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Information and Communications Technology Resources and Mobile Learning in times of COVID-19.

Abstract: - The increase in the Use of Mobile Learning due to the technological trend and even more triggered by the COVID-19 pandemic have called into question the capabilities of the Information and Communication Technology (ICT) Resources that students have. The objective is to know the status (photograph) of the capabilities of these ICT Resources and validate if they are indeed related to the Use of Mobile Learning. Descriptive statistics were used for the analysis of satisfaction levels and inferential statistics for the corroboration of correlational hypotheses and levels of association between variables. We worked with data from 70 graduate students obtained through a survey consisting of a questionnaire of 40 Likert questions with values from 1 to 5. Satisfaction levels were high for ICT Resources (44.29% Satisfied and 32.86% Totally Satisfied) and the Use of Mobile Learning (42.86% Satisfied and 30.00% Totally Satisfied) demonstrating that many students had the ideal capabilities of ICT Resources that allowed them to use Mobile Learning. In turn, the results obtained were for Spearman's Rho (0.837 and $p < 0.05$), Chi-Square (171.287 and $p < 0.05$), Phi Coefficient (1.564 and $p < 0.05$), Cramer's V (0.782) and Contingency Coefficient (0.843), demonstrating that between ICT Resources and the Use of Mobile Learning there was a statistically significant, strong relationship, positive and with a high degree of dependence, where the Use of Mobile Learning depended on ICT Resources.

Keywords: Mobile learning, ICT resources, covid-19, digital tools, digital content.

1 Introduction

Nowadays the use of mobile devices has become widespread, even many people have more than one and this trend is constantly increasing. Only in Peru, in 2019 there were about 26 million lines in service with mobile internet connection and almost 40 million lines with service on mobile devices [1]. This has allowed many students, either consciously or unconsciously, to make use of Mobile Learning. According to the portal [2] worldwide between May 2020 and 2021 Internet access from mobile phones has been 55.31%, 13.32% more than desktop computers.

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While it is true that we live in times where the use of ICT has become widespread worldwide, there are still gaps in the capabilities and qualities that they offer for the proper functioning of many technologies such as Mobile Learning. Al-Hunaiyyan et al (2016) stated many of these technical challenges are related to infrastructure, mobile devices, application development, technical support, security, technical knowledge of instructors, students and other stakeholders, which must be taken into account when implementing a Mobile Learning project [3].

Alshurideh et al (2021) stated the biggest reason why many educational institutions have had to implement online learning solutions is the COVID-19 pandemic [4], is very important to analyze the critical success factors of mobile learning in universities given that students are the main consumers of these online learning solutions, making the Technological Dimension a key success factor, determined by many enabling conditions, as well as all its capabilities and limitation.

According to Naveed et al (2021) these technological problems are related to factors, such as: the stability of Internet connections, keyboard size and screen (related to difficulties in using mobile devices) [5], which is what they demonstrate [6], when they affirm that it is one thing to have technological resources and another that these resources have the capabilities that make it possible for students to continue continuing with their studies; focusing these differences on the qualities, either of the connection or of the device, that is, if you have both, but with low levels of quality that hinder learning there is a problem in these ICT Resources, [7] proposes to study two important variables, ICT Resources and the Use of Mobile Learning, where ICT Resources groups the resources mentioned by many aforementioned researchers.

The situation in times of pandemic showed us that the problem is no longer the non-existence of ICT-based resources, but that the problem now focuses on the levels of quality, capacity, availability, functionality, ease of use, etc. that could determine that technologies such as Mobile Learning have a greater use by students. At the same time, it is important to know the current state of ICT Resources and the use of Mobile Learning in students to analyze, evaluate and determine, in terms of the respective levels of satisfaction, if they have the necessary conditions based on the dimensions of ICT Resources and to what extent they influence the use of Mobile Learning that they currently already perform. At the same time, to inform the authorities responsible for the implementation of technologies in support of education, if ICT Resources have a strong relationship with the use of Mobile Learning, so that they can make the appropriate or corrective decisions for a better use.

