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# Uso de las herramientas Virtual Programming Lab y H5P para el aprendizaje de programación en estudiantes de nivel superior

## *Use of Virtual Programming Lab and H5P tools for learning programming in higher level students*

## *Utilização do Laboratório Virtual de Programação e ferramentas H5P para aprendizagem de programação em alunos de nível superior*

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## Resumen

Debido a la constante dificultad que presentan los estudiantes al iniciarse en el aprendizaje de la programación y que ha repercutido en su rendimiento académico, el presente estudio tuvo como objetivo el desarrollo de materiales didácticos que emplean las herramientas VPL (Virtual Programming Lab) y H5P como estrategia para el aprendizaje de la programación Java en estudiantes de nivel superior de la facultad de informática en la Universidad Autónoma de Querétaro (UAQ). La metodología utilizada fue un método mixto. El enfoque cuantitativo utilizó un diseño cuasiexperimental y análisis longitudinal con dos mediciones, se aplicó el análisis estadístico de la prueba de rangos con signo de Wilcoxon con el fin de conocer el impacto del uso del material didáctico en los estudiantes. El enfoque cualitativo utilizó una entrevista semiestructurada para la evaluación del material didáctico. El estudio se aplicó a una muestra de 17 estudiantes de segundo semestre de la facultad de informática de la UAQ. Los resultados de los análisis permitieron evidenciar el impacto positivo que se obtuvo al utilizar las herramientas H5P y VPL para la comprensión de conceptos y el desarrollo de habilidades de programación obteniendo como resultado en la prueba de rangos con signos de Wilcoxon un valor igual a $T+=1$ a un nivel de significancia de $\alpha = 0.05$. En cuanto a la percepción en el uso del material didáctico, los estudiantes consideraron que los criterios de diseño, navegación e

interactividad tuvieron una valoración más alta con respecto a los criterios que evalúan las categorías pedagógicas y didáctico-curriculares. Asimismo, los estudiantes consideraron que el uso de los OA les permitió comprender mejor la teoría, los conceptos, así como poner en práctica el uso de sintaxis propio del lenguaje Java.

**Palabras clave:** H5P, VPL, programación, lenguaje Java.

## Abstract

Due to the constant difficulty that students have when starting to learn programming and that has had repercussions on their academic performance, the objective of this study was to develop didactic materials that use the VPL (Virtual Programming Lab) and H5P tools as a strategy for learning Java programming in higher level students of the computer science faculty at the Universidad Autónoma de Querétaro (UAQ). The methodology used was a mixed method. The quantitative approach used a quasi-experimental design and longitudinal analysis with two measurements, the statistical analysis of the Wilcoxon signed-rank test was applied in order to know the impact of the use of the didactic material on the students. The qualitative approach used a semi-structured interview for the evaluation of the didactic material. The study was applied to a sample of 17 second semester students of the computer science faculty of the UAQ. The results of the analysis allowed evidencing the positive impact obtained by using the H5P and VPL tools for the understanding of concepts and the development of programming skills, obtaining as a result in the Wilcoxon signed-rank test a value equal to T+=1 at a significance level of $\alpha = 0.05$. Regarding the perception of the use of the didactic material, the students considered that the design, navigation and interactivity criteria had a higher evaluation with respect to the criteria that evaluate the pedagogical and didactic-curricular categories. Likewise, students considered that the use of the LO allowed them to better understand the theory and concepts, as well as to put into practice the use of Java language syntax.

