEB-programming languages it is worth noting that they are divided into two groups: server languages and client languages.

With programs written in server languages WEB-programming is performed on the server side, in the form of client request processing, by interacting with the Database Management System (DBMS). The processed request over the network is returned to the client as a file with possible extensions like: HTML, PHP, ASP, ASPX, Perl, XML, SSI, DHTML, XHTML, etc. Programs in client programming languages are processed by the client-side browser accordingly.

There is a large number of programming languages at present time. They are: JavaScript, C#, C++, Java, Python, PHP, Visual Basic, TypeScript, Ruby, ActionScript, Delphi, Perl, LISP, Kotlin, Swift, Groovy, Go (Golang), Haskell, Scala, Go, Lua and others. This list is constantly growing as the rating of WEB-programming languages is determined annually. Thus, the Ukrainian profile resource DOU.UA conducted their planned survey on programming languages for 2021, which was attended by 7,211 respondents (92% are located in Ukraine) (Figure 1) [8].

The results of this survey showed that among the top five programming languages in Ukraine the leader is JavaScript (18.1%), with the inferior programming languages coming in the following order: Java (14.6%), C# (14.4%), Python (12.1%), PHP (10.1%)

While analyzing programming languages basing on Backend, Frontend, Full Stack and Mobile areas of use (Table 1), we see that the rating of the main Back-end languages as: Java (23.4%), C# (20, 3%), HPH (18.4%),

Python (12.3%).

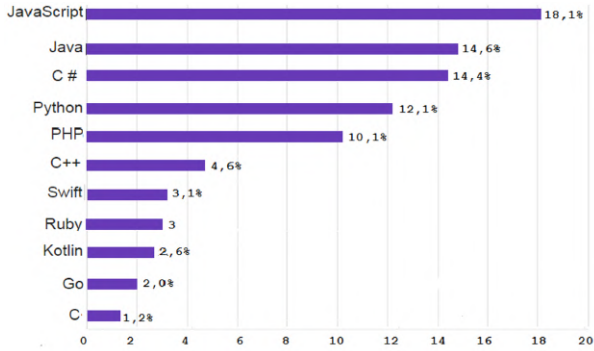


Fig. 1. Programming languages rating 2021

Table 1. Programming languages analysis basing on the spheres of use (Backend, Frontend, Full Stack, Mobile)

Use spheres	Programming languages (%)
Frontend	JavaScript (68,2), TypeScript (26%), Java (1,4) C# (1,2)
Backend	Java (23,4), C# (20,3), HPH (18,4), Python (12,3), JavaScript (5,6), Ruby (5,3), Go (3,5), TypeScript (2,5), Scala (2,3), C++ (1,8) Other (1,4)
Full Stack	JavaScript (36,9), C# (20), Python (10,8), HP (7,7), Java (4,6), Ruby (3,1), Other (3,1)
Mobile	Swift (34,2) Kotlin (26,1), Dart (8,8), JavaScript (8,2), C# (7,9), Java (6,5), TypeScript (3,3), Other (2,8), C++ (2,3%)

The share presence of JavaScript and TypeScript is far not as large and it is comparable to the share of Ruby and Go. It is worth noting that Scala and C++ are also among the top ten backend languages. In fact, the entire frontend is written in JavaScript (68.2%), TypeScript (26%). The use of other languages is purely marginal. In mobile development, the main languages are Swift (34.2%), Kotlin (26.1%) [8].

The European Educational Initiatives project has been implemented

in Ukraine since 2016. This is a joint powerful project of the ICT Industry Competitiveness Council, Higher Education Institutions (HEIs) of Ukraine, leading IT companies, which is implemented with the support and partnership with the Ministry of Education and Science of Ukraine, in particular the Verkhovna Rada Committee on issues of science and education.