2 Background

Table 1 shows a list of some research that addresses and evaluates the same problem as our research. Two objectives are proposed: To know if students have ICT Resources with the ideal capacities to carry out their general activities and specifically to carry out Mobile Learning through the status (photograph) of the levels of satisfaction on the capabilities of the ICT Resources they possess. Validate whether these ICT Resources are indeed an important component as they are related or not and at what level to the Use of Mobile Learning, that is, they condition the use of Mobile Learning.

Table 1 Research Evaluating the Problem

Research	**Year**	**Authors**
Factors Affecting the Use of Smart Mobile Examination Platforms by Universities Postgraduate Students during the COVID-19 Pandemic: An Empirical Study	2021	[8]
Evaluating and Ranking Mobile Learning Factors Using a Multi-criterion Decision-making (MCDM) Approach	2021	[5]
The Digital Divide in Spanish Students in the Face of the Covid-19 Crisis	2121	[6]

Features, barriers, and influencing factors of mobile learning in higher education: A systematic review	2021	[9]
Empirical investigation to explore factors that achieve high quality of mobile learning system based on students perspectives	2016	[10]
Systematic review on the state of the art of methodologies for M-Learning	2020	[11]
Perceptions and challenges of mobile learning in Kuwait	2016	[3]
Mobile telephony in the classroom: digital divide and absence of didactic strategies	2014	[12]

Variables

Each of the variables were made up of 5 dimensions and each dimension by 4 indicators. In Table 2 you can see the variables with their respective dimensions, as well as the number of questions per dimension within the questionnaire.

Table 2 Research Variables and their Dimensions

Variable	Dimension	Question
ICT Resources	Internet connectivity	1-4 (4)
	Mobile Device	5-8 (4)
	Digital Tools	9-12 (4)
	Digital Content	13-16 (4)
	Training in the Use of ICT Resources	16-20 (4)
Using Mobile Learning	Internet connectivity when using Mobile Learning	21-24 (4)
	Mobile Device when using Mobile Learning	25-28 (4)
	Digital Tools When Using Mobile Learning	29-32 (4)
	Digital Content when using Mobile Learning	33-36 (4)
	Training in the use of ICT resources when using Mobile Learning	36-40 (4)

According to Park 2011, the ICT Resources, defined by each of the 4 indicators in each of the 5 dimensions that make up this variable, where the capabilities of these are used by the student in a general way allowing him to perform many activities remotely and which in turn are independent of the technology they support, such as: Electronic Learning, Electronic Commerce, Multimedia Content, Social Networks, etc. [13] makes us aware of many of the attributes, problems, limitations and capacities of a technical nature that would be part of these ICT Resources, so it can be said that they would condition their satisfaction levels; likewise, due to the COVID 19 pandemic, they have become a main actor, not because they do not exist, but because those that already existed were not enough to cover the new demands, as they point out [14] are playing an increasingly important role in education and that the pandemic had generated a massive increase in the use of ICTs, increasing the number of barriers and problems in emerging countries; that is why, for our research, it is very important to study the Technological Dimension formed by ICT Resources, because as Naveed et al (2021) stablished, it as one of the most important Critical Success Factors for the success of Mobile Learning [5].

Morales and Martinell (2015) stated the Use of Mobile Learning, defined in the same number of factors and dimensions as ICT Resources, with which satisfaction levels are measured based on the ICT Resources that support only when Mobile Learning is used, that is, on the ICT Resources that the student uses specifically to perform any task or activity in relation to their learning. From the perspective of Digital Divide, according to

[15] inequalities that may exist related to the use of technology and, in turn, is a phenomenon made up of several dimensions, which means that there are different types of gaps, one of them being the Use Gap. The proposed research model and process to determine the relationship between the two variables is based on some research, such as those proposed in their respective master's thesis by [16]; [17]; [18]; [19]; [20].

