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Application of the ICT module: LaTeX, R and GitHub in teaching thesis writing skills to engineering students

Aplicación del módulo de NTICs: LaTeX, R y GitHub en el aprendizaje de edición de tesis para estudiantes de ingeniería

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Abstract

The study aimed to determine the impact of implementing a module on ICT tools—LaTeX, R, and GitHub—on the learning process of thesis writing in university engineering students. A quantitative, applied approach with a quasi-experimental design was used. The population consisted of ninth and tenth-semester engineering students from a public university. The sample comprised 41 students, divided into a control group (18 students) and an experimental group (23 students), selected using purposive non-probability sampling. Data were collected using a survey and an evaluation instrument with 22 items, organized into three dimensions: conceptual, procedural, and attitudinal learning. The instrument's reliability, measured using the Kuder-Richardson 20 (KR-20) coefficient, was 0.832, indicating high reliability. The results show that implementing the ICT module had a significant effect on thesis writing skills, as evidenced by the Mann-Whitney U test (U = 1.000; z = -5.622), with a p-value < 0.001, exceeding the critical threshold of 1.96. In conclusion, integrating LaTeX, R, and GitHub into the academic curriculum contributes significantly to improving thesis writing skills in engineering students.

Keywords: learning, thesis writing, GitHub, LaTeX, ICT.

Resumen

El estudio tuvo como objetivo determinar la influencia de la aplicación del módulo de NTICs —LaTeX, R y GitHub— en el aprendizaje de la edición de tesis en estudiantes universitarios de ingeniería. Se empleó un enfoque cuantitativo, aplicado, con un diseño cuasi experimental. La población estuvo conformada por estudiantes del noveno y décimo ciclo de Ingeniería de una universidad nacional. La muestra constó de 41 estudiantes, distribuidos en 18 para el grupo control y 23 para el grupo experimental, seleccionados mediante muestreo no probabilístico intencionado. La recolección de datos se realizó con una encuesta y un instrumento evaluativo compuesto por 22 ítems, organizados en tres dimensiones: aprendizaje conceptual, procedimental y actitudinal. La confiabilidad del instrumento, medida mediante el coeficiente KR-20, fue de 0.832, lo que indica una alta fiabilidad. Los resultados muestran que la implementación del módulo de NTICs tiene un efecto significativo en el aprendizaje de la edición de tesis, evidenciado por la prueba estadística U de Mann-Whitney (U = 1.000; z = -

5.622), con un valor p < 0.001, lo que supera el umbral crítico de 1.96. En conclusión, la integración de LaTeX, R y GitHub en la formación académica contribuye de manera significativa a mejorar las habilidades de edición de tesis en los estudiantes de ingeniería.

Palabras clave: aprendizaje, edición de tesis, GitHub, LaTeX, NTICs.

Introduction

In Spain, the programming course for first-year university students faces two opposing challenges: on one hand, students with prior knowledge who are unfamiliar with professional environments, and on the other, students without programming training who find the subject difficult due to its differences from other more familiar foundational courses (Águila et al., 2021). Concurrently, there is an effort to enhance the inclusion of educational services by considering student feedback; however, it is essential to identify, through focus groups in various schools, the main tools used for collaborative work, information exchange, and content creation (Perona, 2020).

In Mexico, there is a growing demand for more interactive guides for programming and project management, driven by the lack of personalized resources that support academic development in the GitHub environment. This presents the challenge of evaluating the impact of an interactive tutor and proposing effective improvements (Reyes et al., 2024).

In Paraguay, there is an acknowledgment of the challenge of understanding the possibilities and limitations of information and communication technologies (ICT) in various fields, including education, in light of the constant evolution of computer, telecommunications, audiovisual, internet, multimedia applications, and virtual reality technologies (Cardozo, 2022).

In Peru, a crucial difficulty in education is the limited alignment between educational objectives and effective access to technology. It is expected that educators not only transmit knowledge but also technically train their students and develop digital competencies that can meet the demands of an increasingly information- and technology-oriented society (Ponce, 2022). In this context, ICT constitutes digital systems that manage emerging technologies for storing, processing, and disseminating information. The challenge lies in adequately integrating them into educational processes, ensuring effective use that enhances academic training and reduces existing technological gaps (Ruiz, 2020).

