Implementation of ICTs in a University Curriculum for the Development of Math and Critical Reading Skills During COVID-19 Pandemic

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Abstract. This research was developed to determine the effectiveness of using ICT as part of the curriculum of Colombian university students in the areas of mathematics and critical reading during the COVID-19 pandemic. The University Academic Accompaniment Plan (AAP) was aimed at freshmen students whose ICFES test results were below the national average. The study's approach was quantitative, where two semesters were analyzed 2020-I and 2020-II consisting in 189 and 146 surveyed students, respectively. The SPSS version 22 statistical program and the Academic Valuation Software were used, and results were parameterized by two tests a pre-test and post-test. Mann Whitney's U-test was applied to contrast the two semesters, to analyze the effectiveness of each semester, the T-Student test was used for related samples and the Wilcoxon test in cases where there was no normality; finally, an exploratory factorial and reliability analysis was carried out through the Cronbach's alpha statistic to determine how related the questionnaire questions were in terms of quality of service and methodologies. According to the results of this study, it was found that the AAP in the two semesters managed to be statistically effective and the methodologies implemented for the approach and development of skills through ICT in both semesters resulted to be statistically significative, reliable, and adequate. These findings lead to the conclusion that the AAP in mathematics and critical reading was effective for skills development, through the working process in remote access during the COVID-19 pandemic.

Keywords: COVID-19 · Mathematics skills · Critical reading skills

1 Introduction

World Health Organization in 2020 stated that COVID-19 can be characterized as a pandemic [1], this led to changes in education systems worldwide, affecting all levels

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of education and thereby hundreds of millions of students [2], forcing educational institutions to turn their sights to methodologies associated with the remote access modality to meet the objectives of education.

In this sense, Information and Communication Technologies (ICT) became an indispensable tool in the teaching and learning processes of students and teachers [3], and in this way meet the proposed objectives set out by higher education, as mentioned by UNESCO at one of its conferences [4], recognizing the formative value that universities provide within society towards advancement and development [5]. That is the reason why several universities around the world have opted for competency-based learning within their educational model, since it has been proven that, by developing math skills in university students in areas of calculus and other disciplines, incorporating ICT positively favors students in their training processes [6]. Likewise, the development of reading skills allows the student in higher education to improve their skills in their writings and reading by integrating ICT into the teaching process [7].

In line with the above, the Universidad de la Costa, through the Academic Vice-Chancellor's office offers an academic accompaniment plan (AAP) for freshmen students whose ICFES (which stands for Instituto Colombiano para el Fomento de la Educación Superior) "saber 11°" test results were below the national average, in order to develop skills in critical reading and math and in this way level them as envisaged in the definitions of the basic standards of language, mathematics, science and civic skills of the Colombian Education Ministry (Ministerio de Educación Nacional or MEN) [8]. Mathematical competencees give the individual thoughtful thinking with a deep understanding and the reading competition allows to develop the knowledge and personal potential to participate in society [9].

In this sense, the purpose of this research was to analyze the effectiveness of the AAP during the global preventive isolation due to COVID-19 in order to develop math and critical reading skills in freshmen students, for the 2020-I and 2020-II academic periods with classes in remote access mode with proper use of ICT, highlighting in this research Microsoft Teams, Moodle platform and Geneally. To this end, a pre-experimental design was made with two parameterized tests; an online pre-test through the Academic Valuation Software, developed to estimate skills levels in math and critical reading, after ten remote access intervention sessions with interactive workshops and guides to help improve skills development; finally, the online post-test was applied with the same Academic Valuation Software version 2.5. The analysis of the data was carried out with the SPSS statistical program version 22.

2 Method

2.1 Population and Sample

The 2020-I and 2020-II semesters were represented by 189 and 146 students respectively, of which 116 were part of the AAP in mathematics and 73 in critical reading from the period 2020-I, meanwhile, 96 in mathematics and 50 in critical reading from the period 2020-II.

2.2 Procedure

The academic accompaniment plan was applied to the population of students identified with performances below the national average in math and critical reading skills in the "Saber 11" test, which is applied by the National Education Ministry. When conducting the interview and registration process, students sign an agreement and enroll the assigned plan on the university's institutional platform. The study was conducted in the following phases:

PHASE 1. An academic assessment test was applied to all students through a software that allows to identify the skills with which students register, not only was the overall score analyzed but the percentage in each math competence and the reading level were checked; this, in addition to the performance level at which students were placed based on their overall test result. This pre-test consisted of 25 mathematical questions with generic elements (quantitative reasoning) and non-generic elements (mathematical elements), and 25 critical reading questions; the test was multiple choice question with only one answer per question. The test was two hours long and measures freshmen students' abilities according to their competences with scores from zero to one hundred and performance levels defined by ICFES [10], who provides theoretical reliability in terms of evaluation. These performance levels bring students together into 4 levels (1, 2, 3 and 4) (Table 1).

