Incorporating Virtual Activities in Higher Education: A Mathematical Model for Describing Teachers According to their Skills

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Abstract. Teachers must innovate in their practices to incorporate virtual activities at the university. They must develop teaching skills related to their own preparation and attitude towards virtual education.
This paper presents a model designed to quantify some manifestations of the preparation and attitude which are necessary to create environments for online distance education. This model has been applied to data processing from CAECE and UNMDP Universities. Some conclusions are presented here.
The following indicators were taken to define faculty preparation: level of use of ICT, training and experience on virtual education and mastery of computing tools. In order to calculate the attitude towards virtualization it was necessary to define the following indicators: level of interest in the use of ICT, interest in virtual training, stance on relationship with ICT and stance on virtual education.

Keywords: distance education, university innovation, virtualization, ICT, teaching skills, indicators

1 Introduction

Incorporating ICT in higher education is a case of innovation that could not exist without the development of backgrounds and environments for technology-mediated education.

These innovation processes mediate education so that, between an student and the content to be learned, instead of having teachers who transmit information, there may be a learning facilitator to guide the student in their search and technological means to provide him not just a lot of information, but also diversity of motivations and forms of communication.

Technology-mediated learning can free the teaching process from temporal-spatial constraints and encourage academic events in which it is feasible to mediate spatial and temporal distance between teacher and student by interactions. Despite this, they continue to establish social bonds.

Therefore, when information technologies are used in education, in addition to students and teachers- technological media is involved. Teachers also fulfill non-traditional roles as they may participate asynchronously with the student. In spite of that, they maintain strong interactions. In this context, the feasibility of incorporating virtual activities into undergraduate courses considering teaching skills has been and is being studied.

This paper presents a model proposed to transform direct scores, obtained from a questionnaire designed ad hoc, into indicators. These new scores provided information to quantify the two standard measures used to characterize teachers: Preparation and Attitude. The teacher questionnaire was adapted from data collection instrument described in [1].

A case study developed at CAECE University (UCAECE), Systems Department, located in Mar del Plata, Argentina is presented for the purpose of sharing the results of processing the collected data but they are currently being contrasted with similar data taken at the Mar del Plata National University (UNMDP), Faculty Economics and social Sciences.

In addition, information obtained by applying the proposed model has been taken as input to the segmentation algorithm described in [2]. The segmentation algorithm was designed with the aim of bringing together teachers according to their preparation and innovative approach for incorporating virtual activities. The proposed segments are: Innovators, Indifferents and Resisters. Uncertainty in decision-making related to selection of teachers, incorporation of online activities into courses and teacher training (such as described in [3]) could be reduced with the analysis of said information.

1.1 Incorporating Virtual Activities in Higher Education

Casas Armengol [4] believes that innovation and virtualization of universities are essential instruments to boost great scientific social changes to effectively progress towards the future knowledge society. Also, according to Garcia et al. [5] distance education has been, since its beginning, the modality that has shown greater readiness to take technological innovations.

Thus, very solid proposals for facilitating change processes and defining factors and approaches designed to achieve widespread use of technology (in relation to the definition of roles, functions and track record) are very abundant.

Writings, studies and research related to teaching skills [6], [7], [8], [9], [10], [11] are frequently made. In 2008, UNESCO published the ICT competency standards for teachers to provide guidance for planning teacher education programs and selecting courses to prepare them for the student's technological training [12].

Moreover, the attitude concept has traditionally been defined as ~~a~~ willingness to respond either favorably or unfavorably towards an object, situation or event [10]. Training and instruction can help improve this attitude. It is understood that the knowledge necessary to incorporate ICT covers various aspects. These aspects are some teaching skills which define the teacher's preparation (training, experience, expertise, etc.) and attitude (intrinsic and extrinsic interests, opinion, etc.) to perform online activities.

1.2 Quantifying Indicators of Teacher's Preparation and Attitude

In psychology, education and social sciences there are aspects which are measured but are not physical or directly observable [13].