Consequently, this study poses the question: What is the influence of the ICT module—LaTeX, R, and GitHub—on thesis editing learning among engineering students? Thus, this study aims to determine this influence under the hypothesis that the application of the module has a significant effect on this competency.

In international background, Sarkar (2021) highlights the relevance of practical workshops on LaTeX, an essential tool in mathematics, physics, and computer science. These workshops help to overcome the learning curve by instructing on commands, formatting, bibliography creation, tables, equations, and technical reports, facilitating collaborative writing with Overleaf. Zheng (2023) confirms that although LaTeX and Microsoft Word are the most commonly used academic typesetting systems, many authors are unaware of LaTeX, which is why their workshops focus on training participants for its efficient academic use. Li et al. (2024) present QuickQuill, a web-based WYSIWYG editor that combines simplicity and power to write mathematical equations in LaTeX, overcoming the complexity of traditional editors and allowing for synchronized editing across browsers.

Sotomayor-Beltran et al. (2021) demonstrated the benefits of using LaTeX in engineering courses, emphasizing its ease of writing equations and managing citations, in addition to the professional quality of the generated documents. Engineering students in systems and electronics recognize the superiority of LaTeX compared to other word processors.

Meanwhile, Lazo et al. (2024) study GitHub Copilot, an artificial intelligence tool that suggests code in real-time, improving productivity and performance in programming, which represents a significant advancement for training in the efficient management and production of information.

The widespread adoption of ICT transforms the global economy, especially in developed countries, shaping the information society. This phenomenon transcends communication and impacts political, social, economic, labor, and legal structures, facilitating rapid information management (Grajales & Osorno, 2019).

LaTeX, created by Leslie Lamport, is a macro-based system of TeX that offers detailed control over typographic composition, generating professional documents across various platforms without being a conventional word processor (Mora-Flores & Borbón-Alpízar, 2012). R is an object-oriented programming language, versatile and equipped with a vast repository of packages for statistical analysis across multiple fields (Jiménez, 2019). GitHub serves as a remote and collaborative code repository, facilitating project management and version control for both public and private projects (López-Pellicer et al., 2015).

The learning of thesis editing is understood as the comprehensive development of competencies from a human perspective, extending beyond academic knowledge to include knowing how to be, knowing how to do, knowing how to know, and knowing how to coexist (Tobón, 2013). This learning encompasses three dimensions: conceptual, related to the meaningful processing of information; procedural, associated with practical application and problem-solving with planning; and attitudinal, which involves motivation, identity formation, and emotional control (Tobón, 2013).

In summary, the general hypothesis posits that the application of the ICT module—LaTeX, R, and GitHub—significantly influences the learning of thesis editing among students in the ninth and tenth cycles of the Faculty of Engineering.

Methodology

This study utilized a quantitative approach, of an applied nature, with a quasi-experimental design. The independent variable was intentionally manipulated, conducting a pre-test and post-test with a specific stimulus (program), which allowed for the comparison of results obtained before and after the intervention (Hernández & Mendoza, 2018).

The population consisted of all students in the ninth and tenth cycles of the Faculty of Engineering at the national university. The sample comprised 41 students, with 18 in the control group and 23 in the experimental group. The sampling was non-probabilistic and conducted for the convenience of the researchers.

The technique employed was the survey, and the instrument consisted of a knowledge test with 22 items, organized into three dimensions: conceptual learning, procedural learning, and attitudinal learning (Tobón, 2013).

The validity of the study was determined through expert judgment, which established that the instrument was valid. Reliability was calculated using the KR-20 coefficient, suitable for dichotomous scales; in a pilot sample of 30 students, the result was 0.832, interpreted as strong reliability.

Results

Descriptive results

The descriptive results are presented in Tables 1 to 4, comparing the levels of thesis editing learning in the control and experimental groups in both the pre-test and post-test.

