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Abstract. The objective was to evaluate the implementation of the knowledge integration model in high school students studying physics in a public educational institution in the city of San José de Cúcuta, Colombia. A quasi-experimental model was applied. An intervention was implemented as a didactic strategy for the integration of knowledge based on the Pragmatic Pedagogical Principles, its operative criteria, and activities. Conceptual progress is reported by means of Hake's normalized factor or gain, which was modified to the rating scales, and the results of partial exams are considered, implementing a continuous and formative evaluation system. The results were compared between the experimental and control groups. It was found that the experimental group showed better academic achievement and performance than the control group. This suggests that the results generated a continuous learning progress thanks to the application of the operative judgments of the corresponding principles.

1. Introduction

Today's university and pre-university students are part of the so-called Net or Millennial Generation [1] [2] to whom teaching models have been proposed and applied [3], but their attitudes and behaviors are different from those of previous generations. This generation is characterized by the impulsive use of information and communication technologies (ICT), so they present academic difficulties. In physics subjects, the loss rates have been, on average, 85% [4] and there is also an increase of 49% in the number of failed students [5]. The previous problem seems to be conditioned by the constant immersion of students in social networks and the extensive use of cell phones.

In addition, the pedagogical practice is limited to the exposition of topics of the traditional model, leaving behind the use of technological resources and innovative strategies [6], so that a flexible curriculum by competencies is still utopian in the teaching of physics.

The described problems motivated the implementation of the educational model Knowledge Integration [7,8], which consists of the construction and implementation of a didactic strategy based on ICT integration activities in the learning process and reinforced by formative assessment in a physics course of grade 11 of middle school in a public institution in the city of San José de Cúcuta, Colombia. The context became a challenge in the application of the model due to the lack of technological resources. This leads to the following research question. How to adapt the knowledge integration model in a context with almost nonexistent or non-existent technological resources?

2. Theoretical pragmatic pedagogical foundations and knowledge integration

The pragmatic didactics of [9] combine the concept of learning and the pragmatic pedagogical principles that state that every person must be able to resort to motivation and commitment to survive with prosperity in the society of the new millennium and higher education must be a builder of a learning society. This is the starting point for the design of an educational strategy, whose foundations combine the concept of lifelong learning and pragmatic pedagogical principles [7].

Knowledge Integration is put into action when it follows pragmatic pedagogical principles to stimulate students' learning by providing them with the opportunity to compare, contrast, critique, and distinguish those ideas and new ideas they may encounter during instruction [8]. That is, when students integrate their own perspectives with new ideas, they develop reasoning processes that will serve them throughout their lives.

The pragmatic pedagogical principles are (1) To make knowledge accessible to all, (2) To make thinking visible among all, (3) To help everyone learn from each other, and (4) To promote continuous learning in everyone [10]. In order to put pragmatic pedagogical principles into practice, some operational criteria and activities are required [7]. Table 1 presents the operational judgements and activities of this pedagogical current.

3. Methodology

3.1. Design

The quasi-experimental design [11] was the design used, with the scheme initial observation (Oi), followed by the application and implementation of the teaching-learning proposal based on pragmatic pedagogical principles (X) and finally a final observation (Of).

For the case of the study, in the initial observation (pretest), the results of the three exams of the period are collected and the result of the final exam is found in the final observation (posttest). The exams contained a series of ten problems according to the topics developed in the period. The final exam covered the topics exposed during all the periods.

3.2. Target population

In the public educational institution of San José de Cúcuta, Colombia, two groups of students were organized with eleventh grade students, considering their characteristics and schedule. One group was oriented to be control, control group (CG), with 45 students.

The teacher in charge of this group carried out his practices according to his criteria; the other group was assigned to be experimental, guided by the researchers, applying 14 operative judgments, developing activities from table one, where the pragmatic pedagogical principles were evidenced, and were identified as experimental group (EG) formed by 44 students.

3.3. Procedure

The exams conducted in each of the periods were composed of basic knowledge questions, such as concepts, definitions and writing equations. Homework and participation in the development of a blog were also given importance.

3.4. Didactic strategy for knowledge integration

According to Table 1, which contains the principles, operational judgments (JOP) and activities (A). For this study, 10 types of activities were performed, achieving the application of 14 operational judgments, classified as follows: We started from A1, through A8, concluding with the last two related to A13 and A14. The rubrics designed to evaluate the students through the 10 activities showed the performance during the semester individually and in groups, allowing the analysis of the grades and averages of the members by means of three partial exams and the final exam.

Table 1. Operational judgments and activities.