**Keywords:** H5P, VPL, programming, Java language.

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**Resumo**

Devido à constante dificuldade que os alunos apresentam ao começar a aprender programação e que tem impactado no seu desempenho acadêmico, o objetivo deste estudo foi desenvolver materiais didáticos que utilizem as ferramentas VPL (Virtual Programming Lab) e H5P como estratégia de aprendizagem. Programação Java em alunos de nível superior da faculdade de informática da Universidade Autônoma de Querétaro (UAQ). A metodologia utilizada foi um método misto. A abordagem quantitativa utilizou um desenho quase-experimental e análise longitudinal com duas medidas, aplicou-se a análise estatística do teste dos postos sinalizados de Wilcoxon para conhecer o impacto do uso do material didático nos alunos. A abordagem qualitativa utilizou entrevista semiestruturada para avaliação do material didático. O estudo foi aplicado a uma amostra de 17 alunos do segundo semestre da faculdade de informática da UAQ. Os resultados das análises permitiram demonstrar o impacto positivo obtido pela utilização das ferramentas H5P e VPL para a compreensão de conceitos e o desenvolvimento de competências de programação, obtendo um valor igual a T+= no teste de classificação sinalizada de Wilcoxon 1 com significância. nível de $\alpha = 0,05$. Quanto à percepção do uso do material didático, os alunos consideraram que os critérios de design, navegação e interatividade tiveram classificação superior com relação aos critérios que avaliam as categorias pedagógicas e didático-curriculares. Da mesma forma, os alunos consideraram que a utilização dos OAs permitiu-lhes compreender melhor a teoria e os conceitos, bem como colocar em prática o uso da sintaxe típica da linguagem Java.

**Palavras-chave:** H5P, VPL, programação, linguagem Java.

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# Introduction

The use of programming for software development has stood out as a skill within the specific competencies in the training of professionals, since today's society demands its use for the creation of information (González-González, 2019). The integration of programming teaching in secondary and higher education institutions has become more necessary (Jiménez-Toledo *et al.* , 2019; Velasco, 2020 ), however, there are studies that indicate that learning programming at an early age has more effective results (González-González, 2019).

Programming requires both the use of skills at a cognitive level and the use of technological tools, which leads to a greater effort on the part of students when acquiring these skills and applying them together, as demonstrated by studies carried out that point out the different difficulties that students present when acquiring programming skills (Chanchí *et al.* , 2018; Jiménez-Toledo *et al.* , 2019), this has its implication in the failure and dropout rates, for Aguilar *et al.* (2020) this points to deficiencies in the methods and strategies used to learn programming.

Over the years, studies have been carried out on the teaching and learning of programming, according to Revelo-Sánchez *et al.* (2018) they point out as a strategy for learning programming the incorporation of actions of practical predominance over theoretical ones, in turn Fonden (2020) points out as a strategy the use of concepts of Object Oriented Programming (OOP) and subsequently the development of its source code to make analogies for the development of abstract thinking. Regarding the use of tools according to Ibarra-Zapata et al. (2021) point out in a study carried out during the period 2010-2020 that there are few works on tools that help the programming teaching process.

The above indicates a lack of strategies and methods that use technological tools for teaching and learning programming. The present study aimed to develop teaching materials that use H5P and VPL tools for teaching programming to higher education students.

At the Autonomous University of Querétaro (UAQ) the subject of Object Oriented Programming is taught using the Java language. In order to support the learning of programming of UAQ students, the hypothesis that supported the development of the research was:

The use of Learning Objects (LO) aimed at the development of programming and the use of the VPL tool will help students improve their knowledge of the Java programming language.

## Theoretical foundation

Learning programming requires the use of various cognitive skills, one of them is computational thinking and the use of abstraction; computational thinking is a skill that includes the use of algorithms, logical thinking, use of abstraction, and pattern management (Fonden, 2020; Jiménez-Toledo *et al.* , 2019) and uses specific computing concepts (Pérez, 2019). It also requires specific problem-solving skills such as understanding and evaluating proposed solutions (Cordenonzi and Del Pino, 2021).

Regarding the abstraction skill, Jaramillo and Puga (2016) mention that it uses an advanced level of thinking that involves deduction, synthesis, interpretation and analysis. In the development of software that uses the Object Oriented Programming paradigm, the abstraction skill allows the modeling of objects taking into account their main characteristics that define said object, and from which their classes are derived to create a representation of the real world.

In this regard, Fonden (2020) proposes a didactic strategy for the development of the skill of abstraction as a fundamental part of learning the OOP that consists of first identifying the classes, attributes and objects of the problem, then encoding and testing the code, finally collaborative work is used to compare results and share experiences.

In addition to the skills required for programming development, the concepts used in programming are difficult to assimilate because students are not familiar with the development environment of a program.(Santimateo *et al.*, 2018). Other studies point out factors such as low motivation for learning, few levels of abstraction, and computational thinking skills. (Chanchí *et al.*, 2018; Jiménez-Toledo *et al.*, 2019).

