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ORIGINAL ARTICLE

The educational software FarmApk as a resource for learning Clinical Pharmacology

El *software* educativo FarmApk como recurso para el aprendizaje de la Farmacología Clínica

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ABSTRACT

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Background: the use of educational software in the teaching-learning process in educational institutions establishes a significant foundation in classes across different subjects, by enabling dynamic teacher-student interaction.
Objective: to describe the evaluative results of the Clinical Pharmacology subject, after the application of the FarmApk educational software.
Methods: a descriptive research study was conducted at the Villa Clara University of Medical Sciences, from February to November 2024. Theoretical, empirical, and mathematical methods were used to express the research results.
Results: after the use of the educational software, the number of students passing increased significantly in 5 out of 7 questions; the strongest impact was seen in questions 5 (40.4% more passes) and 4 (17.3%). Grades improved significantly in questions 2, 3, 4, 5, and 7, with more high marks achieved and a reduction in low-grade categories.
Conclusions: the evaluative results of the Clinical Pharmacology subject improved considerably after the application of the FarmApk software.
MeSH: knowledge management; e-accessibility; information technology; learning; students; education, medical

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RESUMEN

Fundamento: la utilización del software educativo en el proceso enseñanza aprendizaje en instituciones educativas establece una base significativa en las clases de las diferentes asignaturas, al permitir una interacción dinámica docente-estudiante.
Objetivo: describir los resultados evaluativos de la asignatura Farmacología Clínica, después de la aplicación del *software* educativo FarmApk.
Métodos: se realizó una investigación descriptiva en la Universidad de Ciencias Médicas de Villa Clara, en el periodo febrero-noviembre 2024. Se utilizaron métodos teóricos, empíricos, y matemáticos para expresar los resultados de la investigación.
Resultados: posterior a la utilización del *software* educativo, aumentaron significativamente la cifra de aprobados en 5 de 7 interrogantes; el impacto más fuerte se expresó en las preguntas 5 (40,4 % más aprobados) y 4 (17,3 %). Mejoraron significativamente las

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calificaciones en las preguntas 2, 3, 4, 5 y 7, se lograron más notas altas y una reducción en categorías de notas bajas.

Conclusiones: los resultados evaluativos de la asignatura Farmacología Clínica mejoraron considerablemente después de la aplicación del *software* FarmApk.

DeCS: gestión del conocimiento; e-accesibilidad; tecnología de la información; aprendizaje; estudiantes; educación médica

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INTRODUCTION

Clinical pharmacology as a science is very broad, encompassing all aspects related to drugs or medications; however, for the interest of medical students and their future clinical practice, it is more limited. It is a subject that aims to enable future graduates to carry out, on a scientific basis, a rational use of medications and to be capable of continuing their education and educating their patients against self-medication and the unnecessary use of drugs. All of this justifies its presence in the curriculum of the Medical degree.[1]

The fundamental mission of the knowledge society lies in promoting the constant learning of human beings through a network of formal and non-formal institutions that, supported by technological innovation and computer networks, make possible the task of harnessing the new knowledge generated in the fourth industrial revolution.[2,3]

The use of educational software in the teaching-learning process establishes a significant foundation in classes, allowing for dynamic interaction between teacher and students.

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Favorable changes are observed as motivation increases, and the effectiveness and efficiency of knowledge are stimulated.[4]

Software designed for autonomous teaching and learning allows for the development of certain cognitive skills. When mentioned, it refers to interactive educational or didactic programs, created with the purpose of being used to facilitate the teaching-learning process; all programs for general use in educational units are excluded from this type: word processors, database managers, spreadsheets, graphic editors, among others.[4]

It is characterized by being highly interactive; multimedia tools, videos, sounds, photographs, specialized dictionaries, exercises, and instructional games support the evaluation and diagnostic functions; combined with teacher explanations, they manage to elevate knowledge. The objective is for meaningful learning to arise from this exchange.(4) These programs cover a wide range, from those based on traditional behaviorist models to the most advanced intelligent computer-assisted teaching systems.[5]

It is important to consider the use of educational software with appropriate methodologies in different classes; these stimulate interest through new experiences that give rise to knowledge and thought, favor students with skills, knowledge, and mastery of information and communication technologies (ICT) to increase their potential. Their strategies strengthen education at different levels and promote revealing learning, and foster the active participation of students in classes, who then replicate this knowledge in practice.[4]

Understanding and meeting student expectations to increase their satisfaction with academic performance is a challenge, given that when they enter university they bring many expectations.[6]

Clinical Pharmacology is complex due to its topics and assessments; its final evaluative act is a written exam to which a considerable volume of content contributes. For this reason, software was created that includes all topics and each of the teaching organizational forms. It was applied to achieve a better understanding of the contents and obtain better academic

success. The objective of this research is: to describe the evaluative results of the Clinical Pharmacology subject, after the application of the FarmApk educational software.