Table 1

Results of thesis editing learning in the pre-test and post-test for the experimental and control groups

Level	Control Group				Experimental Group			
	Pre-test		Post-test		Pre-test		Post-test	
	fi	f%	fi	f%	fi	f%	fi	f%
Low	8	44.4	11	61.1	12	52.5	0	0.0
Medium	10	55.6	7	38.9	11	26.8	2	8.7
High	0	0.0	0	0.0	0	0.0	21	91.3
Total	**18**	**100.0**	**18**	**100.0**	**23**	**100.0**	**23**	**100.0**

In Table 1, both groups show similar results in the pre-test. However, in the post-test, the experimental group shows significant progress: while in the pre-test this group had 52.5% at a low level and 26.8% at a medium level, in the post-test it reached 8.7% at a medium level and a remarkable 91.3% at a high level. In contrast, the control group maintains higher frequencies in low and medium levels.

Table 2

Results of conceptual learning of thesis editing in the pre-test and post-test for the experimental and control groups

Level	Control Group				Experimental Group			
	Pre-test		Post-test		Pre-test		Post-test	
	fi	f%	fi	f%	fi	f%	fi	f%

Low	1	5.6	1	5.6	3	13.0	0	0.0
Medium	17	94.4	17	94.4	19	82.6	1	4.3
High	0	0.0	0	0.0	1	4.3	22	95.7
Total	**18**	**100.0**	**18**	**100.0**	**23**	**100.0**	**23**	**100.0**

Table 2 shows conceptual learning. Initially, both groups record similar levels, with a predominance of medium and low levels in the experimental group (82.6% and 13.0%, respectively). Subsequently, the post-test reveals substantial improvement in the experimental group, reaching 95.7% at a high level and only 4.3% at a medium level, while the control group continues to show predominantly medium levels.

Table 1

Results of procedural learning of thesis editing in the pre-test and post-test for the experimental and control groups

Level	Control Group				Experimental Group			
	Pre-test		Post-test		Pre-test		Post-test	
	fi	f%	fi	f%	fi	f%	fi	f%
Low	10	55.6	9	50.0	10	43.5	0	0.0
Medium	7	38.9	8	44.4	13	56.8	2	8.7
High	1	5.6	1	5.6	0	0.0	21	91.3
Total	**18**	**100.0**	**18**	**100.0**	**23**	**100.0**	**23**	**100.0**

Regarding procedural learning (Table 3), the pre-test indicates comparable distributions between the groups, with the experimental group showing 43.5% at a low level and 56.8% at a medium level. In the post-test, this group improves considerably, presenting 91.3% at a high level and 8.7% at a medium level, while the control group reflects few changes.

Table 4

Results of attitudinal learning of thesis editing in the pre-test and post-test for the experimental and control groups

Level	Control Group				Experimental Group			
	Pre-test		Post-test		Pre-test		Post-test	
	fi	f%	fi	f%	fi	f%	fi	f%
Low	2	11.1	2	11.1	7	30.4	0	0.0
Medium	7	38.9	11	61.1	6	26.1	0	0.0
High	9	50.0	5	27.8	10	43.5	23	100.0
Total	**18**	**100.0**	**18**	**100.0**	**23**	**100.0**	**23**	**100.0**

Finally, in Table 4, regarding attitudinal learning, the pre-test shows that the experimental group has 30.4% at a low level, 26.1% at a medium level, and 43.5% at a high level. In the post-test, this group reaches a high level of 100%, indicating clear progress. The control group, on the other hand, shows less significant changes.

Inferential analysis

Normality tests

Table 5

Results of the test

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.

Thesis Editing Learning Pre-test	0.138	41	,047
Thesis Editing Learning Post-test	0.249	41	,000
Conceptual Learning Pre-test	0.205	41	,000
Conceptual Learning Post-test	0.247	41	,000
Procedural Learning Pre-test	0.220	41	,000
Procedural Learning Post-test	0.285	41	,000
Attitudinal Learning Pre-test	0.247	41	,000
Attitudinal Learning Post-test	0.418	41	,000

Table 5 presents the results of the Kolmogorov-Smirnov normality test for the main variable and its dimensions. In all cases, the significance values are less than 0.05, indicating that the data distribution does not follow a normal curve. Therefore, it is appropriate to employ a non-parametric statistical model, specifically the Mann-Whitney U test, to contrast the proposed hypotheses.

Hypothesis testing

The null hypothesis (H0: μ1=μ2) states that the application of the ICT module—LaTeX, R, and GitHub—does not significantly influence the learning of thesis editing among ninth and tenth cycle students of the Faculty of Engineering.

