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Participation Metrics within Virtual Collaborative Workspaces Oriented to Generation of Didactic Interventions

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Abstract. The incorporation of technology as tool in the learning process in undergraduate and post-graduate level has generated a multitude of factors to be considered, one of them, students´ interaction in Virtual Collaborative Workspaces (EVTC), where observing the student during the group learning process must also be mediated by technology. In this paper, we propose an adaptation of certain metrics used in SNA field (Social Network Analysis) as a professor's tool to decide proper didactic intervention in order to achieve the course objectives.

Keywords. Technology as a tool, learning process, virtual collaborative workspaces, adaptation of sociometric metrics, didactic intervention.

1. Introduction

The technological contributions in educational area always have been present. They have evolved from slate to computer. Nowadays what has changed is that there is a new "environment" in which educational process may take place: the web [Litwin, 2000]. There are several educative models: presential, semi-presential or distance. This models coexist and each one of them has its particularity. In all of them we find professors and students, but, as work environment for students has changed because of using web, this implies that there is a change in ways of student´s observing by professor, during the group learning process in virtual workspaces. Hence the need of new concepts which allow evaluate in virtual workspaces, the learning process of student who interacts with his group, focusing on levels of participation and membership. This paper proposes a metric based on the participants´ interaction in a virtual collaborative workspace (EVTC), having as reference framework the SNA (social network analysis).
Within this context, the theoretical framework for observing groups is presented in detail, characteristics of the different roles and adaptation of sociometric techniques as a tool for observing interactions within group

(section 2); the problem is defined (section 3); a solution based on the adaptation of definitions of sociometric field and of social dynamics in virtual groups is proposed, and a method of calculation of the indicators defined in adaptation (section 4) ; the application of the proposed definitions and techniques are shown in a proof of concept (Section 5); and preliminary conclusions on this research line are summarized (section 6) .

2. Theoretical Framework

In this section the theoretical framework that considers the interaction among participants in working groups is presented (section 2.1), the concept and characteristics of role in working groups (section 2.2) and sociometry as a tool of observing the roles (section 2. 3).

2.1. Interaction in Virtual Workspaces (EVTC)

An interpretation of the factors that make the interaction of participants in a EVTC, are the asynchronous processes among them, where the new web-based learning environments and training web platforms allow greater exchange in time [Williams et al., 1999]. Hence one can distinguish the different skills and roles of the participants. Facing these new elements shifts the focus of teaching and how to get information from the need in an didactic intervention.

The "visible" things,, where which is visible may have implications related to knowledge and the way to access to it. In word of Querrien [1979] "... this established order but not altered by the individual, by his sudden movements, his unreasoned natural needs ...if what is seen, is readed, is observed; is the representation of what is done or what should be done; so that what should be done has been previously set, and can not therefore be modified in the future ... .this identification of imposition order and visible order, at same time that thoughts and visible things also have enormous consequences in the innovation domain ... "

In an EVTC, exchanges can be synchronous and asynchronous, but the degree of visibility of the participants is zero, hence the importance of observation and its characteristics. De Ketele [1980] defines that "...observing is a process that includes voluntary-attention and intelligence, guided by a target or an organizing goal, and is directed onto an object for obtaining information from him". Due to the particular circumstances of the environment, its degree of visibility is determined by the interaction / participation of members and the need to generate appropriate metrics.

2.2. Concept "Role" in Working Groups

Unlike traditional / formal education, which prescribes fixed roles to extreme of stereotyping them, this methodology proposes changeable roles (but not symmetrical) for participants. The "informal" expression refers to a group of persons in which roles have not been previously agreed. The system of relations is dynamic; is developed and modified over time, but it may be taken in mind that certain behaviors can be repeated, such as aggression, apathy, rejection among participants. Hence, the importance of being able to identify bonds among members, in order to review and make didactic interventions. This seeks for to avoid competition that generates aggression and impoverishes the quality of the achievements of the group. It should aim to roles that enable collaboration between participants and achieve different visions of common project [Pasel & Asborno, 1993].