The measurement of an attribute by a test gives a score-direct but a person's raw score on a test is not directly interpretable if it is not compared, for example, with the performance of people from the same group [14]. It has no meaning in itself. It becomes meaningful when it is compared with standard tables and previously constructed scales with scores obtained from the group by applying the test [13]. Thus, a subject's score on one aspect (indicator) may be compared (in certain scale) with people who make up the group scores [14].

In the research reported in this paper, in addition to analyzing the direct scores obtained using the questionnaire described in [1], we propose a model for transforming direct scores into derived scores, which normalizes the two measures taken to characterize teachers (see Table 1). The model which allowed to calculate and to assign a value representative of the dimensions Preparation (P) and Attitude (Q) of each teacher by calculating their respective indicators is described below.

Table 1. Indicators to calculate P and Q composite indexes.

Preparation **(P)**	Attitude **(Q)**
(R) Level of ICT use	(U) Interest in the use of ICT
(O) Mastery of tools	(I) Interest in virtual training
(F) Training in Virtual Education	(N) Stance on relationship with ICT
(E) Experience on Virtual Education	(G) Stance on virtual education

2 Model to Quantify Teacher Preparation and Attitude

Let P be Preparation index and let Q be index Attitude to incorporate online activities in teaching, δ the set of teachers who are studied, π the set of quantitative p_i indicators, as understood in this paper, teacher Preparation (P), and θ index, the equivalent for Attitude, with $q_i \in \theta$, may be defined by extension as π = {R, O, F, E} and θ = {U, I, N, G} respectively.

The following describes proposed calculus to obtain a representative value for each teacher, considering all their quantitative indicators, based on data collected through the survey of opinion. With their application you get the ζ set of ordered pairs of the form (P, Q) representing an element of the set of teachers.

2.1 Composite index from Teacher Preparation (P):

The teacher's preparation is defined by P index and it is calculated with Equation 1. It can reach the maximum 10 decimal points. Each indicator can bring his a maximum score of 2.5 points:

$$P = R + O + F + E\ . \quad (1)$$

With P, Preparation index, R, Levels of ICT use; O, Mastery of tools, F, Training on Virtual Education, E, Experience with virtual education and 0 >= P <= 10; 0 >= R <= 2,5; 0 >= O <= 2,5; 0 >= F <= 2,5; 0 >= E <= 2,5.

ICT use level (R). Classifications used to quantify R and U indicators were taken from the CBAM (Concerns-Based Adoption Model). IT is described in [4].

CBAM includes seven levels teachers go through during the process of incorporation of technology. Table 2 shows these levels, and an additional one to include teachers who don't use ICT.

Table 2. Levels of ICT use (R)

Levels of Use	Behavioral Indicators of Level
7, Renewal	Teacher seeks to improve the use of ICT. He/she reevaluates his/her use and examines new innovations as better options
6, Integration	Teacher is making deliberate efforts to coordinate with colleagues in using innovation to improve results
5, Refinement	Teacher is considering implementing changes in the use of ICT to improve learning outcomes of his students
4, Routine	Teacher performs a basic use of ICT because he has an established pattern of use; changes are specific
3, Mechanical	Teacher has focus on immediate and mechanical aspect of ICT, he/she uses it repeatedly and at their own convenience
2, Preparation	Teacher is prepared to use ICT
1, Orientation	Teacher is learning what are TIC about, he/she begins to discover ICT
0, Non-Use	Teacher is taking no action; he/she does not do any activity with ICT

This classification is useful for monitoring the level educators are going through in relation to interest in the use of ICT and the degree they use it effectively ~~it~~ [15].

Teachers go through the levels sequentially. Therefore, the maximum score (R = 2.5) of the indicator is linked to the most comprehensive selection (Ri = 7) and corresponds to the maximum level attained. Level 0 provides no score (Ri = 0). Thus, the chosen r_j can take an integer value in the range [0, 7], which coincides with the highest level achieved by the teacher.

$$R = \frac{2{,}5 * r_j}{7}. \quad (2)$$

Whit 0 <= r_j <= 7.

Mastery of tools (O): The teacher may indicate his/her proficiency in the use of each tool to be very appropriate, appropriate, regular, inappropriate, very

inappropriate and may indicate "do not know or no answer". It is understood, therefore, that the maximum contribution that each item can make to teacher preparation is verified when the “very appropriate” option selected for a specific tool.