In contrast, the alternative hypothesis (Ha: μ1≠μ2) posits that this module does significantly influence that learning.

Table 6

Results of the thesis editing learning contrast according to the pre-test and post-test

Ranks

	Group	N	Average Rank	Sum of Ranks
Thesis editing learning Pre-test	Control	18	20.75	373.50
	Experimental	23	21.20	487.50
	Total	**41**		
Thesis editing learning Post-test	Control	18	9.56	172.00
	Experimental	23	29.96	689.00
	Total	**41**		

Test Statistics[a]

	Thesis editing learning Pre-test	Thesis editing learning Post-test
Mann-Whitney U	202.500	1.000
Wilcoxon W	373.500	172.000
Z	-0.120	-5.622
Asymptotic Sig. (two-tailed)	0.904	0.000
a. Grouping variable: Group		

According to Table 6, in the pre-test, the average ranks are similar between the control group (20.75) and the experimental group (21.20), reflecting the absence of significant differences. However, in the post-test, the experimental group presents a much higher average rank (29.96) compared to the control group (9.56).

The Mann-Whitney U test yields a value of 1.000 in the post-test, with a Z statistic of -5.622, which exceeds the critical value of 1.96 in absolute terms, placing it in the rejection zone of the null hypothesis. Additionally, the p-value is 0.000, lower than the significance level α = 0.05.

Therefore, the alternative hypothesis is accepted, and the null hypothesis is rejected, concluding that the application of the ICT module—LaTeX, R, and GitHub—significantly influences the learning of thesis editing among ninth and tenth cycle students of the Faculty of Engineering.

Discussion

After analyzing the results of the study, it is confirmed that the application of the ICT module—LaTeX, R, and GitHub—significantly influences the learning of thesis editing among ninth and tenth cycle students of the Faculty of Engineering. This is supported by the values obtained from the Mann-Whitney U test (U = 1,000), a Z statistic of -5.622, which exceeds the critical value of 1.96, and a p-value of 0.000, which is below the established significance level (α = 0.05).

These findings closely relate to the study by Sarkar (2021), who emphasizes the importance of developing practical workshops that introduce LaTeX as an essential tool for preparing high-quality documents. According to this author, LaTeX facilitates professional typographic composition, offers clear advantages over traditional editors like MS Word, and allows for the creation of bibliographies, tables, equations, and technical reports, in addition to promoting collaboration through platforms like Overleaf. Participants in these workshops overcome the learning curve and improve their ability to draft technical documents and guide others in its use, which is supported by Sarkar's teaching experience with engineering students.

Complementarily, Zheng (2023) identifies that LaTeX and Microsoft Word are the most widely used academic typesetting systems, although many authors are unaware of the complexities of LaTeX, making an interactive workshop essential to familiarize users with this tool to optimize academic writing.

Moreover, Li et al. (2024) point out the need for quick and simple document editors that combine functionality and ease of use, such as the QuickQuill editor, which integrates the writing of mathematical equations in LaTeX with a WYSIWYG interface, overcoming the difficult learning curve typical of pure LaTeX or simple editors like Markdown.

At the national level, Sotomayor-Beltran et al. (2021) agree by highlighting the benefits of LaTeX in engineering research courses, emphasizing its ease of writing mathematical equations and managing different citation styles (APA, IEEE, Vancouver), in addition to generating professional documents.

Finally, based on the theoretical perspective of Tobón (2013), the learning of thesis editing is conceived as the process through which competencies are developed from a comprehensive human education that transcends traditional academic content, encompassing knowing how to be, knowing how to do, knowing how to know, and knowing how to coexist—essential elements for education.

Conclusions

The study concludes that the application of the ICT module—LaTeX, R, and GitHub—significantly influences the learning of thesis editing among ninth and tenth cycle students of the Faculty of Engineering, as evidenced by the Mann-Whitney U value of 1,000 and a Z statistic of -5.622. In this sense, the proposed workshop effectively contributes to participants overcoming the learning curve of LaTeX, facilitating its use both in drafting technical documents and in guiding other users in handling this tool.

Furthermore, it is confirmed that the use of these new technologies optimizes the quality of writing and academic formatting, strengthens data analysis and representation through R, and fosters the development of skills for collaborative management and version control via GitHub.

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