For the present study, a teaching material was developed that used the H5P and VPL tools, a pedagogical strategy was followed that was based on the foundations for teaching programming in virtual environments proposed by Djenic and Mitic (2017) which consists of teaching in the theoretical-practical way, in the theoretical phase the teaching of syntax, concepts, algorithms and methods is mentioned, the subsequent phase is the practice, in which the elements of coding, use of syntax and development of instructions in a programming language; likewise, for both phases the use of multimedia resources such as simulations and animations that reflect the active role of the student is indicated.

Programming requires, in addition to cognitive skills, knowledge of a programming language for the development of instructions that the machine must execute.

There is currently a variety of programming languages, some more used than others due to the characteristics they possess, one of them is the paradigm they use, according to the TIOBE (s.f.) report, which is an indicator that analyzes the programming languages most used by the majority of expert developers in software development, the languages: Python, Java, C and Javascript stand out as the languages with the greatest demand and popularity in software development, The results obtained from this report point out the importance of learning the Java programming language for the development of specific skills in the vocational training process.

The use of technology has allowed, among other things, the acquisition of skills for the development of solutions that facilitate processes in any field, however, the use of technology in conjunction with programming is a challenge for both teachers and students (Tejera-Martínez *et al* ., 2020), so it is necessary to emphasize teacher training on the use and application of technological resources so that they can benefit in the development of their teaching work.

The use of digital resources within the teaching and learning processes as a means of support has had positive results. Various authors express that the use of certain teaching resources such as images, videos, diagrams, among others, can help abstract thinking (Donatien, 2014; Fonden, 2020).

The use of learning objects has been the subject of research due to their particular characteristics, as well as the benefits they provide in the teaching-learning processes. These arise from a specific educational need and, accordingly, the main elements that make up the learning object are created; in turn, Saldivia *et al.* (2019) point out that due to the way in which LOs are designed, they can be useful to cover different aspects of students' learning styles.

There are various definitions of Learning Objects, initially the definition of Wiley (2002) emerges, which defines learning objects as "any digital resource that can be reused to support learning", another clear definition is the one expressed by López (2017) which defines them as "any resource with a formative intention, composed of one or more digital elements, described with metadata, that can be used and reused within an e-learning environment can be considered an LO".

The characteristics that LOs possess, such as reusability, accessibility, interoperability, portability and durability, make LOs flexible in various educational contexts. The development of LOs requires knowledge of some software for incorporation into the online learning platform; the use of tools such as H5P allows the development of didactic elements that have characteristics such as LOs. The main characteristic of this tool is that it allows the creation of interactive content, and the learning units generated with this tool can be reusable and shared through the web; Its main use is for teaching purposes, since its use helps improve understanding and learning (Rossetti et al., 2020). H5P is a free and open access tool, it maintains a growing community of developers that contributes to the maintenance and continuous improvement of this tool. Its integration with the Moodle

platform makes it easier for teachers to develop educational resources such as interactive videos, presentations, among others.

In accordance with the portability characteristics of LO, the H5P tool can be used on different platforms such as WordPress, Canva, Blackboard, Drupal, Moodle, among others. Its use and adaptability on different platforms responds to the need that arises with the increase in the use of virtual platforms, according to Bobadilla et al. (2020) when they mention that the use of virtual environments encourages the development of skills for professional development.

In accordance with the use of virtual teaching platforms, we can mention the use of virtual laboratories, these allow for a deeper understanding of the topics covered in class, and make it possible to make the curriculum of face-to-face programs more flexible (Infante, 2014).

In the programming activity, Adu-Manu *et al.* (2013) suggest that the use of laboratory practices for programming activities favors students in the development of programming skills; likewise, Partida *et al.* (2023) mention that methodologies that incorporate practical activities improve programming learning because their development allows for more meaningful learning for the student.

The VPL tool is a support resource with educational purposes. This tool allows you to create, configure and manage practical programming activities, and is included as a free module within the Moodle virtual learning platform.

For the study, the VPL tool was used for programming practice, with the purpose of having students develop specific programming skills, such as the use of a development environment in which the student must code, debug, compile and execute, by solving problems proposed in the activities within this tool.