Table 1. Scores of performance levels according to ICFES

Performance level	Math test scores	Critical reading test scores
1	0 to 35	0 to 35
2	36 to 50	36 to 50
3	51 to 70	51 to 65
4	71 to 100	66 to 100

PHASE 2. Students were socialized with the results and based on them a series of interventions were developed, through guides and infographics as another learning resource, which were designed by the AAP teachers; a total of ten guides taking into account math and critical reading skills with interactive, dynamic and engaging content using the tool Geneally for this purpose, and for each session, introductory problems and multiple-selection questionnaires were designed with only one answer focused on the competences development and uploaded to the Moodle platform. Classes and meetings were developed through the Microsoft Teams platform that enables real-time interaction between the teacher and the student and using the prepared guides in Moodle.

PHASE 3. A post-test was applied to assess progress in each competence and performance level according to the results obtained with the same characteristics described in phase 1 for the pre-test.

PHASE 4. A perception survey was applied in course satisfaction and ICT use and mediation in the learning process and strengthening of the evaluated skills. Twelve questions were asked from which four of them were associated to the platforms and focused on students' perception of these digital resources and the methodologies associated with their use, and which answers were established with a Likert scale, with five answer choices: 1 (Strongly disagree), 2 (Disagree), 3 (Neither agree nor disagree), 4 (Agree) and 5 (Strongly agree).

PHASE 5. Results were analyzed and a group performance report was organized to show significant student progress in their competencies. For the analysis for each academic period: 2020-I and 2020-II, it was analyzed whether the differences between pre-test and post-test came from a normal distribution taking as a reference the scores of students, which are quantitative variables, this is why and according to the size of the samples, that for both academic periods (2020-I and 2020-II) the Kolmogorov-Smirnov test is used. In this regard, Wilcoxon's non-parametric signed rank test was used for non-normality in critical reading for the period 2020-I and the T-Student test to the paired differences for the case of normality in the math 2020-I, math 2020-II, and critical reading 2020-II groups.

Mann Whitney's non-parametric U-test allowed to contrast the post-tests of the semesters 2020-I and 2020-II, which led to an assessment of whether the pedagogical strategies and tools used for the development of competences were the same, with performance levels understood to be random ordinal variables.

The perception of methodology, management, resources, use of digital tools and quality of service was determined by a survey, where its reliability was assessed through the Cronbach's alpha statistic and an exploratory factor analysis to determine how related the questions were. Sand used the IBM SPSS (Statistical Product and Service Solutions) version 22 statistical package for information analysis.

3 Results

Through the Kolmogorov-Smirnov test, with a significance level of $\alpha = 0.05$, it was determined that the differences between the pre-test and the post-test of the groups: Math 2020-I, Math 2020-II and Critical Reading 2020-II, are distributed normally with p-values equal to: 0.139, 0.2 and 0.2, respectively; on the contrary, the differences between the pre-test and the post-test of the Critical Reading 2020-I group, where the data is not normally distributed with a p-value $= 0.033$.

Data analyses show in both semesters better results in critical reading and math post-tests (Table 2) and their differences are statistically significant (Table 3 and 4).

To contrast methodologies in both semesters, student performance levels were considered (Table 1), so the procedure was to determine if the data came from a normal distribution through the Kolmogorov-Smirnov test with a significance $\alpha = 0.05$, in this sense, it was obtained that post-tests in the 2020-I and 2020-II semesters in mathematics and critical reading do not come from a normal distribution with p-values-$0.000 \leq 05$. In addition, the results of the Mann-Whitney U test determined that there are no significant differences between the 2020-I and 2020-II post-tests, so students received the same

Table 2. Mean, Median and standard deviation of the grades.

	Math 2020-I Pre-test	Math 2020-I Post-test	Critical Reading 2020-I Pre-test	Critical Reading 2020-I Post-test	Math 2020-II Pre-test	Math 2020-II Pos-test	Critical Reading 2020-II Pre-test	Critical Reading 2020-II Post-test
Mean	30.9	59	36.55	47.73	43.71	61.96	37.85	52.5
Median	32	60	36	48	44	64	38	47.6
Standard deviation	10.676	14.445	9.691	11.913	11.68	15.012	12.288	22.823

Table 3. Paired samples T Test results pre-test vs post-test scores

	95% Confidence interval of the difference		t	Sig. (2 tailed)
	Lower	Upper		
Pre-test vs Post-test Math 2020-I	−31.172	−25.035	−18.141	*0.000
Pre-test vs Post-test Math 2020-II	−21.948	−14.552	−9.798	*0.000
Pre-test vs Post-test Critical Reading 2020-II	−21.143	−8.169	−4.54	*0.000

* Value of p indicates significant difference between the compared data ($p \leq 0.05$)

Table 4. Wilcoxon signed ranks test

Pre-test vs Post-test Critical Reading 2020-I	Z	Asymp. Sig.(2 tailed)
	−5.454	*0.000

*Value of p indicates significant difference between the compared data ($p \leq 0.05$).

study materials and the same treatment in both academic periods, there were no changes or alterations in the process, this means that the same methodologies were implemented in terms of the development of the classes (Table 5).