The minimum contribution ($O_i = 0$) corresponds to the mastery of tools “very inappropriate” choices (or “do not know” / no answer).Therefore, intermediate options which refer to appropriate mastery, regulate and inappropriate provide intermediate values for preparation weighted as 0.75, 0.5 and 0.25 respectively. Consequently, the estimate of this indicator can be defined as normalization of the sum of the values v_j of each items which contributes to the indicator O, weighted:

$$O = \frac{2{,}5 * \sum_{j=1}^{11} (v_j * t)}{11} \quad (3)$$

with $v_j = 0$, if the chosen alternative in the item is "Do not know / no answer", or 1 in any other election, and t the weighting factor for the election as following: Very appropriate, 1; Appropriate, 0.75, Regular, 0.50, Inappropriate, 0.25; Very inappropriate, 0.

Items on which the teacher should define his/her mastery of tools are: browsing institutional virtual campus; reporting news, files or sites in the institutional virtual campus; obtaining information and resources via the Internet; using e-mail for sending and receiving messages; using e-mail for sending and receiving enclosed files (attachments); creating groups or rules; being involved in discussion milieu, opinion forums and blogs; being involved in chat rooms; administrating and managing blogs; creating office documents; creating of multimedia documents.

Training on virtual education (F). Since each choice sets up a contribution, it adds one value for each chosen subject (v_i). That is, the maximum score that f_i can bring to the teacher´s preparation –previously defined– (F = 2.5) corresponds to the 6 values of $v_i = 1$, which is the case in which the teacher has been trained in the 6 issues referred into the polls, while the lowest score ($R_i = 0$) corresponds to the teachers who have not been trained in any of them.

$$F = \frac{2{,}5 * \sum_{j=1}^{6} v_j}{6} \cdot \quad (4)$$

with $v_j = 1$ if the option was chosen by the teacher and $v_j = 0$ otherwise.

The options the teacher can choose for this indicator and for interest in training (I) are the following: use of ICT and/or media; methodologies that can improve teaching practice if using ICT; techniques of learning facilitation for virtual education; alternative assessment methods appropriate for when using ICT and instructional design, management and/or planning of virtual education.

Experience on Virtual Education (E). The v_j items also provide one value for every positive teacher e_j choice. Therefore, if the teacher did not choose any option, e_j value is 0 and if the teacher chose all options, it will be E = 2.5. The latter is the case where the 7 v_j values are equal to 1.

$$E = \frac{2{,}5 * \sum_{j=1}^{7} v_j}{7} \cdot \tag{5}$$

With $v_j = 1$ if the option was chosen by the teacher and $v_j = 0$ otherwise.

The options the teacher can choose for this item are: He/she has attended courses on virtual education (distance learning, online, open, e-learning); has attended training courses not related to virtual education but virtually dictated; has taught courses on virtual education; has taught courses unrelated to virtual education but performed virtually; has performed as a learning facilitator in online courses; has designed or planned courses delivered virtually or has managed them in some way; has actively participated in virtual congresses (with at least 20 hours of virtual activities).

2.2 Composite index from Teacher Attitude (Q):

The Q composite index is calculated with Equation 6. It can reach the maximum 10 points in the decimal scale. Each indicator can bring his a maximum score of 2.5 points.

$$Q = U + I + N + G \, . \tag{6}$$

With Q, Attitude index; U, Interest in the use of ICT; I, Interest in virtual training; N, Stance on relationship with ICT and G, Stance on virtual education and 0 >= Q <= 10; 0 >= U <= 2,5; 0 >= I <= 2,5; 0 >= N <= 2,5; 0 >= G <= 2,5.

Interest in the use of ICT (U). The maximum score (U = 2.5) of the U indicator corresponds to u_j = 7; it describes teachers who reached the highest level. This indicator has a similar treatment of the scale "Levels of ICT use". The lower contribution (U_i = 0) corresponds to the choice made by those teachers who neither know nor have any interest in ICT.

$$U = \frac{2{,}5 * u_j}{7}. \quad (7)$$

Whit 0 <= u_j <= 7 that coincides with the level reached by the teacher.