## Background

The use of H5P and VPL tools in the educational field has been used in different areas of learning. In a study carried out by Rossetti *et al.* (2020) on the use of LOs using the H5P platform for teaching marketing to higher level students, it showed the effectiveness of using LOs for understanding concepts, and it was also concluded that their use improved motivation for learning, as well as academic performance.

On the other hand, studies have been found where the use of LOs as teaching resources was applied and it was not possible to improve student motivation, such is the case of an

experimental research carried out by Feria-Marrugo and Zúñiga-López (2016) in which they used LOs for teaching the English language and where only 8% of the students mentioned an increase in interest in this learning.

In turn, Guerrero and García (2016) used generative learning objects for the development of algorithmic thinking in the programming fundamentals course. As a result, a better academic performance was obtained, in terms of the perception of the LOs that were used, the contents and activities that were integrated were valued positively, however, the elements referring to sound and videos were valued as deficient.

For their part, Aguilar *et al.* (2020) implemented LO in their study within a MOOC (Massive Open Online Course) for teaching data structures at a higher level, in which they used videos and questionnaires. The result was a positive acceptance and an interest in using LO to improve their programming knowledge. However, students point out deficiencies in the feedback on the resources used, as well as shortcomings in the quality of the videos, activities, and tasks.

In a research work carried out by Ramos *et al.* (2021) on the impact of using VPL in programming classes, a low level of usability was obtained in the specific aspects of satisfaction, efficiency and usefulness, as well as teachers expressing that they had some difficulties when using the tool.

The research by Lovos and González (2014) presents a proposal for collaborative teaching and learning, using the Moodle environment and the VPL tool for the development of laboratory activities for the Computer Programming subject in the Systems Degree. The activities carried out in the virtual classroom consisted of the development and testing of programs based on algorithms that were carried out in the classroom in person. The Forum and Wiki tools provided by the Moodle environment and the Virtual Laboratory (VPL) were used for collaborative work. As a result, it was found that it was difficult for students to adopt the use of the Forum and Wiki tools, however, this was not the case with the development of collaborative activities using the VPL tool.

In accordance with the above, the present study aims to make a contribution by showing the methodology used for the development of teaching materials that use the H5P and VPL tools together as a strategy for teaching OOP.

# Methodology

A mixed method with a quantitative approach was used. According to Hernández *et al.* (2010), the mixed method employs the collection and analysis of quantitative and qualitative data, and also uses joint discussion to obtain a greater understanding of the phenomenon studied. The purpose of using a mixed method in this research is to delve deeper into the results and obtain a greater understanding of the data.

In the quantitative approach, the quasi-experimental design was used. This approach sought to determine whether students improved their knowledge of the Java programming language by using the teaching material. To do this, a questionnaire on knowledge of the Java language was applied.

## Quantitative data collection

The topics of the questionnaire were based on the topics that guide the Java learning path proposed by Mahipal ( s.f. ), this learning path is composed of areas of knowledge, some of which were selected based on the topics that are handled in the curricular program of the Object-Oriented Programming subject of the UAQ.

The content and wording of the created items were subsequently validated, with each item being assessed by expert judges in the areas of Software Engineering and Computer Engineering, in order to verify the coverage and relevance of the content and reagents. The questionnaire consisted of 34 questions, with four response options each. Table 1 specifies the variables used to construct the questionnaire:

**Table 1.** Specification of the variables for the preparation of the questionnaire

| Variable | Dimension | Indicators |
|---|---|---|
| Knowledge of computational algorithms | Learning the basics of programming | - Knowledge of the concept of algorithm<br>- Knowledge of the concept of data flow<br>- Knowledge of the concept of algorithmic structures<br>- Operations with algorithmic structures<br>- Knowledge of arrangements<br>- Knowledge of operators and operations with arrays |
| Knowledge of Object Oriented Programming (OOP) | Learning the Object Oriented Programming (OOP) paradigm | - Knowledge of the object-oriented programming paradigm<br>- Knowledge of objects and classes in OOP<br>- Knowledge of introductory programming languages |
| Introduction to Java | Learning about the main elements of a Java program | - Knowledge of the Java work environment: jre and jdk<br>- Knowledge of basic elements of a Java program: comments, constants, variables and operators |
| Development environments | Know the characteristics of development environments, and their use to create Java programs | - Knowledge of NetBeans features and creating a new project with this IDE |
| Collections in Java | Know and apply the types of collections in Java | - Knowledge of the use and types of collections in Java |

Source: Own elaboration

After applying a pilot test to the students from the Moodle platform, the Kuder-Richardson (KR20) test was used to validate the internal consistency of the items, which resulted in a KR20=0.71, according to various authors, who point out that the value shows an acceptable correlation between the items, resulting in a useful resource for the stated objective.