METHODS

A descriptive research study was conducted at the Faculty of Medicine of the Villa Clara University of Medical Sciences, from February to November 2024. The study population consisted of students who took the final exam for the Clinical Pharmacology subject in the academic years 2023 (group 1, n=229) and 2024 (group 2, n=199), and the results were compared. Theoretical and empirical methods were used, as well as mathematical methods to express the research results.

Theoretical methods used:

- Analysis-synthesis: for the theoretical foundations of the topic based on the literature review conducted.
- Induction-deduction: to interpret the results obtained and arrive at the conclusions of the work.

Empirical methods: documentary review of the final exam for the Clinical Pharmacology subject to investigate its results, and the grade record of third-year medical students who take the subject. Data corresponding to the academic years studied were collected from each student's exams. The results of exam success and grades for each question were compared, considering their type and content.

In both academic years, the subject's syllabus, and consequently the objectives, were similar. In preparing the exams, care was taken to ensure that the type and complexity of the questions were equivalent.

All information was collected and categorized to create the database. It was entered manually into a computer with the technical requirements to execute the professional statistical software packages IBM® SPSS® Statistics version 22.0 for Windows with quality,

with which the information processing was carried out. The data were stored in a file generated by the software itself, compatible and exportable to other databases and computer systems, which allows for the generalization of the research.

The datasets were evaluated using parametric normality tests, to detect the basic assumptions about the distribution that must be considered in the multivariate analysis, fulfilling all statistical tests, and thereby the properties of homoscedasticity, linearity, normality, and non-multicollinearity.[7]

Summary measures were used in the description of the variables. For quantitative variables, measures of central tendency, dispersion, and position were used (mean and standard deviation (SD) for normally distributed data; median and interquartile range (IQR) for non-normal distributions). For qualitative variables, frequency distributions expressed in absolute and relative values (number and percentage) were performed.

For all hypothesis tests performed, a significance value (p) of 0.05 was considered for statistical decision-making ($p > 0.05$ not significant and $p \leq 0.05$ significant). Statistics with p-values ≤ 0.01 were considered very significant and $p \leq 0.001$ highly significant.

To determine the effect size, Cliff's delta (r) was used (adapted for non-parametric tests), where $r \approx 0.1$ (Small effect), $r \approx 0.3$ (Moderate effect), and $r \approx 0.5$ (Large effect).

Ethical aspects: the conception and implementation of the research took care not to violate the principles of health research ethics. When analyzing the success results of the different groups, their privacy and anonymity were respected.

RESULTS AND DISCUSSION

In reviewing the subject's final exam for the 2024 academic year, slightly higher results were observed compared to the results from the previous year when the educational software had not been used.

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The success rate for the 2023 academic year was 88.9%, lower than that for 2024 (89.8%); it is observed that after the use of the software, the success rate increased by 0.9%, a result that from a statistical point of view is not significant; the authors consider that, given the complexity of the subject, an increase in the success rate, even if slight, is always a satisfactory and revealing result.

These results coincide with those of Gutiérrez Segura[8] who notes the value of software, and refers to the contribution of these learning resources to the preparation of students and teachers for practical classes, independent work, and theoretical-practical classes. Furthermore, they assess its quality and the positive changes achieved in the students' knowledge level.

Teaching constitutes the process of organizing and directing cognitive activity in which the teacher and student interact, and therefore it is called the teaching-learning process; it constitutes a system in which each of its components: objectives, content, methods, means, and evaluation are interrelated. Evaluation is the regulatory mechanism of the system and can be considered as the instrument for controlling the quality of the product resulting from the process.[8]

Academic performance expresses the evaluation of competencies acquired in the school environment. A student with good academic performance is one who obtains positive grades on the exams they must take in a course. It is one of the most important dimensions in the teaching-learning process.[8]

The authors consider that the use of educational software constitutes a strength for students, agreeing with Borja Santillán *et al.*,[9] who state that properly handling teaching materials, whether conventional or through multimedia and interactive techniques, will improve the understanding of information or knowledge, specify its objectives in their individual work, and enhance the development of attitudes such as responsibility and teamwork.

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Descriptive statistical analysis

Normality tests (Shapiro-Wilk) were performed; it was found that all questions in both groups showed $p < 0.001$ (non-normal distributions), so it was determined to use non-parametric Mann-Whitney U tests to carry out the comparison between groups.