Table 3 shows levels of interest in the use of ICT and their descriptions.

Table 3. Levels of Interest in the use of ICT

Levels of Interested	Behavioral Indicators of Level
7, Refocusing	The teacher has ideas about how to improve the use of ICT and how he/she can do a better implementation of them
6, Collaboration	Teacher discusses how to collaborate with colleagues involved with ICT
5, Consequence	Teacher begins to consider the impact that ICT can have on student learning
4, Management	Teacher has concerns about the administrative and logistical challenges posed by ICT; they consume his/her time
3, Personal	Teacher asks himself what impact ICT can have on his/her person in relation to time and his/her own abilities
2, Informational	Teacher, at this level, wants to know more about ICT
1, Awareness	Teacher knows about ICT but they don't generate him/her any concern
0, Without Awareness	Teacher has not yet begun the process of innovation

Interest in virtual training (I). This indicator assigns a score to current or past interest in training. Each v_j positive choice for the 6 statements of the questionnaire, provides a point i_i. Each question has been asked in a "mirrored" way with 6 items consulting on current training (v'_j), corresponding to the indicator O.

The negative choices of the I indicator were considered positive when the equivalent in training already performed was positive.

Consequently, the indicator I carries a value of 2.5 points when the 6 values v_j (or its equivalent v'_j defined by questionnaire items by the indicator O) are equal to 1 because they have been selected by the teacher (see Equation 8)

$$I = \frac{2{,}5 * \left(\left(\sum_{j=1}^{6} (v_j \quad OR \quad v'_j) \right) \right)}{6}. \quad (8)$$

with $v_j = 1$, $v'_j = 1$ when the option was chosen by the teacher, and $v_j = 0$, $v'_j = 0$ otherwise and OR logical operator truth table V_j OR V'_j.

Stance on relationship with ICT (N): It is understood that the contribution of each v_j item to the Q index is defined by the option the teacher chose for each one.

The "Total agree" choice adds 1 point, the intermediate options (agree, neither agree nor disagree and disagree) contribute to N index 0.75, 0.5 and 0.25 points respectively, while "Total disagreement" brings 0.

Therefore, the calculation of N will be defined as the normalization of the sum of the V_j weighted. See equation 9.

$$N = \frac{2{,}5 * \sum_{j=1}^{6} (v_j * t)}{6} \cdot \tag{9}$$

with $v_j = 0$, if the selected option in the item is "Do not know / no answer", or $v_j = 1$ in any other selection and t, the weighting factor of the election, according to the same weight as the R indicator.

The teacher responds to the following items: If his/her own computer knowledge is appropriate for his/her needs and if it is suitable for the use he/she wants to give it; if his/her ICT skills meets current personal expectations; if his/her attitudes towards the use of ICT is positive; if teachers can obtain benefit from virtual education because they can better manage their time; if it may be beneficial for the teacher to dictate blended courses; if dictating virtual courses can bring some benefit or utility (professional development, work from home, etc.) for the teacher.

Stance on virtual education (G). G indicator has a similar treatment N indicator. The maximum score of G indicator is given to the choice made by the teacher on the maximum degree of agreement (total agreement) for v_j items associated to the indicator. Intermediate options are valued with the respective weighting factors 0.75, 0.5, 0.25 and 0.

$$G = \frac{2{,}5 * \sum_{i=1}^{7} (v_j * t)}{5} \cdot \tag{10}$$

with $v_j = 0$, if the selected option in the item is "Do not know / no answer" or $v_j = 1$ in any other election and t, the weighting factor of the election.