The questionnaire was subsequently applied at two given moments during the intervention, the first was carried out before the students used the teaching material (pre-test) and the second after using the teaching material (post-test).

## Qualitative data collection

The qualitative research approach was carried out by applying a semi-structured interview. The instrument used was a survey which was based on the instrument developed by Morales (2008). This instrument was evaluated by expert judges in the areas of education and educational resource design. The measurement of the specified criteria used a five-point scale. The criteria that were evaluated were the psychopedagogical aspects, didactic-curricular aspects (logical significance) and technical and functional aspects (design and navigation). The instrument consisted of 12 questions with a Likert-type scale and open questions. The purpose of the instrument was to know the evaluation of the teaching material by the students, as well as their perception in the use of specific LO and VPL resources for learning the theory and developing the practice of programming.

## Sample

The type of sampling was a non-probabilistic sample and the technique used was convenience. The objects of study that were selected were the second semester students of the UAQ who are taking the Object Oriented Programming course. The students in this semester have already taken the programming fundamentals course in the previous semester, which was important to consider for the analysis of the OOP topics in the elaboration of the LO and exercises for the practice of programming with VPL. For this study, 17 students participated; through the support of the subject teacher, the students were provided with the form for their informed consent.

## Pedagogical strategy

The pedagogical strategy used for the development of the teaching material was based on the basic principles for teaching programming that are used in learning environments proposed by Djenic and Mitic (2017). These principles are based on teaching theory as a basis and then practical activity, emphasizing the active learning teaching methodology.

## Structure of the teaching material

The teaching material that was developed for the research was made up of twelve learning modules, the activities provided in each module were structured as follows:

1. **Review of the theoretical part** , where the content was presented in text format on a web page.
2. **Use of educational multimedia videos** as a complement to theoretical review.
3. **Learning activities** , which used the H5P tool for the development of interactive content, the activities developed are described below.
4. **Practical programming activities** , using the VPL tool, activities were configured that consisted of solving problems and their representation through code in Java language about the topics: collections, use of classes and objects, attributes and methods, and the use of OOP principles. Through this tool, the student accesses a development environment designed to facilitate the completion of activities. For this task, the Moodle VPL extension, version 4.0.1, has been installed.
5. **Self-assessment questionnaire** on the knowledge acquired in each learning module.

Table 2 shows the activities used with the H5P and VPL tools and the proposed learning topics:

**Table 2.** Activities used with the H5P and VPL tools

| Tool | H5P Tool Activity | Applied Topics | Subtopics |
|---|---|---|---|
| H5P | Interactive videos | - Programming concepts: Arrays, OOP properties, classes and objects | - Data structures in Java<br>- Inheritance, polymorphism, encapsulation and abstraction<br>- Attributes and methods. Abstract classes and methods |
| | Fill in the blanks | - Using classes and methods | - Classes, abstract classes and methods |
| | Drag words | - Introduction to Java | -Java working environment: jre and jdk<br>- Elements of a Java program: comments, constants, variables and operators |
| VPL | Programming practice | - The collections framework in Java<br>- Methods and classes | - Types of methods in Java, and their application in a Java program<br>- Practical use of classes and objects in a given problem |

Source: Own elaboration

The objective of the activities mentioned above and how they were used to teach Java programming are described below.

- Use of interactive videos to support the learning of programming concepts. According to Fonden (2020) when he mentions that making analogies of abstract concepts with real-life examples allows obtaining a certain skill or abstract thinking. In the interactive video activities, questions were set up that students had to answer during the course of the video. At the end, the student is shown a summary of the questions and the score obtained. In this way the student can be aware of his own acquired learning.

- Fill in the blanks in a text: in this activity users must complete the missing words in a given text. After completing all the words, the result or solution is displayed according to the settings.

The objective of this type of activity is the correct use of syntax on programming code, in this activity instructions are shown in source code of the Java language about the topics of classes and methods, the student must complete the instructions using the syntax of the language, at the end the correct solution is shown.