2.3. Sociometry as Observing Tool for Roles

Sociometry is the technique that investigates centralism index, communication channels and experiences within a human group, hence the degree of belonging to it and participation with their respective functions in the group. It was created by the psychiatrist Jacob Levy Moreno (American psychiatrist born in Bucharest, Romania, 1889-1974). Among the techniques developed in this discipline are the sociometric test and sociometric perception test, aimed at the systematic study of the psychological properties of people, putting into action an experimental technique based on quantitative methods. Among the applications in the educational field we can cite the work in early childhood education by Bastin [1966], at the primary level by Leibovich [1980], and at the secondary level by by Perez-Alvarez [1991]. The related process may be adapted to be applicable to obtain different measures of virtual interaction of a group within an asynchronous collaborative environment. [Charczuk et al.,, 2013]

3. Identified Problem

Sociometric techniques are used to find out who are the actors of the dynamics of a working group: leaders, marginalized, rejected, normal, and others. Is an open problem to determine these type of roles in groups that interact mediated by internet based technology, either students in a virtual classroom, or professionals in a virtual office.

In virtual environments the socializing link occurs through interactions [Rodriguez and Garcia-Martinez, 2014]. Then, relationships all-parts and parts-all are determined by the flow of interactions, this is consistent with the fact that systems are constituted by actions among complex units formed turn by interactions [Morin, 1980].

In [Charczuk et al., 2013] has been proposed the goal of developing sociometric techniques for project development groups mediated by EVTC based on sociometric test techniques such as Bastin [1966] and Leibovich [1980].

4. Proposed Solution

This section presents definitions to be used for reformulation of sociometric techniques to diagnose of group dynamics in virtual collaborative workspaces (section 4.1), and the process for calculating the measures of diagnostic/membership in group dynamics (Section 4.2)..

4.1. Definitions

In this section we define and redefine sociometric concepts to enable their application in virtual collaborative workspaces:

4.1.1. Communication Density (DC)
Is the number of messages sent per time unit by the member S_i the member S_j

4.1.2. Interaction Matrix (M)
It can be built the matrix M of working group interactions, where M (i,j) is the amount of messages sent / answered of the member S_i to member S_j.

4.1.3. Communication Density Matrix Member-Group (MDCSG)
It is built using the matrix M and contents in the position MDCSG(i,j) the density that member S_i has of each member of the group.

4.1.4 Segmentation Step (ES)
It is the value obtained dividing by 5 the subtraction of the higher value of Communication Density minus lower value of Communication Density (this generates five quintiles)

4.1.5 Conversion of DC values to Indicators of Metrics
It is the value obtained by assigning each DC value within the ranges generated by distribution in quintiles (see Table II).

4.1.6. Communication Density Reference Matrix Interactions (MRDCI)
It is built using the matrix MDC and contents in the position MRDCI(i,j) the resulting value from the conversion of communication density parameter related into the segmentation rank of each group member (see Table II).

4.1.7. Auto- collaboration Index (IAC_i)
It is the value representing the degree of collaboration that member S_i has about himself in relation to the group. This index is calculated by the expression (where X represents the weighting value, n represents the relative frequency of value x, N represents the absolute frequency):

$$IAC = \frac{\sum_{i=1}^{n} xi.ni}{N}$$

4.1.8. Hetero-collaboration Index (IHCi)
t is an approximate value of the degree of collaboration that has the group with respect to member S_i. This index is calculated by the expression (x, n, N; iden IAC_i):

$$IHC = \frac{\sum_{i=1}^{n} xi.ni}{N}$$

4.1.9. Collaborative Reality Index (IRC_i)

It is a value that represents the difference between the above indices and to determine the degree of collaboration member-group / group-member. This index is calculated by the expression: $IRC_i=10 \times (IAC_i - IHC_i)$. This value has the coefficient 10 which multiplies the difference between indices, because of that differences between values may be a value by rounding not significant enough. It is proposed that this index is interpreted according to the following decision rule:

IRCi > 0 The member S_i is over-estimated in relation to estimated by the group in the collaborative process.

IRCi = 0 The valuation of the member S_i is similar with the which one group has of him.

IRCi < 0 The member S_i is under-estimated in relation to estimated by the group in the collaborative process.