The dimensions of our variables have been defined taking as references the research of [23], [24], [10], [25], [26], [27], [28], [29] as well as several of the areas of the Mobile Learning Maturity Model referred to by [30] in his article called "A Framework for Progress in Mobile Learning".

Indicators by Variables

The indicators specified in Table 3 have an origin in terms of quality, either on the capabilities and functionalities, given that the quality of the service in all these ICT Resources positively influences the adoption of Mobile Learning by students, as manifested by [31], stating that students would be willing to adopt mobile learning systems when the quality of service is perceived as good and beneficial to their studies, in turn, this quality of service is perceived in terms of response time, reliability, security and quality of content; so in our research like [32], we take as a reference some Frameworks that are used to evaluate Quality in E-Learning, such as: Rubric for Online Instruction (Online Organization & Design, Instructional Design & Delivery and Innovate Teaching with Technology), ECB Check (Media Design and Technology: Equipment & Infrastructure) and Quality Matters (Accessibility and Usability); as well as, some of the features and sub-features of Software Quality Standards, such as ISO/IEC 9126, such as: Functionality (Suitability and Interoperability), Compatibility, Usability (Operability and Attractiveness), Reliability, Efficiency (Use of resources) and Quality of Use, as well as the 6II International Scientific Congress on Research, Development and Innovation ISTE - CIDI (2022). [33] in Information and Communications Technology Resources and Mobile Learning in Times of Covid-19 as well as [34], ISO/IEC 25010:2010 (SQuaRE), such as: Functionality (Suitability), Reliability (Availability), Usability (Operability, Accessibility), Portability (Adaptability), Efficiency (Behavior over time and Use of resources) and Quality of Use (Effectiveness, Productivity, Satisfaction and Context of Use).

Table 3 Indicators of the Dimensions of the ICT Resources Variable

Dimension	**Indicator**
Internet connectivity	Signal Coverage
	Bandwidth
	Internet Connection Availability
	Internet Connection Performance
Mobile Device	Processor Performance
	Storage Memory Capacity
	Screen Size
	Ease of Use
Digital Tools	Availability of Digital Tools
	Functionalities of Digital Tools
	Interoperability between Digital Tools
	Ease of Use of Digital Tools
Digital Content	Content Availability
	Presentation of the Contents
	Content Management
	Quality of Content
Training in the use of ICT resources	In the use of Connectivity
	In the use of the Mobile Device
	In the use of Digital Tools
	In the use of Digital Content

3 Methodology

The methodological process is directed under the paradigm of Correlational Descriptive, Analytical Purpose, Cross-sectional Time Sequence, Control of Observational Assignment and Start of Retrospective Study. The universe was Finite, and the Analysis Unit was made up of 295 Graduate students of the Faculty of Systems Engineering and Informatics (FISI-UNMSM), where the inclusion criteria were: to be a student with regular enrollment in a Postgraduate program (Master, Doctorate or Diploma) in the academic semester 2021-II and not have a digital divide in ICT Resources or digital divide for the Use of Mobile Learning. The sample consisted of 70 students. The sample was obtained by means of simple random probability sampling. It was carried out through a single survey that was carried out virtually through a Google form. The link to the survey was sent via email through the Graduate Unit of the FISI-UNMSM.

The Survey technique was used and a Questionnaire as an instrument. The questionnaire consisted of two parts, the first part for the capture of some demographic data such as: Gender, Academic Level and Age. The second part consisted of a questionnaire of 40 questions. The answers were based on a Likert-type scale, where 1 was Totally Dissatisfied, 2 was Dissatisfied, 3 was Regularly Satisfied, 4 was Satisfied, and 5 was Totally Satisfied. After the survey was completed, all the data was downloaded into an Excel file.

According to Valarezo (2021) for Descriptive Statistics, MS Excel and SPSS statistical software were partly used; in turn, for Inferential Statistics, only SPSS statistical software was used to process the data and determine the hypothesis checks. First, we proceed to determine the distribution of the data of our variables by means of the Kolmogorov-Smirnov test [35].