Table 5. Statistics Test ($\alpha = 0.05$)

	Mann-Whitney U	Z	Asymp. Sig.(2 tailed)
Post-tests levels Math (2020-I and 2020-II)	5303.500	−0.645	*0.519
Post-tests levels Critical Reading (2020-I and 2020-II)	1786.000	−0.212	*0.832

* Value of p indicates no significant difference between the compared data ($p > 0.05$)

Exploratory factorial analysis with KMO = 0.94 > 0.5 and Bartlett's test of sphericity with p-value = 0.000 confirm the correlation of questionnaire questions and their reliability using Cronbach's alpha coefficient with the value of 0.95. Figure 1 represents the questions about the results of students' perception of digital resources used and associated methodologies versus their use.

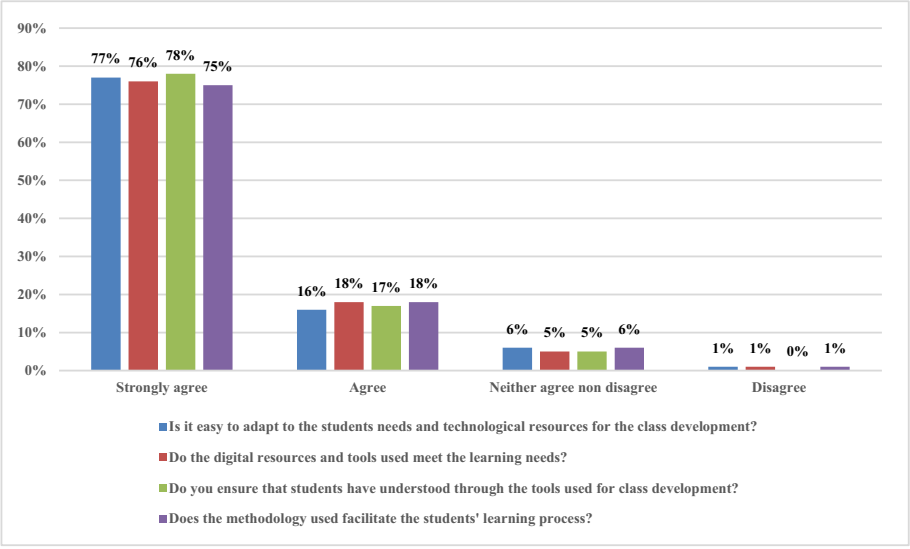

Fig. 1. Questions analysis.

Below are the questions asked in the survey regarding students' perception of methodologies, management, resources, use of digital tools and quality of service (Table 6).

Table 6. Survey results

Questions asked in the survey	Mean	Variance
Q1: Assess quality of service received	4.63	s
Q2: Is the teacher punctual in the development of the sections?	4.75	.272
Q3: Does the teacher have good conceptual and theoretical management of the topics taught?	4.69	.353
Q4: Does the teacher easily adapt to the students' needs and technological resources for class development?	4.67	.468
Q5: Does the dynamics used enable the active participation of students?	4.68	.356

(*continued*)

Table 6. (*continued*)

Questions asked in the survey	Mean	Variance
Q6: Do the digital resources and tools used meet the learning needs?	4.69	.395
Q7: Do teachers ensure that students have understood through the tools used for class development?	4.73	.292
Q8: Does the methodology used facilitate the students' learning process?	4.67	.386
Q9: Does the teacher consider the ideas, opinions and suggestions given?	4.73	.251
Q10: Does the teacher establish together with the students, rules that create a stable, safe environment that promotes the proper functioning of the sessions?	4.69	.282
Q11: Do you consider that the Academic Accompaniment Plan contributed significantly to the development of your generic competences?	4.77	.248
P12: Does the teacher care about those students who are frequently absent?	4.63	.535

4 Conclusion

This research showed that the academic accompaniment plan AAP is an effective university strategy for skills development in math and critical reading, in the midst of the process of working in remote access in pandemic (Table 2, 3 and 4), studies show that developing high school competences allows students to perform better in their college careers [11], and it is for this reason that the university as a strategy proposes to the community this mandatory service for freshmen students, although if we add to this teaching experience the remote access modality with the complexity of the COVID-19 pandemic, this process does not always turn out to be effective and impactful in students [12].

The results of this study show that there was assertiveness in the methodologies applied and the digital tools implemented, so it was statistically proven that in the two academic semesters the same strategies were used in the skills development process and this was significant (Table 5); similar studies show that such treatments help improve students' grades [13].

In addition, it was found that the implemented questionnaire to find out the effectiveness of strategies, methodologies, and quality in the process, turned out to be reliable with a Cronbach's alpha coefficient of 0.95; then students' acceptance of digital resources for ICT learning development is evident (Fig. 1) and the same goes for their quality of service satisfaction (Table 6), studies reaffirm that the use of these resources and methodological strategies in this research, are effective and interesting by students for their learning [14, 15]. Certainly, the new teaching trends demonstrate the direction that the educational system is taking towards achieving a true cohesion between education and technology at all levels [16].

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