4.1.10. Absolute Reality Index (IRCA)

It is the absolute value of the Collaborative Reality Index of a member and a group obtained by accumulation of IRCA of members. The average value of the index of absolute reality (MIRCA) indicates the overall assessment of the group, if it is close to zero, it means that group is mature in collaborative issues. Otherwise, the more it moves away from zero, it means the non-maturity of the grpup in collaborative tasks. The Absolute Reality Index is calculated by the following expression (where L is the number of subjects in the group):

$$V_{MIRCA} = \frac{\sum_{i=1}^{n} IRCAi}{L}$$

4.1.11. Degree of Colaboration Member-Group (GCSG)

The GCSG of member W allow observing which is the interaction behavior among member W and group. GCSG(Si,P) represents the amount of interaction with value P that has member W. The assessment of GCSG of the member W is given by the vector:

($Acceptor_i$, $Normal_i$, $Rejectorr_i$)

Where:

$Acceptor_i$ = GCSG(Si,5) + GCSG(Si,4)

$Normal_i$ = GCSG(S_i,3) + GCSG(S_i,2)

$Rejector_i$ = GCSG(S_i,1) + GCSG(S_i,0)

The decision rules proposed in this paper are:

S_i is $Acceptor_i$ of Group IF

$Acceptor_i >= Normal_i + Rejectorr_i$

S_i is $Normal_i$ of Group IF

$Normal_i >= Acceptor_i + Rejectorr_i$

S_i es $Rejector_i$ of Group IF

$Rejector_i >= Normal_i + Acceptor_i$

If the weighting find with the same value in two of the three components (Acceptor, Normal, Rejector), then the attributes of weighting will be shared.

4.1.12. Degree of Colaboration Group-Member (GCGS)

The GCGS of Group related to a member W allows observing by pooling the amounts of interactions between other members of the group and S_i which is group behaviour in interaction with the member S_i. GCGS (S_i,Q) denotes the amount of weights with Q value of the group with respect to member S_i. The assessment of GCGS of the member S_i is given by the vector:

($Important_i$, $Normal_i$, $Outcast_i$)

Donde:

$Important_i = GCGS(S_i,5) + GCGS(S_i,4)$

$Normal_i = GCGS(S_i,3) + GCGS(S_i,2)$

$Outcast_i = GCGS(S_i,1) + GCGS(S_i,0)$

The decision rules proposed in this paper are:

S_i is Important of Group IF

$Important_i >= Normal_i + Outcast_i$

S_i is Normal of Group IF

$Normal_i >= Important_i + Outcast_i$

S_i is Outcast of Group IF

$Outcast_i >= Normal_i + Important_i$

If the weighting find with the same value in two of the three components (Important, Normal, Outcast), then the attributes of weighting will be shared. The "Important" role may correspond to a potential leader.

4.1.13. Communication Channels

They are the various ways in which all members of Group can communicate. It will be denoted with the letter K. Since the maximum number of possible communication channels is determined by the following expression (where L represents the number of subjects in the group):

$$K = \frac{L}{2} * (L - 1)$$

4.1.14. Percentage of Effective Channels of Communications

This Value represents the percentage of cases relating to effective communication; it is proposed to interpret as effective communication to cases in which the analyzed weight corresponds to the upper half of the matrix MRDCI. $Ft_i(5,4,3)$ is the sum of the relative frequencies using weights with value 5, 4 and 3 in the lower triangular submatrix of interactions matrix, and $Ft_s(5,4,3)$ is similar one using upper triangular submatrix of interactions matrix. From both submatrices a value is obtained, the lowest of them is selected by interpreting the worst case in the communication process, which divided by the maximum number of channels allows to obtain:

$$Percentage\ of\ Effective\ Channels\ of\ Comunications = \frac{F(5,4,3)}{K} * 100$$

4.1.15. Percentage of Communication Lack

The lack of communication is determined by the amount values of zeros (using weighting matrix MRDCI there is no communication) divided by the possible communications in the interactions matrix.

$$Percentage\ of\ Communication\ Lack = \frac{Amount\ of\ Zeros}{(L-1) * L} * 100$$

4.2 Proposed Method

In this section we present the calculus method for predefined indicators as follows:

- Step 1: Identification of amount of sent / received messages and time-lapse records.
- Step 2: Construction of Interactions. Matrix M(i, j).
- Step 3: Construction of Communication Density Matrix MDC(i,j).
- Step 4: Calculus of Segmentation Step (ES).
- Step 5: Assigning DC values related to corresponding ranges of Segmentation Steps.
- Step 6: Reinterpretation of table MDC(i, j), assigning parameters to Table I and Table II
- Step 7: Construction of Matrix MRDCI(i,j)
- Step 8: Calculus of $IAC_{n+1,j}$ and del $IHC_{i,n+1}$
- Step 9: Calculus of Collaborative Reality Index (IRC_i) for member S_i.
- Step 10: Interpretation of resulting Collaborative Reality Index (IRC_i) for each member S_i.
- Step 11: Extended of Communication Density Reference Matrix Interactions Member-Group (SG) with the row Degree of Collaboration Member-Group (GCSG)
- Step 12: Interpretación of matrix MRDCI of Member-Group (SG) interactions.
- Step 13: Extended of Communication Density Reference Matrix Interactions Group-Member (GS) with the row Degree of Collaboration Group-Member (GCGS).
- Step 14: Calculus of: Communication Channels, Percentage of Effective Channels of Communications, and Percentage of Communication Lack
- Step 15: Interpretation of results of Channels Calculus
- Step 16: Calculus of DC value bias with respect to its mean value
- Step 17: Graphing DC bias and its mean value with respect to the communication links.

5. Case Study

In this section we present a case study (section 5.1), the application of the proposed method (section 5.2), and the interpretation of obtained results (section 5.3).

5.1. Case Study Description

The case study is based on the e-mails among the four members of a student-group. The group has to use the virtual workspace to manage the group work related to solve a problem of software development assigned by their professor. Proposed metrics were evaluated using e-mails among students of the group.

5.2. Applying the Proposed Method

In this section we present the results of each step of the proposed method:

Step 1: Identification of amount of sent / received messages and time-lapse records

Step 2: Construction of Interactions. Matrix M(i, j)

	S_1	S_2	S_3	S_4
S_1		5	5	4
S_2	12		12	10
S_3	55	55		67
S_4	48	48	60	

Results Step 1: Amount of time: 22 days

	S_1	S_2	S_3	S_4
S_1		0,23	0,23	0,18
S_2	0,55		0,55	0,45
S_3	2,50	2,50		3,05
S_4	2,18	2,18	2,73	

Results Step 2

Step 3: Construction of Communication Density Matrix MDC(i,j).

ES= (3,045-0,182) / 5

ES= 0,57272

Step 4 and 5: Calculus of Segmentation Step (ES); Assigning DC values related to corresponding ranges of Segmentation Steps.

a. 2,473 – 3,045
b. 1,900 – 2,473
c. 1,327 – 1,900
d. 0,755 – 1,327
e. 0,182 – 0,755

Results Step 3

Member i	Member j	DC	Order Nber
S_3	S_4	3,045	1
S_4	S_3	2,727	2
S_3	S_2	2,500	3
S_3	S_1	2,500	4
S_4	S_1	2,182	5
S_4	S_2	2,182	6
S_2	S_1	0,545	7
S_2	S_3	0,545	8
S_2	S_4	0,455	9
S_1	S_2	0,227	10
S_1	S_3	0,227	11
S_1	S_4	0,182	12

Results Steps 4-5

Step 6: Reinterpretation of table MDC(i, j)

Step 7: Construction of Matrix MRDCI(i,j)

	S_1	S_2	S_3	S_4	Amount 5	Amount 4	Amount 3	Amount 2	Amount 1	Amount 0	Acceptor	Normal	Rejector	IAC
S_1		1	1	1					3		0	0	3	1,00
S_2	1		1	1					3		0	0	3	1,00
S_3	5	5		5	3						3	0	0	5,00
S_4	4	4	5		1	2					3	0	0	4,33
Amount 5	1	1	1	1										
Amount 4	1	1												
Amount 3														
Amount 2														
Amount 1	1	1	2	2										
Amount 0														
Important.	2	2	1	1										
Normal														
Outcast	1	1	2	2										
IHC	3,33	3,33	2,33	2,33										

Amount of 5,4,3 = 6

Amount of 5,4,3: 6

Results Steps 6-7

Step 8, 9 and 10: Calculus of IACn+1, j and del IHCi,n+1; Calculus of Collaborative Reality Index (IRCi) for member Si; Interpretation of resulting Collaborative Reality Index (IRCi) for each member Si.