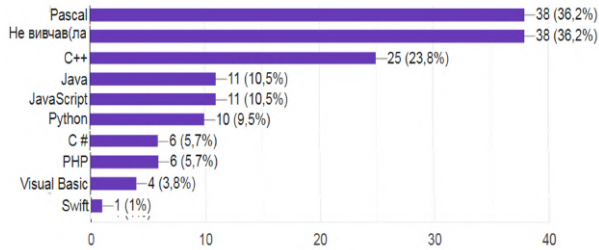
NTUU “Igor Sikorsky Kyiv Polytechnic Institute” became one of the first institutions of higher education, which started implementing the European Educational Initiatives project in its educational and professional programs. The purpose of the project is to provide everyone willing with quality modern education in the field of information technology, as well as to help IT specialists to be competitive in the labour market and have a guarantee of employment [9].

Thus, within the framework of this project, a survey of students in the field of knowledge 12 — “Information Technology”, specialties “Software Engineering” and “Information Systems and Technologies” at the Faculty of Informatics and Computer Engineering (FICT) was conducted. The survey was attended by 105 student respondents, among them: 4<sup>th</sup> year of study students (87%), 3<sup>rd</sup> year of study (10%), other years (3%).

The purpose of the survey was to find out which programming languages senior students independently choose when developing programs within the educational and professional programs of the faculty and how they correlate with software used by programmers in the implementation of large projects in IT enterprises, including WEB-programming languages, integrated development environments, platforms, frameworks, technologies and libraries.

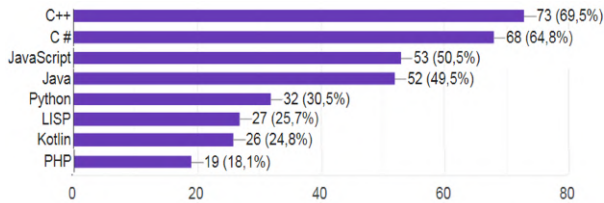
- Before studying at the university.
- While studying at the university.
- Additional study of software.
- Programming languages and integrated development environments use in real projects.
- Student recommendations on the selection of software to link the content component of the studying course.

Figure 2 presents the programming languages that students managed before studying at the university. It turned out that 36.2% of respondents did not learn any language at all, 36.2% studied Pascal, which is now considered a dead language, 23.8% had a skill of programming in C++.



**Fig. 2.** Programming languages managed before the university studying

The results of the survey on the study of programming languages while being at the university showed the following picture: first place — C++ (69.5%), second place — C# (64.5%), third place for JavaScript (50, 5%). The rating of other programming languages is presented in Figure 3.



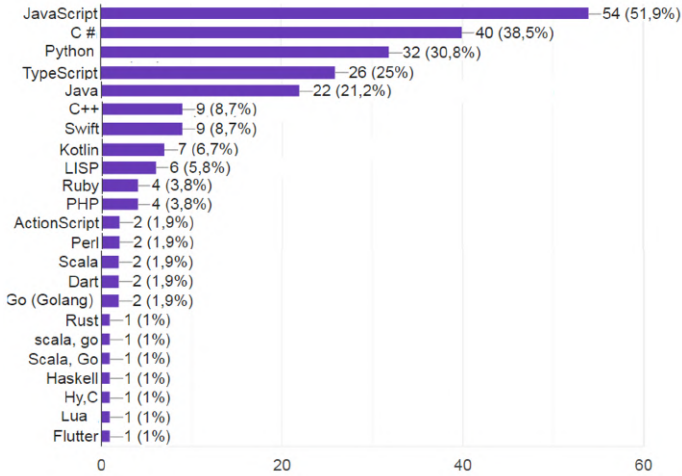
**Fig. 3.** Programming languages covered by educational programs of the university

Throughout the study, along with lectures, seminars, laboratory and practical work, teachers and students pay great attention to the students' individual work, starting from the first year. Individual work organization promotes the development of students' independence, responsibility and organization, as well as forming a creative approach to problem solving on both educational and professional level [10, p. 349]. At the Faculty of Informatics and Computer Science, students and teachers develop an extreme level of responsibility on this issue.