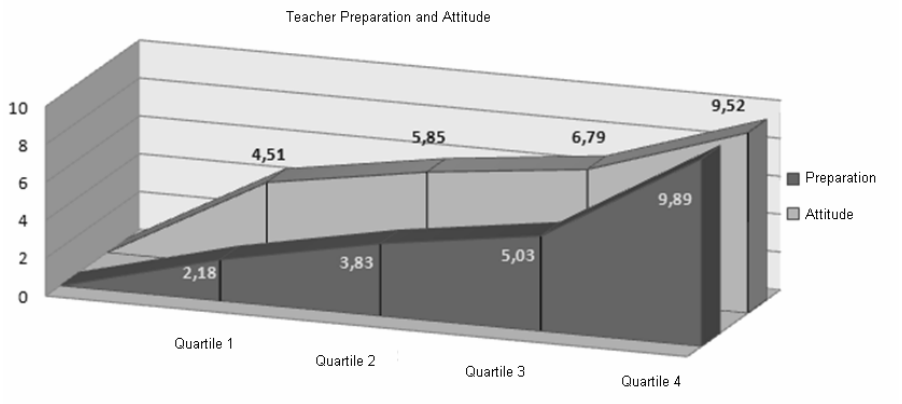
The items on which the teacher has to deliver an opinion are:

the quality of virtual education can be equivalent to classroom education using appropriate methodologies; the teacher can achieve academic interventions in virtual education such that they are equivalent to interventions performed in classroom education; Educational model based on the use of ICT can help the professional development of teachers; Educational model based on the use of ICT can help to the teaching practice in the classroom; Distance learning can provide benefits to teachers in relation to time management.

3 Conclusions

The model presented in this paper has allowed arriving to relevant information for decision making related to teachers, so as to promote appropriate environments for distance education. Its aim is to quantify certain manifestations of preparation and attitude to incorporate virtual activities in higher education.
The following information emerges from data analysis on which the model is applied. It is currently being compared with data obtained in other study house. For further information see [3].

The graph below describes preparation and attitudes of teachers, separated by quartiles. The second quartile (50th percentile) coincides with the median value. Denotes a low preparation (measured in 3.83, when the maximum possible value of P is 10) and a positive attitude (5,83).



Graph 1 – Preparation and teaching attitude for incorporating virtual activities

Both the teacher preparation average and the teacher attitude average are slightly higher than the averages reported by auxiliary teachers survey responses.

It is notoriously high the attitude of students playing the role of assistants with

respect to most of the sample, in most disciplines. The following table presents summary information for the statistical analysis carried out for indicators which describe the P index.

Table 4. Summary of statistical analysis of P (Preparation)

Statistical Analysis	Level of ICT use (R)	Mastery of tools (O)	Training in Virtual Education (F)	Experience on Virtual Education (E)	**Prepara-tion (P)**
Mean	1,25	1,52	0,59	0,44	**3,80**
Median	1,43	1,59	0,42	0,36	**3,83**
Mode	0,00	1,82	0,00	0,00	**4,32**
Deviation	0,92	0,55	0,71	0,48	**2,00**
Maximum	2,50	2,50	2,50	2,50	**9,89**

Statistical Analysis	Interest in the use of ICT (U)	Interest in virtual training (I)	Stance on relationship with ICT (N)	Stance on virtual education (G)	**Attitude (Q)**
Mean	1,61	1,21	1,49	1,20	**5,51**
Median	1,79	1,07	1,56	1,31	**5,85**
Mode	1,79	0,71	1,88	1,50	**6,46**
Deviation	0,64	0,66	0,61	0,64	**2,06**
Maximum	2,50	2,50	2,50	2,50	**9,52**

Note that the range of valid values of the indicators make possible calculation of P and Q is [0, 2.5] and the range of valid values of P and Q index is [0, 10].

Finally, as a corollary, it is stressed that P & Q indexes were taken as segmentation variables for classifying each teacher [2]. Three clusters have been defined (Innovators, Indifferents and Resistors) because it was understood teachers at least can be classified into three categories [15]: Teachers with positive attitude towards ICT who improve the standards for teaching and learning, teachers who assume neutral position regarding ICT use in education and teachers with explicit negative attitudes toward new technologies.

At CAECE University, it emerges from the application of the algorithm that 17.39% of the overall sample was included in the cluster of Innovators, the wide majority of 53.62% was located in the segment of Indifferents and 28.99% of them fell in Resisters group-teachers with negative attitudes towards new technologies. Similar tendencies were found at the University of Mar del Plata applying the algorithm. This information was used for decision making related to teacher training and planning to open virtual classrooms providing information to design a training plan and to anticipate the amount of virtual classrooms requested. This will be shared in future presentations.

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