- Word dragging activity: in this The student must drag text fragments to complete a given expression. The purpose of this activity was to learn the elements that make up a Java program. Through texts that define the elements, the student relates the text or expression with the corresponding concept or element from a set of options.

- Practical programming activity: in this The student is asked to solve problems with the aim of being able to apply the theoretical knowledge acquired using a development environment within the teaching material.

## Results

The score obtained in the questionnaires was measured on a scale of 1 to 10. The average obtained for the pre-test group was 6.09 and the post-test was 8.30. The data obtained are shown in Table 3.

**Table 3.** Grades obtained in the pre-test and post-test

| Student No. | Pre-test rating | Post-test rating |
|---|---|---|
| 1 | 5.44 | 7.21 |
| 2 | 5.15 | 8.53 |
| 3 | 4.85 | 6.62 |
| 4 | 4.56 | 5.59 |
| 5 | 5.15 | 6.18 |
| 6 | 5.15 | 9.26 |
| 7 | 6.91 | 8.97 |
| 8 | 6.62 | 9.26 |
| 9 | 6.91 | 8.09 |
| 10 | 6.62 | 8.24 |
| 11 | 6.03 | 9.26 |
| 12 | 7.21 | 8.38 |
| 13 | 5.15 | 8.53 |
| 14 | 6.62 | 8.97 |
| 15 | 9.71 | 9.56 |
| 16 | 5.44 | 9.41 |
| 17 | 6.03 | 9.12 |

Source: Own elaboration

The data obtained presented a non-parametric distribution, therefore, the Wilcoxon signed rank test was used, it is the non-parametric equivalent of the paired test, which is based on scores of the differences between the medians and takes into account Its magnitude counts in the observed differences Randles (2006). This test is used to compare two ranges of measurements and determine that the difference is statistically significant. This study requires determining whether the grades obtained after using the teaching material (post-test) increased significantly with respect to the grades obtained before using the teaching material (pre-test). According to the Wilcoxon test, Table 4 shows the differences and ranges obtained.

**Table 4.** Differences and ranges in the data obtained.

| Student No. | Pre-test rating | Post-test rating | Difference | Ranks |
|---|---|---|---|---|
| 1 | 5.44 | 7.21 | -1.76 | 7.5 |
| 2 | 5.15 | 8.53 | -3.38 | 14.5 |
| 3 | 4.85 | 6.62 | -1.76 | 7.5 |
| 4 | 4.56 | 5.59 | -1.03 | 2.5 |
| 5 | 5.15 | 6.18 | -1.03 | 2.5 |
| 6 | 5.15 | 9.26 | -4.12 | 17 |
| 7 | 6.91 | 8.97 | -2.06 | 9 |
| 8 | 6.62 | 9.26 | -2.65 | 11 |
| 9 | 6.91 | 8.09 | -1.18 | 4.5 |
| 10 | 6.62 | 8.24 | -1.62 | 6 |
| 11 | 6.03 | 9.26 | -3.24 | 13 |
| 12 | 7.21 | 8.38 | -1.18 | 4.5 |
| 13 | 5.15 | 8.53 | -3.38 | 14.5 |
| 14 | 6.62 | 8.97 | -2.35 | 10 |
| 15 | 9.71 | 9.56 | 0.15 | 1 |
| 16 | 5.44 | 9.41 | -3.97 | 16 |
| 17 | 6.03 | 9.12 | -3.09 | 12 |

Source: Own elaboration

A significance level of $\alpha = 0.05$, after using the *Wilcox.test()* instruction in the R Studio program to obtain the *p-value* probability value, a value of 0.0002 was obtained, also, taking as the critical value of the T in the Wilcoxon table at this level of significance, a T value equal to 41 is obtained, therefore, since $1 < 41$ and $0.0002 < 0.05$ the null hypothesis is rejected, that is, there is a significant difference between the data obtained. Table 5 shows the results of the Wilcoxon signed rank test applied to the results in the pre-test and post-test grades of the experimental group.

**Table 5.** Results of the Wilcoxon signed-rank test

| N | α | p-value | Critical value | T+ |
|---|---|---|---|---|
| 17 | 0.05 | 0.0002 | 41 | 1 |

Source: Own elaboration

The result shows that students increased their knowledge of the Java language significantly after using the teaching material.