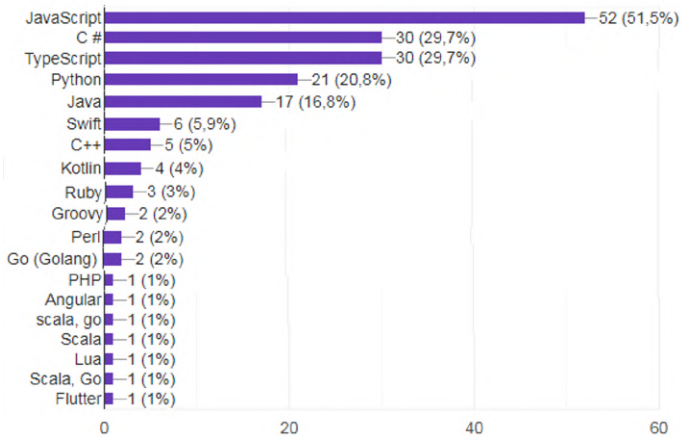
The diagram in Figure 4 illustrates the additional study of software, namely the improvement percentage or self-study of new programming languages by students-programmers during their course at the university.

The use of programming languages in IT-firms real projects done by students is shown in Figure 5. We can see that JavaScript comes out on top (51.5% of the surveyed student respondents). The second position is divided between C# (29.7%) and TypeScript (29.7%), the use of which is rapidly

gaining momentum in software development. The top three programming languages are completed by Python (20.8%).

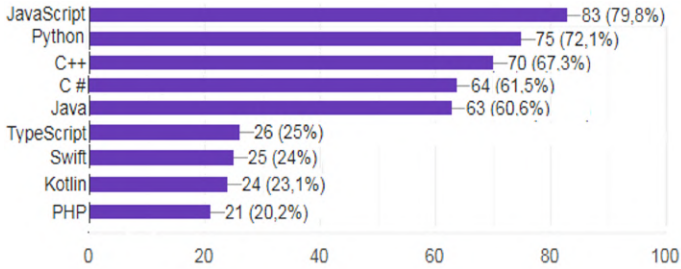


**Fig. 4.** Programming languages that students improve or study independently



**Fig. 5.** Programming languages used by 4 year students in doing real projects in IT companies

It appears important to take into account the graduate students' recommendations on software selection to refer to the strengthening component of the course. The results of the survey of those recommendations are presented in Figure 6: JavaScript (79,8%), Python (72,1%), C++ (67,3%), C# (61,5%), Java (60,6%).



**Fig. 6.** Graduate students' recommendations on programming languages selection

While analyzing the survey results on the use of programming languages by students of the Faculty of Informatics and Computer Engineering, the authors conclude that students most often use JavaScript both in real projects and in their independent study of new programming languages. It is worth noting that the TypeScript programming language in real projects also ranks as second widespread. The third place belongs to Python (Figure 3, Figure 5).

In the top three use of programming languages in Ukraine, the leader is the JavaScript programming language, which is inferior to the Java and C# programming languages.

The third position of using the JavaScript programming language in university studies, after C++ and C#, indicates that this WEB-programming language began to be learned from senior courses, in contrast to C++ and C#, which are studied from the first course and is used in all disciplines, including laboratory work. In the new educational programs, starting from the second year, each student can build an individual learning trajectory.

The other aspect, which was given a lot of attention during the survey, is the selection and use of integrated development environments (IDE) for program code writing. Quite a few of IDE definitions can be found on the Internet. Some of them are given below:

“An Integrated Development Environment is nothing but an application

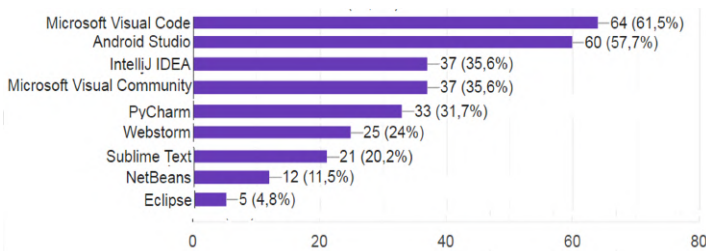
that provides web developers with the tools required for developing software. Ideally, it comes with a text editor, automation tools, code compilation, and a debugger” [11].