The result of the normality tests showed us that the distributions of the data of both variables were not normal, so according to Cabrera and Sánchez (2018), the Non-Parametric Test of Spearman's Rho Correlation Coefficient should be used [36]; as stated by Hernández et al (2014), Spearman's Rho Coefficient was used to statistically relate Likert-type scales since we consider our categorical ordinal variables [37]. At the same time, Chi-square was used as an alternative and comparative mode [38]. In turn for Hernández et al (2014), other coefficients were used to validate these correlations, such as: Phi Coefficient, Cramer's V Coefficient and Contingency Coefficient [39], the confidence interval used was 95% with a margin of error of 0.05%. Table 4 shows the decision criteria for each of the statistics used.

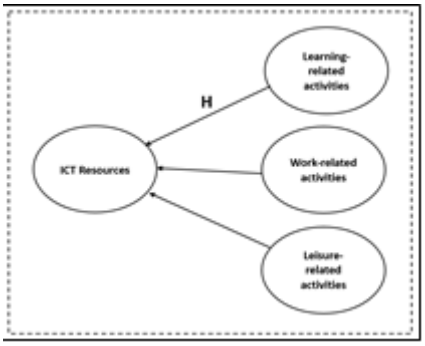
Table 4 Decision Criteria of Statisticians

Statistical	Criteria	References
Kolmogorov-Smirnov test	P <= 0.05, non-normal distribution P > 0.05, normal distribution	[35], [36], [18]
Non-Parametric Test Spearman's Rho coefficient	Close to 1, strong and positive correlation Close to -1, strong and negative correlation	[35], [36],
Pearson's Chi-Square	P <= 0.05, H1 accepted P > 0.05, H0 accepted	[40], [41], [42], [39], [43]
Coefficient Phi (Intensity of Association)	-1, perfectly negative relationship 0, no association 1, perfectly positive relationship	[37], [43], [44]
Crammer's V coefficient (Relationship	0-0.2, no association 0.2-0.6, Moderate Association 0.6-1, strong partnership	[37], [43], [44],

Intensity)		
Contingency Coefficient (Relationship Intensity)	0<=C<=1 Close to 0: lower intensity of dependence. Close to 1: higher intensity of dependence.	[37], [43], [44]

According to Eger et al. (2020) to the model, proposed in Figure 1, we can see that today we basically carry out three categories of activities related to the use and consumption of ICT Resources, such as: activities related to work, fun and obviously learning [45]; which leads us to think, if these same ICT Resources will have the same performance in all categories of activities that are carried out, and even more specifically when tasks or activities related to learning are carried out from a mobile device, that is, when we make use of a particular technology such as Mobile Learning.

Figure 1 Model of the Relationship between ICT Resources and the Use of Mobile Learning



4 Data analysis

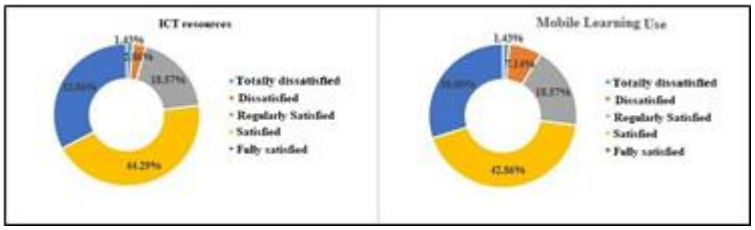
According to Table 5, at the gender level, men have been the most participatory, surpassing women by 48,572%, in turn, at the academic level, master's students represent the vast majority with 80,000%, with doctoral students having the lowest participation with 7,143% of the total. At the age level, the highest participation is among students between the ages of 31 and 40 with 37,143%, with the oldest being the least representative with 7,143%; However, the youngest of the group between 20 and 30 years old have an important participation with 27,143% of the total. It is important to highlight that young people between 20 and 30, who are those who belong to the so-called Generation Z are represented in 27,143%, since they represent those who have the greatest attachment to technology.