Subsequently, the data from the survey applied to evaluate the teaching material from the Moodle platform were collected. The results obtained from the descriptive analysis applied are shown in Table 6.

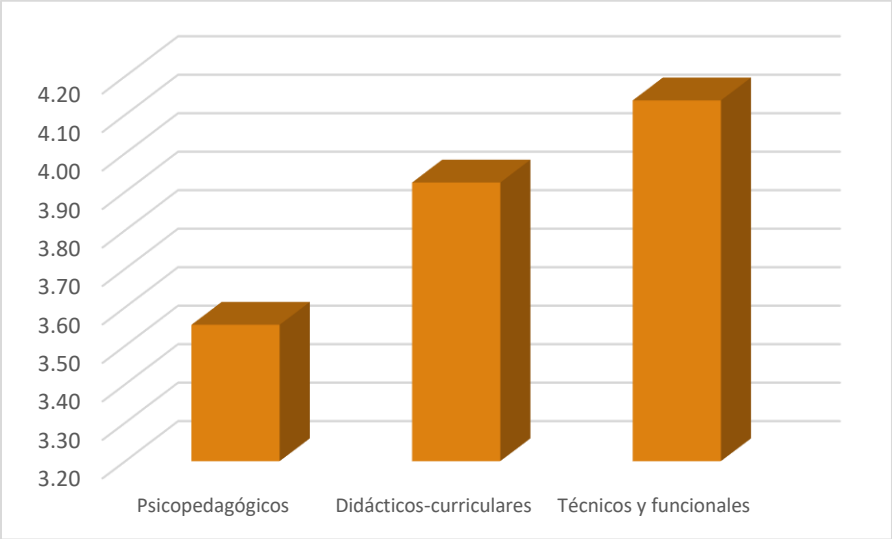
**Table 6.** Results of the evaluation of teaching materials

| Categories | Criteria | n | M | x̃ | Mo | s |
|---|---|---|---|---|---|---|
| Psychopedagogical | Motivation | 17 | 3.65 | 4 | 3 | 0.70 |
| | Difficulty | 13 | 3.46 | 3 | 4 | 1.90 |
| Didactic-curricular | Stake | 12 | 3.88 | 4 | 4 | 1.17 |
| | Description | 17 | 3.76 | 4 | 4 | 0.90 |
| | Goals | 17 | 3.88 | 4 | 4 | 0.70 |
| | Contents | 17 | 4.00 | 4 | 5 | 0.87 |
| | Activities | 17 | 3.82 | 4 | 3 | 0.95 |
| | Time | 12 | 4.06 | 4 | 4 | 1.29 |
| | Feedback | 17 | 4.06 | 4 | 4 | 0.78 |
| Technical-functional | Interactivity | 17 | 4.12 | 4 | 5 | 0.88 |
| | Navigation | 17 | 4.18 | 4 | 5 | 0.86 |
| | Design | 17 | 4.12 | 4 | 4 | 0.75 |

Source: Own elaboration

According to the measurement scale ranging from 1 to 5, it was found that the category that evaluates the technical and functional aspects was the category that obtained the highest score in the evaluation of the teaching material. Figure 1 shows the average obtained in the evaluated categories graphically.

**Figure 1.** Average obtained in the evaluated categories




Source: Own elaboration.

Regarding the questions asked to the students about their perception of the use of LO and VPL teaching resources for learning programming, Table 7 shows the total number of students who agreed on the effective use of the mentioned resources, the percentage they represent and the justification for the response.

**Table 7.** Evaluation of teaching resources

| Elements evaluated | Total students | Affirmative answers | Students % | Justification |
|---|---|---|---|---|
| Learning activities were an effective resource to achieve learning | 11 | 11 | 100 % | · The material was adequate<br>· They allowed me to put my learning into practice<br>· Better understanding of the topics<br>· Better understanding of concepts<br>· Interactive activities helped to better understand the theory |
| The time required to learn the VPL tool did not prevent me from carrying out my activities. | 11 | 10 | 91 % | . It was appropriate<br>· It took a little time<br>· Its use was clear |
| Using VPL allowed me to practice programming learning | 11 | 8 | 73 % | · It was very helpful<br>· It is a different way of learning |

Source: Own elaboration.