Harish Rajora suggests that “Web development IDEs are powerful tools equipped with heavy features such as autocomplete, syntax checking, debugger, provide a suggestion, views live web page inside the IDE for better understanding of the output, etc.” [12].

“An integrated development environment (IDE) is an application that facilitates application development. IDEs are designed to encompass all programming tasks in one application. Therefore, IDEs offer a central interface featuring all the tools a developer needs, including the following: Code editor, Compiler, Debugger, Build automation tools. In addition, some IDEs might also include the following: Class browser, Object browser, Class hierarchy diagram” [13].

Depending on the number of supported programming languages, environments can be multilingual or monolingual.

Surveys on IDE use while writing programs during the university studies showed the following results (Figure 7): the greatest demand came for IDE Microsoft Visual Code (61.5%), second place — Android Studio (57.7%) third place — IntelliJ (35,6%) and Microsoft Visual Community (35,6%).



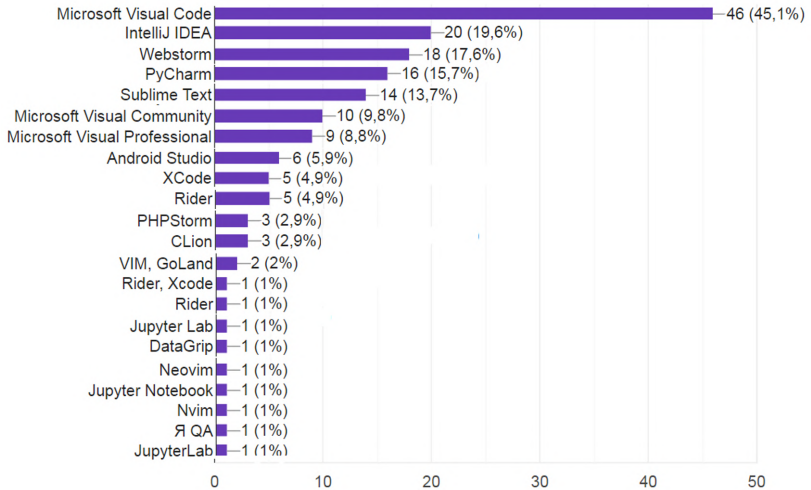
**Fig. 7.** IDE use while writing programs during the university studies

Regarding IDE use in real projects at IT companies done by students, the authors observe that the most popular IDEs appear to be also Microsoft Visual Code (45,1%), IntelliJ IDEA (19.6%), Webstorm (17.6%), PyCharm (15,7%), Microsoft Visual Community (15.7%).

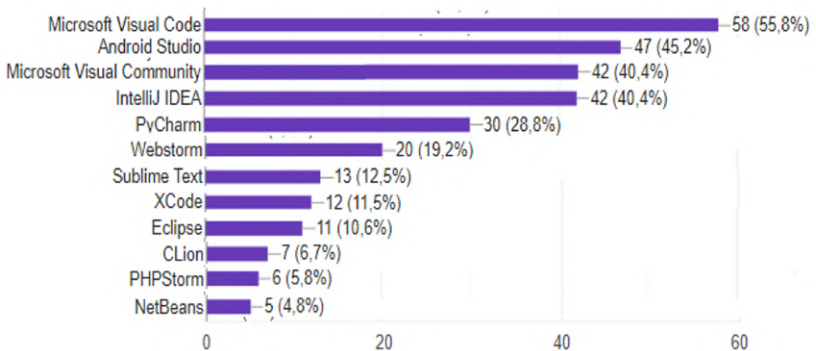
In their recommendations for studying IDEs within the university educational programs, students also range IDE in the following sequences: Microsoft Visual Code (55.8%), Android Studio (45.2%), Microsoft Visual Community (40.4%), IntelliJ IDEA (40.4%), PyCharm (28.8%), etc.