Table 5 Demographic Analysis

Indicator	**Category**	**Quantity**	**Percentage**	**Total**
Gender	Male	52	74.286 %	100%
	Female	18	25.714 %	
Academic Level	PhD	5	7.143 %	100%
	Mastery	56	80.000 %	
	Graduate	9	12.857 %	
Age	20-30	19	27.143 %	100%
	31-40	26	37.143 %	
	41-50	20	28.571 %	
	51-60	5	7.143 %	

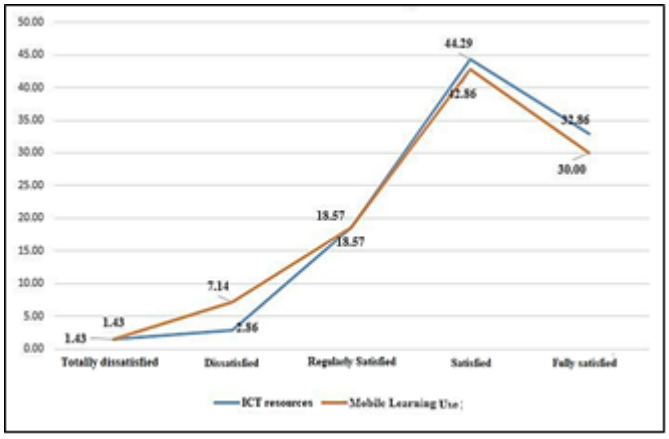
4.1 Descriptive Analysis by Variable

Figure 2. Relative Frequencies in Percentages by Level of Satisfaction and Variable



The percentages of the Relative Frequencies of each of the variables according to the Satisfaction Levels are shown in Figure 2, where the percentage of the level of satisfaction "Totally Dissatisfied" is equal for both variables with 1.43%, on the other hand, the level of satisfaction with the highest percentage in both variables is the "Satisfied" with 44.29% for ICT Resources and 42.86% for the Use of Mobile Learning, in turn, the second highest percentage is the level of satisfaction "Totally Satisfied" with 32.86% in ICT Resources and 30.00% for the Use of Mobile Learning; however, for the Use of Mobile Learning in the level of satisfaction "Unsatisfied" there is 4.29% more than in ICT Resources.

Figure 3. Comparison of Satisfaction Level Between Variables



On the other hand, according to Figure 3, the perception of satisfaction levels (Satisfied and Totally Satisfied) between the two variables is very similar, which shows that the ICT Resources available to the postgraduate students of the FISI-UNMSM are within the appropriate capacities that allow them to carry out activities related to their learning from a mobile device, that is, the Use of Mobile Learning. There is also a slight difference of 4.29% of the level of satisfaction "Dissatisfied" added to the 1.43% of the level "Totally Dissatisfied" and added to the 18.57% of the level "Regularly Satisfied" is the GAP in terms of capabilities of ICT Resources that need to be aligned so that graduate students of the FISI-UNMSM can fully exploit the benefits offered by the Use of Mobile Learning. Although postgraduate students have the economic resources to have the best ICT resources, there is still almost 24% dissatisfaction with their ICT resources, which shows the GAPS in the limited capacities currently offered by the providers of these ICT Resources or perhaps the same market and everything that may imply. In other words, a graduate student can have the money to buy a mobile device with the best capabilities to make use of Mobile Learning, but there is no operator network that supports it or wants to have an internet network that has a better capacity to use Mobile Learning, but in the area where he lives there is no type of technology or coverage is not very good. That is why, it is not enough to have access to these ICT Resources, perhaps the internet connection is enough to surf or make some purchases or payments via the internet, but insufficient to attend classes for hours. Therefore, from a point of view of Satisfaction Levels (indirectly Quality), as stated [9] one of the barriers to the use of Mobile Learning is Technology, that is, if the

ICT Resources available do not have the appropriate capabilities and functionalities, the benefits of Mobile Learning cannot be exploited to the maximum and therefore, become a barrier, which is evidenced by having obtained both at the level of ICT Resources and the Use of Mobile Learning very high indicators in terms of Satisfaction Levels, also corroborating what they affirm [4] that the main parameter that promotes the use of a mobile exam platform, is Quality.