Operational judgments (JOP)	Activities (A)
P1: Facilitating the acquisition of knowledge for all	
JOP1. Concept developments from stimulating their own ideas and opinion writing.	A1. Through proposals made by students develop activities to strengthen concepts and take evidence.
JOP2. By posing meaningful problems to confront their preconceptions and strengthen them through personal research collaboration.	A2. Continuous progression of task complexity accompanied by formative assessment.
JOP3. Encourage the enrichment of knowledge through participation in inquiry and research processes.	A3a. Consultation of relevant topics of the course in specialized web portals. A3b.Development of simple demonstrations and experiments.
JOP4. Encourage communication of expertise by sharing it with others.	A4: Presentation of progress of previous activities.
P2: Presentation of conceptual advances	
JOP5. Identification of errors thanks to the modelling of the construction of concepts inducing their constate.	A5: Problem solving and situation analysis workshop (cases).
JOP6. Support the explanation of others' ideas.	A6: Problem solving workshop through monitored student activities.
JOP7. Provide multiple visual representations using a variety of media.	A7: I use interactive presentations, videos, applying diverse didactic resources, such as concept maps and mind maps.
JOP8. Encourage the systematization of the knowledge achieved through records.	A8: Logbooks or notebooks of classified and ordered notes.
P3: Helping everyone learn from each other.	
JOP9. Stimulate actions that promote listening and learning from each other.	A9: Problem solving and situation analysis workshop (cases).
JOP10. Design social activities that generate productive and respectful interactions.	A10: Activity of student monitors in problem-solving workshops.
JOP11. Encourage the application and design of standards and judgments.	
JOP12. Structure and organize multiple social activities.	
P4: Promote lifelong learning (learning for life)	
JOP13. Commitment to personal progress in reflecting on their way of learning and strengthening the metacognitive process.	A13: Continuous review of concept mapping and activities.
JOP14. Commit to being critical of the information handled.	A14: Selection of information referred to in web pages and in the various information media prior to established judgments.
JOP15. Promote participation in activities aimed at establishing a culture of permanent development.	Not applicable.
JOP16. Establish generalizable inquiry processes that are appropriate in diverse educational projects.	Not applicable.

3.5. Pragmatic didactics

For the design of pragmatic didactics, it was essential to practice the operative judgments corresponding to each pragmatic pedagogical principle, considering the following moments [10,11]:

3.5.1. Detection of preconceptions. Activation or reactivation of concepts. Activity A1: development of concepts from experimental evidence proposed by the students. Activity A2: performance of weekly tasks according to the traditional way. Activity A14: establish selection judgments of information on the Internet.

3.5.2. The presentation and/or construction of new concepts. Derived from Activity A1.

3.5.3. Problem-solving workshop. Student monitors and presentations - confrontation of concepts with experimental evidence. Activity A5: problem solving and situation analysis workshop (cases). Activity A6: participation of student monitors. Activity A7: use of videos and presentations.

3.5.4. Final presentation of results (constructed knowledge). Activities A3a and A3b: visiting some web pages and performing experiments. Activity A4: short presentation of results of activities A3a or A3b.

3.5.5. Evaluation. Activity A8: notebooks sorted and classified. Activity A13: periodic review of how to perform activities and construction of concept maps.

3.6. Information analysis
The modified Hake factor (h´) was the indicator to consider the averages of the scores of each group, considering that the same test was applied to both groups. To investigate the effectiveness of the applied strategy, the Hake factor formula, or the so-called normalized gain [12] was used, modified to the needs of the study, changing the pretest and posttest percentages by the mean of the partial evaluations (MEP) and by the final evaluation (EF), on a scale of 0 to 5, as visualized in Equation (1).

$$\mathrm{h}' = \frac{(\mathrm{EF}) - (\mathrm{MEP})}{5 - (\mathrm{MEP})} \tag{1}$$

This factor can take values between 0 and 1, where 0 represents no learning, while 1 corresponds to the maximum possible learning. Establishing with the relative learning gain it is possible to classify three levels of achievement, these are: high with $\mathrm{h}' > 0.7$; Medium with $0.3 < \mathrm{h}' \leq 0.7$ and low with $0 \leq \mathrm{h}' \leq 0.3$.

4. Results

To apply the modified Hake factor (h´), the results of the grades of the partial pre-test and the final evaluation of the course were analyzed. Table 2 presents the averages of the individual student grades for each of the groups, where PE1, PE2 and PE3 represents the average of partial examination 1, partial examination 2 and partial examination 3, respectively. MPE is the average of the three partial exams and MFE is the mean of the final evaluation. Based on the above information, we can analyze that, in the control group, the three pre-scores have a higher value than the final evaluation, leading to a setback in academic performance. The above, according to the negative value for the factor h´.

Table 2. Midterm and final exam averages and modified Hake's factor (h´).

Group	PE1	PE2	PE3	MPE	MFE	h´
CG	2.89	2.77	2.41	2.69	2.58	-0.046
EG	2.78	2.54	3.94	3.09	4.03	0.495

Considering the above, it can be evidenced how favorable the application of the formative partial previews and the cumulative final was; the development of the activities, considering the operative judgments of the pragmatic pedagogical principles, favored the learning and understanding of the subject in the experimental group. It is also evident that the experimental group (EG) obtained better scores in the partial exam 3 as the average of the exam scores and in the final exam of the period and showing a higher value in the modified Hake's factor (h´).

Finally, pragmatic didactics is emphasized in relation to traditional teaching. For this purpose, it is considered important to select contents, according to the general objective of the subject, the

implementation of activities with the operative judgments of pragmatic pedagogical principles, the application of continuous and formative evaluations.

5. Discussion

The implementation of the knowledge integration strategy and its pragmatic pedagogical principles evidenced good results in academic performance coinciding with [13].

Cooperative work foundations the process of integration, socialization, equality, and inclusion among students' social benefits also exposed by [14].

The strengthening of the metacognition and self-training process influenced by the collaborative work developed by the students founded the satisfactory results suggested by factor h´ in agreement with [15].

6. Conclusions

In this work, the current situation of students who are about to enter higher education and how difficult it is to adapt the integration of knowledge to an environment in which there is no easy and full access to the current technological means and resources, for which the educational model Knowledge integration as a basis for the development of pragmatic didactics using ICT was explained. Good results were evidenced in the academic performance of the students with the Knowledge Integration model and its pragmatic pedagogical principles. The cooperative and collaborative work developed by the students supported the satisfactory results suggested by the factor h´.

Finally, it was revealed that students have the potential to perform better in everyday life with access to web pages as a basis for formative research.

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