For each group and question, the descriptive statistics of mean and standard deviation of the grades on the questions; percentage of passes (grade ≥ 3); and frequency distribution (Excellent, Good, Fair, Poor) were calculated.

Table 1 shows the percentage of passes (grade ≥ 3) for all questions in both groups, along with the p-values from the statistical test (Mann-Whitney U to compare distributions) and the effect size (r).

Table 1. Percentage of passes and statistical significance. Final exam for Clinical Pharmacology. Academic year 2023 (group 1, n=229) and academic year 2024 (group 2, n=199)

Question	Group 1	Grup 2	Difference (G2 - G1) % point	p-value (Mann-Whitney U)	Effect Size (r)
P1	90.8 %	93.5 %	+2.7 %	0.052	0.09 (Not significant)
P2	77.3 %	86.4 %	+9.1 %	0.004	0.13 (Small)
P3	80.8 %	88.4 %	+7.6 %	0.018	0.13 (Small)
P4	68.6 %	85.9 %	+17.3 %	<0.001	0.28 (Moderate)
P5	51.1 %	91.5 %	+40.4 %	<0.001	0.65 (Large)
P6	83.4 %	82.9 %	-0.5 %	0.412	0.03 (Not significant)
P7	87.3 %	94.0 %	+6.7 %	<0.001	0.20 (Small-moderate)

Source: database.

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Effect size is evaluated using Cliff's delta (r), adapted for non-parametric tests, where r≈0.1 (Small effect), r≈0.3 (Moderate effect), and r≈0.5 (Large effect). The results are presented in Table 2.

The questions with the greatest improvement in pass rates were question 5: +40.4% (from 51.1% to 91.5%, $p<0.001$, Large effect) and question 4: +17.3% (from 68.6% to 85.9%, $p<0.001$, Moderate effect).

Questions without significant changes were questions 1 and 6, with minimal and non-significant differences ($p>0.052$ and $p>0.412$ respectively).

According to effect size: Large effect: only in Q5 (r=0.65); Moderate effect: Q4 (r=0.28); Small effect: Q2, Q3, Q7. The pedagogical novelty (educational software) allowed for a significant increase in passes in 5 out of 7 questions (Q2, Q3, Q4, Q5, Q7); the strongest impact was in Q5 (40.4% more passes) and Q4 (17.3%). There was no effect on Q1 and Q6 (they already had high pass percentages).

The authors of this research consulted experiences and agreed with others(9,10) on the importance of didactic resources with elements that the teacher adapts or modifies according to the learning objective, to make their task as mediator easier, while facilitating the student's understanding and assimilation of content; it awakens and captures their interest and enhances their creative abilities. These materials can be conventional, audiovisual, and technological.

Educational software influences the learning of university students. Navarro Huaringa *et al.*[11] demonstrated that it intervenes positively with highly significant values. Similarly, this result agrees with Zenteno Ruiz *et al.*,[12] who applied the Micromundos Pro educational software in the Mathematics subject. Aburto Garcés[13] analyzed the usefulness of educational software in Medical Optometry (SE-OM).

Comparison between groups

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The non-parametric Mann-Whitney U test is used to compare medians between independent groups, with a null hypothesis H0 (no differences between groups) and alternative hypothesis H1 (differences exist). If the p-value < 0.05, it indicates that there are significant differences.

Effect size is evaluated using Cliff's delta (r) (adapted for non-parametric tests), where r≈0.1 (Small effect), r≈0.3 (Moderate effect), and r≈0.5 (Large effect). The results are shown in Table 2.

Table 2. Questions with greatest impact and effect size. Final exam for Clinical Pharmacology. Academic year 2023 (group 1, n=229) and academic year 2024 (group 2, n=199)

Question	-P value	Effect Size (r)	Interpretation
P1	0.052	0.09	Not significant
P2	0.004	0.16	Small effect
P3	0.018	0.13	Small effect
P4	<0.001	0.28	Moderate effect
P5	<0.001	0.65	Large effect
P6	0.412	0.03	Not significant
P7	<0.001	0.20	Small-moderate effect

Source: database.

The results derived from the interpretation of Table 2 show that the questions with the greatest impact were 5, 4, and 7.

Question 5:

- Largest mean difference (+1.45 points).
- 40.4% more passes in Group 2.

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- Large effect (r=0.65).

Question 4:

- Difference of +0.61 points.
- 17.3% more passes.
- Moderate effect (r=0.28).