4.2 Instrument reliability analysis.

The results of the reliability analysis of Cronbach's alpha for the entire instrument were 0.98. Regarding the variables: ICT Resources obtained a Cronbach's Alpha 0.973 and Mobile Learning Use 0.984.

Table 6. Results of Cronbach's Alpha Analysis by Variable Dimension

Variable	Dimension	Cronbach's alpha
ICT Resources	Internet connectivity	0.974
	Mobile Device	0.942
	Digital Tools	0.943
	Digital Content	0.961
	Training in the use of ICT resources	0.955
Use of Mobile Learning	Internet connectivity when using Mobile Learning	0.966
	Mobile Device when using Mobile Learning	0.977
	Digital Tools When Using Mobile Learning	0.964
	Digital Content when using Mobile Learning	0.969
	Training in the use of ICT resources when using Mobile Learning	0.979

According to the results of Table 6, the values of Cronbach's Alpha are within very high levels, between the range of 0.8 to 1 according to [20], so the instrument used in the research to obtain the data has a very high reliability, as can be corroborated as stated in the master's theses of [17], [41] and [46]

4.3 Normality Tests.

To determine whether the data come from a Normal or Non-Normal Distribution we use the Kolmogorov-Smirnov Normality Test, whose condition is that the sample is greater than 50 as stated [35].

Table 7 Results of the Kolmogorov-Smirnov Normality Tests

		ICT Resources	Using Mobile Learning
Parameters Normal	Stocking	4.04	3.93
	Desv. Standard	0.875	0.953
Maxims	Absolute	0.252	0.258

Differences Extreme	Positive	0.191	0.170
	Negative	-0.252	-0.258
Static Test		0.252	0.258
Asymptotic sig. (bilateral)		0.000	0.000

Based on the results of Table 7, the p-value values are 0.000 (Asymptotic Sig.) in both variables being in turn less than 0.05 (significance level); therefore, it is concluded that the data of both variables come from a Non-Normal Distribution; therefore, the Nonparametric Test of Spearman's Rho Coefficient should be used to determine the Level of Association or Independence between the variables, as stated [35] and [36], in their respective research papers.

4.4 Hypothesis Check.

We define the Null Hypothesis as H0 and the Alternative Hypothesis as H1:

H0: Isn't there a statistically significant relationship between ICT Resources and the Use of Mobile Learning?

H1: Is there a statistically significant relationship between ICT Resources and the Use of Mobile Learning?

Table 8 Results of the Nonparametric Test of Spearman's Rho Coefficient

		ICT Resources	**Using Mobile Learning**
ICT Resources	Correlation Coefficient	1.000	0.837*
	Sig. (bilateral)	-	0.000
Using Mobile Learning	Coefficient of Correlation	0.837*	1.000
	Sig. (bilateral)	0.000	-

Based on the results obtained in Table 8, the value of the Correlation Coefficient is 0.837 and the value of the significance level is 0.000, which in turn is lower than the significance level 0.05; therefore, the Null Hypothesis H0 is rejected and the Alternative Hypothesis H1 is accepted, as corroborated by the statement by Zegarra (2017) [47], therefore the existence of a statistically significant relationship between the two variables is demonstrated, with the Correlation being strong and positive because the value of the Correlation Coefficient is very close to 1. This result corroborates the results of [27], in his master's thesis where he determined the existence of a factor called Infrastructure and that this has a great influence on the use of Mobile Learning. Likewise, [5], state that of 4 factors found that influence and facilitate the use of Mobile Learning, one is the Technological Dimension. In turn, [26], successfully tested five factors in the application of Mobile Learning, one of them, the Infrastructure Factor, because they consider that the effectiveness of learning requires a good IT Infrastructure. All the research refers in some way to ICT Resources, corroborating the existence of a relationship between these technological factors embedded within ICT Resources and the Use of Mobile Learning as evidenced by hypothesis testing.