IDE performance is increased by accelerating development tasks,

reducing setup time, constant updating developers and development process standardization. Conventionally, IDEs are divided into three categories: IDE for Frontend-development, IDE for Backend-development and cloud IDE.



**Fig. 8.** IDE use while writing programs at real projects in IT companies done by students (beyond university)



**Fig. 9.** Graduate students recommendations on integrated development environments)

Each IDE has its own features, advantages and disadvantages. For example, we consider the features, advantages and disadvantages of one IDE from each category, namely Visual Studio Code (Frontend), IntelliJ IDEA (Backend), Visual Studio Codespaces (Cloud) (Table 2) [14].

**Table 2.** Programming languages analysis basing on the spheres of use (Backend, Frontend, Full Stack, Mobile)

IDE (Developing company)	IDE specifics	Advantages	Disadvantages
Visual Studio Code Microsoft Windows, Linux and Mac	<ul style="list-style-type: none"> <li>• Debugging support</li> <li>• Very customizable</li> <li>• Built-in version control</li> <li>• Works well most popular programming languages</li> <li>• Marketplace with extensions</li> <li>• Live Share for for easy remote collaboration</li> </ul>	<ul style="list-style-type: none"> <li>• Cross-platform</li> <li>• Flexible and extensible</li> <li>• Open-source</li> <li>• Free</li> <li>• Popular so it's easy to find help or extensions</li> </ul>	<ul style="list-style-type: none"> <li>• Built on Chrome so uses a lot of memory</li> <li>• Requires extra setup for certain projects and languages</li> </ul>
IntelliJ IDEA JetBrains	<ul style="list-style-type: none"> <li>• Integrated unit testing tools</li> <li>• Debugging support</li> <li>• User interfaces for common commandline tools</li> <li>• Built-in version control Database tools</li> </ul>	<ul style="list-style-type: none"> <li>• Customizable</li> <li>• Cross-platform</li> <li>• Lots of tools that make development easier</li> <li>• Similar to other JetBrains IDEs, common experience</li> <li>• Built on open-source platform</li> </ul>	<ul style="list-style-type: none"> <li>• Subscription needed for most use cases</li> </ul>
	<ul style="list-style-type: none"> <li>• Visual Studio Code in your</li> </ul>	<ul style="list-style-type: none"> <li>• Free if you host an</li> </ul>	<ul style="list-style-type: none"> <li>• You pay for the resources</li> </ul>

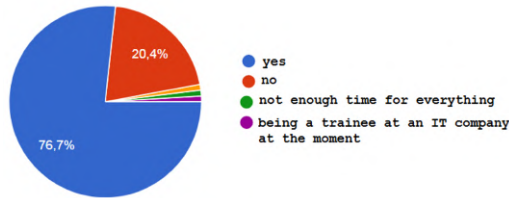
IDE (Developing company)	IDE specifics	Advantages	Disadvantages
Visual Studio Codespaces Microsoft	browser <ul style="list-style-type: none"> <li>• Works with Visual Studio Code</li> <li>• Works with Visual Studio (though still in private preview)</li> <li>• LiveShare built-in for collaboration</li> <li>• Integrated debugging and coding assistance</li> <li>• Terminal available for commandline tools</li> </ul>	environment yourself <ul style="list-style-type: none"> <li>• You can use familiar tools (Visual Studio, Visual Studio Code)</li> <li>• Personalization (dotfiles, themes, and certain extensions) carry over between environments</li> <li>• Only the essential processing is done on the server, saving you bandwidth</li> <li>• Very easy to get started</li> </ul>	you use

IDE survey results showed that students most often use Microsoft Visual Code, both during studies and in real projects. Next popular are IDE IntelliJ IDEA, Microsoft Visual Community, Webstorm, PyCharm.