Question 7:

- Increase of +0.34 points.
- Small-moderate effect (r=0.20).

Four of the seven questions showed significant differences (Q2, Q3, Q4, Q5, Q7):

- Greatest improvement: Q5 (comprehension/depth)
- No changes: Q1 and Q6
- Average effect size: r=0.22 (global small-moderate effect)

The results of the comparison between groups showed that grades improved significantly in Q2, Q3, Q4, Q5, and Q7, with the greatest impact in Q5, and that there was no effect in Q1 and Q6 (possibly content already mastered). It also highlighted that overall pass rates increased, especially in Q5 (+40.4%).

Ongoing teacher training in new didactic strategies enables them to strengthen the teaching learning process of their students as an integrated part of their daily work, rather than as an extra activity at the end of their student life. The different strategies require teachers to be the first to learn about them, use them, and encourage their implementation, so that students can experience various solution paths, even when they are not the traditional ones.[9]

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The different situations presented in classes demonstrate the need to use tools that facilitate knowledge and promote interactive and practical learning. It is necessary to make an effective change that allows taking actions aimed at correcting possible errors in order to achieve an overview of the current situation of teaching and learning in different educational institutions.[4]

To make a specific comparison by grade categories between the groups, relative frequency analysis and the Chi-Square test were used to determine if there are significant differences in their distribution between the groups.

Results of the frequency distribution by category and question

The percentage of students in the grade categories (Excellent 5; Good 4; Fair 3; and Poor 2) was calculated for both groups (group 1, without the application of educational software; group 2, with its application) for all questions, to evaluate the percentage differences, as observed in Table 3.

Tabla 3. Distribución porcentual por categoría y preguntas. Examen final de Farmacología Clínica. Curso 2023 (grupo 1, n=229) y curso 2024 (grupo 2, n=199)

Question	Group 1 (n=229)				Group 2 (n=199)			
	(5) %	(4) %	(3) %	(2) %	(5) %	(4) %	(3) %	(2) %
P1	32.3	40.2	18.3	9.2	38.2	42.7	12.6	6.5
P2	27.5	32.3	17.5	22.7	35.7	38.2	12.5	13.6
P3	29.7	34.1	17.0	19.2	35.2	40.2	13.0	11.6
P4	18.3	30.1	20.2	31.4	28.6	40.2	17.1	14.1
P5	15.7	35.4	27.1	21.8	43.8	47.7	8.5	0.0
P6	30.1	35.4	17.9	16.6	31.2	38.2	13.5	17.1
P7	33.2	38.0	16.1	12.7	45.2	38.7	10.1	6.0

Source: Database.

A greater impact is achieved in the high-grade categories:

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- P5: 28.1% increase in Excellent (from 15.7% to 43.8%)
- P7: 12.0% increase in Excellent (from 33.2% to 45.2%)

A reduction is achieved in the low-grade categories:

- P5: complete elimination of the Poor grade (0% in Group 2 vs. 21.8% in Group 1).
- P4: 17.3% reduction in Poor.

Question 6 showed minimal changes (differences less than 5% in all categories); there was an increase in Excellent in group 2 for most questions (especially P5: +28.1%); reduction in Poor. (e.g., P5: -25.4%).

The use of technologies in medical education has introduced new paradigms: student-centered education, self-learning, and knowledge management. The historical role of teachers has also changed, as they become facilitators, modulators, and moderators of the process, promoting the creation of virtual educational spaces that, based on new pedagogical models, can guarantee student learning using innovative strategies, increase the level of motivation and their ability to search for solutions to the problems posed.[4]

Similar results were found by other authors[4,14,15] when applying their digital products, who noted an increase in the level of knowledge after applying the tool, suggesting that the information offered in the multimedia is of sufficient quality and depth.

The Chi-Square test is performed to assess whether the differences in the distributions are statistically significant. The results are shown in Table 4.

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Tabla 4. Prueba Chi-Cuadrado. Examen final de Farmacología Clínica. Curso 2023 (grupo 1, n=229) y curso 2024 (grupo 2, n=199)

Question	χ^2	p-value	Significant (p < 0.05) ?	Effect Size (φ)
P1	6.21	0.102	No	0.12
P2	12.45	0.006	yes	0.17 Small effec
P3	9.87	0.020	yes	0.15
P4	28.34	<0.001	yes	0.26 Moderate effect
P5	142.11	<0.001	yes	0.58 Large effect
P6	4.99	0.172	No	0.10
P7	15.73	0.001	yes	0.19 Small-moderate effect

Source: Database.