	IRC	IAC	IHC	IRCA	Int. IRC
S_1	-2,33	1,00	3,33	2,33	-
S_2	-2,33	1,00	3,33	2,33	-
S_3	2,67	5,00	2,33	2,67	+
S_4	2,00	4,33	2,33	2,00	+

Results Steps 8-9-10

Step 11, 12 y 13: Extended of Communication Density Reference Matrix Interactions Member-Group (SG) with the row Degree of Collaboration Member-Group (GCSG); Interpretation of matrix MRDCI of Member-Group (SG) interactions; Extended of Communication Density Reference Matrix Interactions Group-Member (GS) with the row Degree of Collaboration Group-Member (GCGS).

Results of Steps 11,12 y 13 are included in matrix MRDCI of steps 6 and 7.

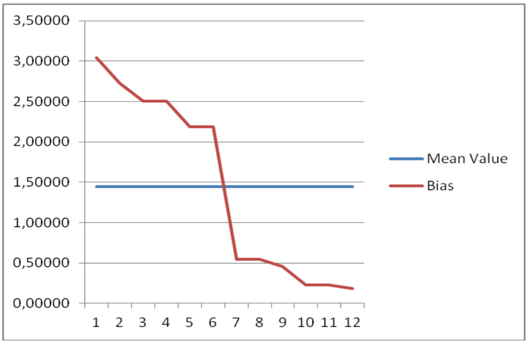
Step 14 and 15: Calculus of: Communication Channels, Percentage of Effective Channels of Communications, and Percentage of Communication Lack; Interpretation of results of Channels Calculus

Amount of Communication Channels	6
Percentage of Effective Channels of Communications	100
Percentage of Communication Lack	0

Step 16 and 17: Calculus of DC value bias with respect to its mean value; Graphing DC bias and its mean value with respect to the communication links.

DC	Mean Value	Bias
3,045	1,44318	1,602
2,727	1,44318	1,284
2,500	1,44318	1,057
2,500	1,44318	1,057
2,182	1,44318	0,739
2,182	1,44318	0,739
0,545	1,44318	-0,898
0,545	1,44318	-0,898
0,455	1,44318	-0,989
0,227	1,44318	-1,216
0,227	1,44318	-1,216
0,182	1,44318	-1,261

Results of Step 16



Results of Step 17

5.3. Interpretation of Results

The interpretation of resulting Collaborative Reality Index (IRC_i) for ech member S_i, is denoted by "+" when member S_i overestimates himself in relation with the group estimation. It is denoted by "-" when member S_i underestimates himself in relation with the group estimation. It is denoted by "0" when member Si estimates himself in the same way as do group. This value represents the lack of communication among participants, and is used to calculate the percentage of Communication Lack (section 4.1.15). The interpretation of the results Member-Group (Matrix MRDCI) is based on the conventions specified in definitions 4.1.11 and 4.1.12.
From the results it follows that in the polarized group behavior are noticeable: S1 and S2 = Rejecters; S3 and S4 = acceptors; S1 and S2 = Important; and S3 and S4 = Outcast.

6. Conclusions

Our work aims to develop analytical tools that bring out the underlying structure of the group interaction mediated by a virtual workspace, allowing hypotheses with quantitative basis on likes and dislikes of individuals to each other and in relation to collaborative task [Cirigliano & Villaverde, 1966]. Preliminary results obtained in the experimental virtual workspace, show binding elements with distance education, where participants have synchronous and asynchronous communications are observed. In the future, it is expected: [a] do a systematic validation of indicators in a large sample group in virtual collaborative work spaces; and [b] explore ways of tailoring Sociometric other indicators.

The human component involved in the interaction mediated by virtual workspaces, generates effects on individual learning, raising the need for tools to assist the diagnosis for the necessary intervention of teachers in the educational processes in use of virtual workspaces dedicated to education.

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