The results of the survey also showed that 76.7% of graduate students in the 4<sup>th</sup> year of studying are already employed in IT firms as full-time employees (Figure 10). This high employment rate indicates that KPI graduate students are competitive in modern IT labor markets.

#### 4 Conclusions and further research perspective

The article studies the analysis of the use of WEB-oriented technologies in the process of WEB-programming learning by students of the Faculty



**Fig. 10.** The percentage of studying with work in an IT company combination by students

of Computer Science. In the scope of this aim a comparative analysis of students' surveys on the use of programming languages and integrated development environments was conducted.

It was found that before studying at the university, students either studied outdated programming languages or did not study programming at all. During university studying, the priority programming languages were C++ and C#.

Third priority language is JavaScript, which indicates the fact that this WEB-programming language is studied only at senior years of university learning, compared to C++ and C# which are studied in the first year at university and is used in all disciplines when performing laboratory work.

New educational programs imply that, starting from the second year of studying, each student can create his or her individual learning trajectory by choosing disciplines offered by the faculty management.

The scientific novelty of the study lies in the fact that a study and analysis was done for the first time on observing student surveys on the use of programming languages and integrated development environments before and during the university course, on the choice of programming languages while independent studying and self-improving in IT specialties, as well as the use of programming languages and integrated development environments in real projects by senior students.

The high level of preparation of students at the faculty is evidenced by the fact that in the 4<sup>th</sup> year 76.7% of graduate students are already employed in IT companies as full-time employees. It is this high employment rate that indicates that KPI graduate students are competitive in today's IT labor market.

The study is unique, no similar comparisons of scientific papers have been found, so the relevance of this issue is undoubtful.

The authors believe that the material found in this article will be

interesting not only for researchers, teachers and students of higher education institutions of Ukraine, but scientists from Europe, USA, Australia, Japan as well for both improving their educational programs and implementing practical work in collaboration with IT companies.

The high level of preparation of students at the faculty is evidenced by the fact that in the 4<sup>th</sup> year 76.7% of graduate students are already employed in IT companies as full-time employees. It is this high employment rate that indicates that KPI graduate students are competitive in today's IT labor market.

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### **Використання WEB-орієнтованих технологій у процесі навчання WEB-програмування студентів технічних вузів**

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**Анотація.** Реалії XXI століття — інформатизація, цифрова трансформація, високі технології, зокрема WEB-технології — ставлять українську державу перед глобальними викликами створення цифрової держави. Це реалізація низки цифрових проєктів, які формують цифровий простір держави, а саме тих, що координуються Міністерством цифрової трансформації України.

Розробка значної кількості додатків вимагає від держави постійного їх оновлення, підтримки їх працездатності, для чого потрібні кваліфіковані програмісти. Завданням технічних університетів є підготовка конкурентоспроможних спеціалістів у сфері ІТ. У цьому дослідженні проаналізовано результати опитування студентів НТУУ «Київський політехнічний інститут ім. Ігоря Сікорського», метою якого було з'ясувати, які інтегровані середовища розробки та мови програмування студенти старших курсів самостійно обирають при розробці програм у межах освітньо-професійних програм факультету, і які співвідносяться з програмним забезпеченням, що використовується програмістами при реалізації великих ІТ-підприємств, зокрема мовами WEB-програмування. Результати дослідження також показали, що рейтинг мов програмування й використання інтегрованих середовищ розробки відповідають сучасним вимогам до розробки програмного забезпечення. Вставлено, що 76,7% випускників ще під час навчання працевлаштовані в ІТ-компаніях як штатні працівники. Високий відсоток зайнятості свідчить про те, що аспіранти факультету інформатики й обчислювальної техніки НТУУ КПІ ім. Ігоря Сікорського є конкурентоспроможними на сучасному ринку ІТ-праці.

**Ключові слова:** мова програмування, інтегроване середовище розробки, конкурентоспроможність випускників ІТ.