The results shown in the table above indicate that the learning activities were an effective resource to achieve the learning objectives. They mentioned that it was an easy-to-use resource, understandable for the development of the activities, and it also allowed them to better understand the theory, the concepts, as well as put into practice the topics seen in the module. In the evaluation of the VPL tool, 73% of them considered that it allowed them to put into practice the learning about programming, 91% of them mentioned that they had no problems in the use of this tool; However, 9% of the students mentioned the opposite,

because the tool was paused, which meant that the practices were not delivered in their entirety.

## Discussion

The use of learning objects as learning activities had a positive acceptance by the students, who considered that it was an easy-to-use, understandable resource for the development of the activities; this tool also allowed them to better understand the theory, the concepts, as well as to put into practice the topics seen in the learning modules; the results obtained coincide with those of Rossetti *et al.* (2020) where their research used the LOs for the learning of programming fundamentals, the results showed a positive impact on the students, who indicated that they contributed to their motivation for learning; Likewise, the effectiveness of the LOs in the acquisition of programming language skills could be demonstrated, obtaining significant differences in the experimental group; in the same way, the results obtained coincide with those of Guerrero and García (2016) where the use of LOs was applied for the learning of programming fundamentals, the students perceived that the LOs contributed to their motivation for learning and the effectiveness of the LOs in the acquisition of algorithmic thinking skills could be shown.

In the evaluation of the VPL tool, 81% of the students considered that it allowed them to effectively carry out programming activity practices; 19% mentioned having had problems in using the tool. The results obtained coincide with those of Lovos and González (2014) where they used the VPL tool for an introductory programming course, which resulted in positive acceptance by students for the development of programming activities; and in contrast to the results of Ramos *et al.* (2021) where the level of usability was measured when using the VPL tool applied to 37 students of the Introduction to Programming subject, the results showed a low level in the specific aspects of learning capacity and usefulness.

Regarding the evaluation of the teaching material that used LO and the VPL tool for learning Java programming, the students considered that the aspects of interactivity, navigation and design were appropriate for the learning process of Java programming, these results agree with what was expressed by Urbina (2019), in his study he mentions that the effectiveness and success in the use of techno-pedagogical material depends on factors such as visual design, coherent activities, quality of multimedia resources, accessibility and usability.

# Conclusions

According to the hypothesis raised by this study, a statistical analysis was applied using the Wilcoxon signed rank test in order to validate whether the use of teaching material that used the H5P and VPL tools contributed significantly to improving the learning of the Java language. As a result of this analysis, it was observed that the level of knowledge in students increased significantly.

The development of learning activities with the H5P tool allowed the design of activities that present code specific to the Java programming language. Through interaction, students can improve the use of syntax, as well as the assimilation of fundamental programming concepts through a more meaningful experience.

Using the VPL tool for programming practice helped in the development of programming skills such as the use of Java language syntax, use of programming logic for problem solving and specific skills such as the use of a development environment which is an essential skill for software developers.

The research showed the joint use of LOs and VPL teaching resources as a pedagogical strategy for the theoretical and practical teaching of programming, which had a positive impact on students by improving their knowledge of the Java programming language, as well as specific programming skills.

This article aims to provide a contribution to teaching strategies when using these ICT-based resources, highlighting the methodology used and the results obtained, with the aim of supporting the learning of programming in students who take subjects related to computing, as well as improving the skills that allow them to integrate into today's information society.

It is important to note that one of the limitations of the study was that a small sample was used, so it is not possible to make generalizations from the data obtained. Instead, it is suggested that future research apply this methodology to a larger sample.

## Future lines of research

Finally, it is proposed to continue analyzing the use of learning activities using the H5P tool in programming subjects, since it has been verified, through this study, the interest in the use of these activities in students, reflected in their motivation and acquired learning.

The development of the research took place within the facilities of the UAQ, so the teaching and learning process was carried out in the face-to-face modality, the professor participated in the implementation of the activities as well as being a guide and advisor in the activities, so it is left as future research to test the efficiency of the use of these tools for the e-learning and b-learning modalities, where communication is often carried out asynchronously, which represents a challenge for both students and teachers.

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