Table 9 Chi-Square Test Results

	Value	Mexico City	Signification Asymptotic (bilateral)
Pearson's Chi-Square	171.287	16	0.000

Likelihood Ratio	96.938	16	0.000
Linear association by linear	52.530	1	0.000

The results of Table 9 show that the Chi-square value is 171.287 with 16 degrees of freedom and an Asymptotic Significance of 0.000, this value being lower than the significance level 0.05; so, the Null Hypothesis H0 is also rejected and the Alternative Hypothesis H1 is accepted. With respect to the Likelihood Ratio, whose value is 96.939 and with an Asymptotic Significance of 0.000 that is also less than 0.05 confirms that H0 must be rejected and H1 must be accepted, determining that there is a dependency relationship between the variables. In relation to the statistical Linear Association by linear or Correction by Continuity of Yachts, whose values are 52,530 and 0,000, the same conclusions (with respect to the hypotheses) reached with Chi-Square and the Likelihood Ratio are confirmed.

Table 10 Results of Chi-Square-Based Symmetric Measurements

	Value	Signification Approximate
Phi	1.564	0.000
V of Cramer	0.782	0.000
Contingency Coefficient	0.843	0.000

Based on the results of Table 10, all values of the Approximate Significance of the statistics are 0.000, which in turn are lower than the significance level of 0.05; therefore, the Null Hypothesis H0 must also be rejected and the Alternative Hypothesis H1 must be accepted; with which, it is affirmed that ICT Resources and the Use of Mobile Learning are Associated. According to the value of the Contingency Coefficient 0.843, there is a high degree of dependence between the variables because it is a value very close to 1. As for the value of the Phi Coefficient 1.564, it is determined that the relationship between both variables is strong and directly proportional. Finally, the value of Cramer's Coefficient V 0.782 indicates that the association between the variables is strong because its value is greater than 0.6.

Today and increasingly in the not too distant future, almost nothing can be done without the use of these ICT Resources, and education is no exception as demonstrated [24], which determine the existence of Technological Factors that have a preponderant role in the use of Mobile Learning. As stated by [6], it is not enough to have Technology if it does not make it possible to continue with the studies, as ICT Resources are strongly related to the Use of Mobile Learning, it is very important to be able to investigate in greater depth the ICT Resources and more specifically the dimensions that compose it, which are the basis on which Mobile Learning operates, In order to validate if the capabilities of these will have the same level of performance when tasks or activities related to mobile learning are carried out, and even more, after having verified at a high level the existence of the relationship between the variables that contain them, that is why we propose the realization of a future research that allows to analyze in detail each of the dimensions of the ICT Resources with respect to the Use of the Mobile Learning, to determine if there is a statistically significant relationship between each of the dimensions of ICT Resources (Internet Connectivity, Mobile Device, Digital Tools, Digital Content, and Training in the use of ICT Resources) and the Use of Mobile Learning.

5 CONCLUSIONS

Given the high levels of satisfaction obtained from graduate students at the level of ICT Resources (44.29% Satisfied and 32.86% Totally Satisfied) and the Use of Mobile Learning (42.86% Satisfied and 30.00% Totally Satisfied), it is demonstrated that students do have ICT Resources with the ideal skills to carry out their activities related to their learning, that is, make use of Mobile Learning.

The statistical results determine the existence of a strong and positive correlation (0.837) between ICT Resources and the Use of Mobile Learning with a very high degree of dependence (0.843), where the Use of Mobile Learning depends on ICT Resources, with which it can be concluded that ICT Resources and their dimensions that make them up form an important component with respect to the Use of Mobile Learning by students and which in turn conditions its use.

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