Question 5 shows the greatest difference (χ^2=142.11, p<0.001).
Detailed comparison considering questions 4 and 5, which showed the largest effects:

Question 5 (greatest impact):

- Excellent:increase of 28.1% (from 15.7% to 43.8%)
- Good: increase of 12.3% (from 35.4% to 47.7%)
- Fair:decrease of 18.6% (from 27.1% to 8.5%)
- Poor: decrease of 21.8% (from 21.8% to 0%)

Question 4 (moderate effect):

- Excellent: increase of 10.3% (from 18.3% to 28.6%)
- Poor: decrease of 17.3% (from 31.4% to 14.1%)

The applied pedagogical novelty drastically reduced low grades (Poor) and increased high grades (Excellent), shifting them towards higher grades (Excellent and Good), especially in Q4, Q5, and Q7.

Impact on high grades: significant increase in the Excellent grade (e.g., +28.1% in Q5).
Reduction of low grades: Poor decreased by up to 21.8% (Q5).

ICTs have become a fundamental instrument in teaching-learning processes worldwide. Educational software is associated with greater student motivation thanks to its attractive, entertaining, and sometimes fun design; they have proliferated in all educational systems due to their significant contribution to learning.[10]

Maldonado Zúñiga *et al*.,[4] before applying the product, evidenced a predominantly low level of knowledge (59%); after its application, these figures decreased by 4.8%, which showed a high level of knowledge in 75.7% of students. Similarly, Martínez Mayorga *et al*.[10] demonstrated that students who used technological tools had better academic performance than those who did not use them as pedagogical support.

To perform a combined comparison by categories between the groups, the Chi-Square test (χ^2) was applied to evaluate if there are significant differences in the proportion of students with high grades (5+4) vs. low grades (3+2). The results are presented in Table 5.

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Table 5. Percentages of Excellent + Good (High grades) vs. Fair + Poor (Low grades). Final exam for Clinical Pharmacology. Academic year 2023 (group 1, n=229) and academic year 2024 (group 2, n=199)

Question	Group 1		Group 2		(G2 - G1) Diference
	(5+4)	(3+2)	(5+4)	(3+2).	Δ (High – Low)
P1	72.5 %	27.5 %	80.9 %	19.1 %	+8.4 %
P2	59.8 %	40.2 %	73.9 %	26.1 %	+14.1 %
P3	63.8 %	36.2 %	75.4%	24.6 %	+11.6 %
P4	48.4 %	51.6 %	68.8 %	31.2 %	+20.4 %
P5	51.1 %	48.9 %	91.5%	8.5 %	+40.4 %
P6	65.5 %	34.5 %	69.4 %	30.6 %	+3.9 %
P7	71.2 %	28.8 %	83.9 %	16.1 %	+12.7 %

Source: Database.

Questions with greatest impact:

- Q5: +40.4% in high grades (φ=0.45, Large effect).
- Q4: +20.4% in high grades (φ=0.22, Moderate effect).
- Q2, Q3, Q7: Significant improvements (φ=0.14 to 0.16).
- Questions without changes:
- Q6: Not significant (p=0.362).

The effectiveness of the pedagogical novelty implied a significant increase in the proportion of high grades in 6 out of 7 questions, with the greatest impact in Q5, Q4, Q7, and Q2 in that order. Maximum impact in Q5: 91.5% of students achieved Excellent or Good (vs. 51.1% in Group 1).

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The use of educational technologies in teaching has a significant and positive impact in the present study, supported by the fact that these tools allow for personalized learning, offer immediate feedback, and facilitate the understanding of complex concepts. According to Zambrano-Vera *et al*.,[16] an interactive environment such as the one implemented in this study fosters students' intrinsic motivation and promotes an essential shift in pedagogical strategies towards more dynamic and inclusive approaches. The impact implies a strengthening of academic performance and prepares students to face real problems.

The findings of Sánchez[17] agree with the results of this study; he mentions that the use of educational software significantly improves academic performance by providing interactive environments that motivate students. Similarly, Meza Arguello *et al*.[18] determined that there was continuous improvement in the teaching-learning process with a medium to high level of performance.

In the authors' consideration, the use of this pedagogical tool was of great help to students in achieving improvement in their average grades across the different questions.

Scientific contribution

This research demonstrated the importance of the application of educational software in general in the teaching-learning process, and the effectiveness of FarmApk as a resource for learning Clinical Pharmacology in medical sciences.

CONCLUSIONS

The application of the educational software demonstrated better results in student learning, performance, and grades in the Clinical Pharmacology subject.

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Declaration of interests

The authors declare no conflicts of interest.

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