Effects of the COVID-19 pandemic in higher education: a particular case from the perspective of complex systems

Velásquez-Rojas, F., Fajardo, J., Zacharías, D. & Laguna, F.

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Effects of the COVID-19 pandemic in higher education: a particular case from the perspective of complex systems

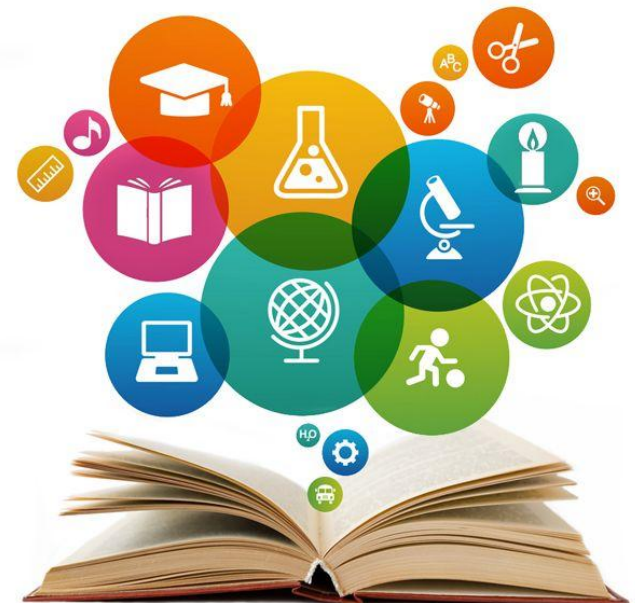**Daniela Zacharías**
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MOTIVATION

Classroom: Individuals who influence each other
➜ Dynamics of collective behaviour ➜ Complex Systems

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... the COVID-19 pandemic abruptly changed the classroom context ...

MOTIVATION

*Classroom: Individuals who influence each other
➤ Dynamics of collective behaviour ➤ Complex Systems*

... the COVID-19 pandemic abruptly changed the classroom context ...

Adapt to a new daily life incorporating new strategies and tools

OUR GOAL

To analyze the Knowledge Acquisition (KA) process in two different contexts: face-to-face (before the onset of the pandemic) and virtual (during confinement)

To propose improvements to current methods and strategies

KNOWLEDGE ACQUISITION (KA)

Process in which the human being learns and develops her/his intelligence, that is, she/he builds knowledge.

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Dynamic variable influenced by different factors, in a classroom:

- *Intrinsics: Aptitude, motivation and previous knowledge on a topic.*
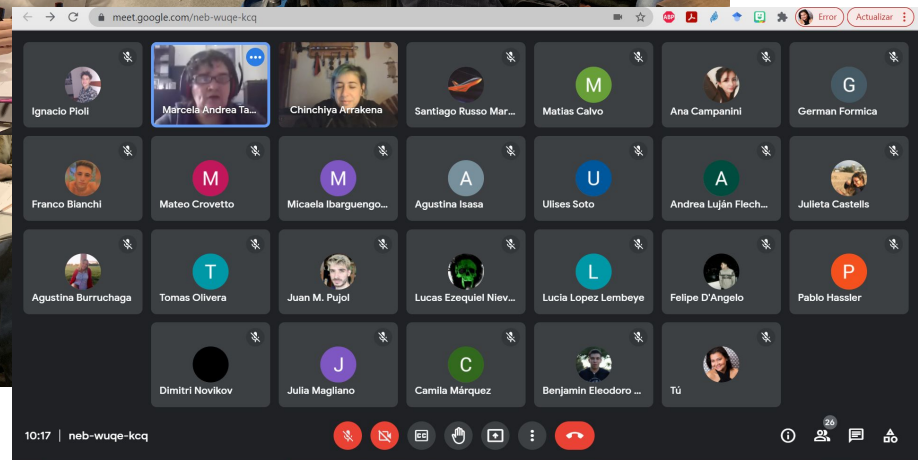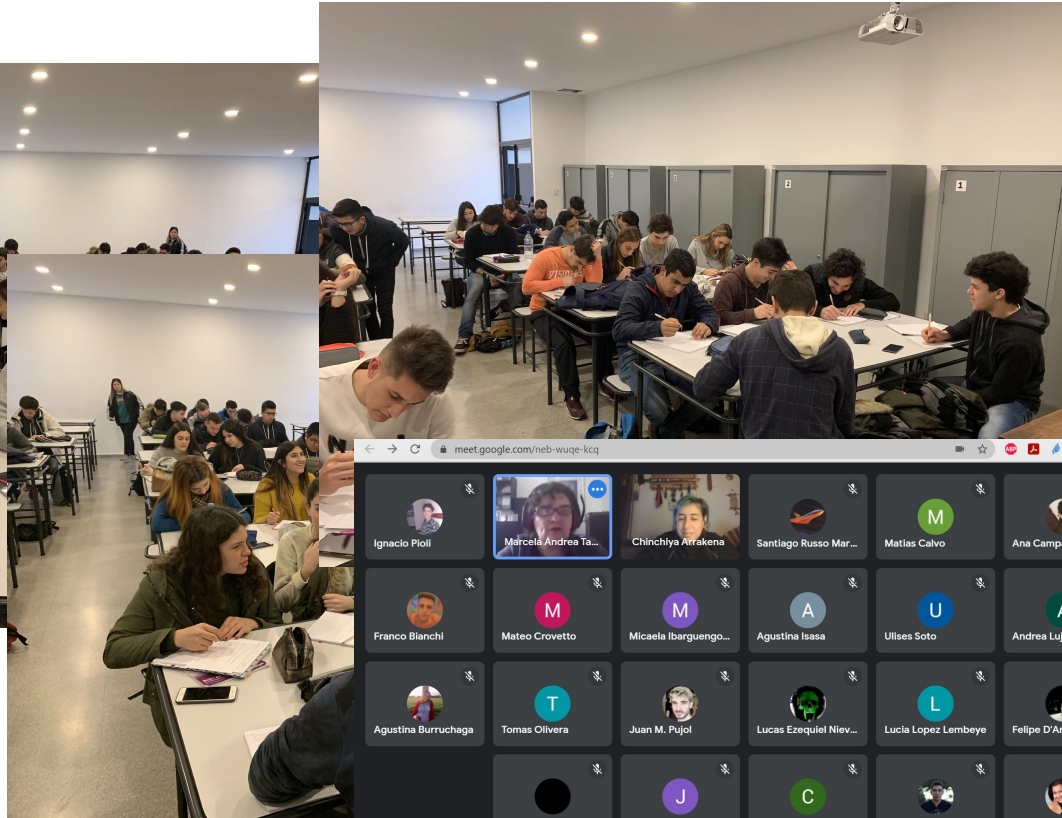- *Extrinsics: Interaction of the individual with her/his environment (teachers, peers).*

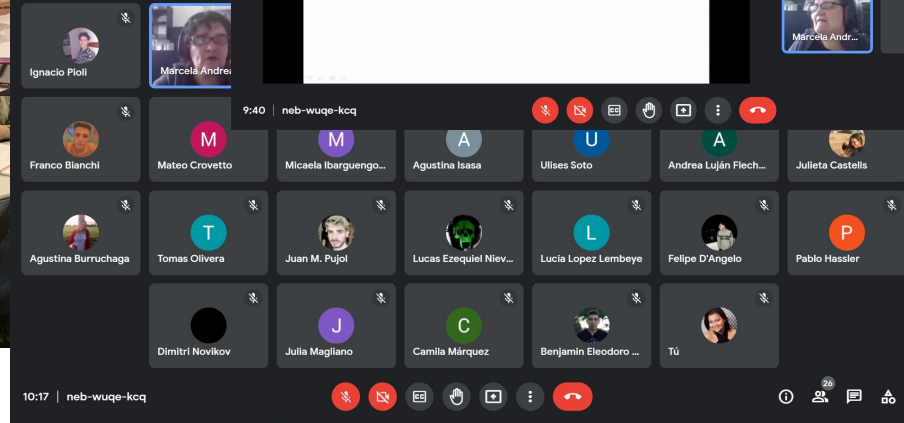# EDUCATIVE CONTEXT

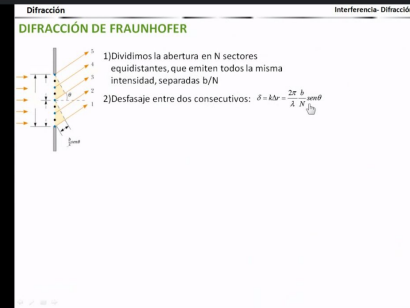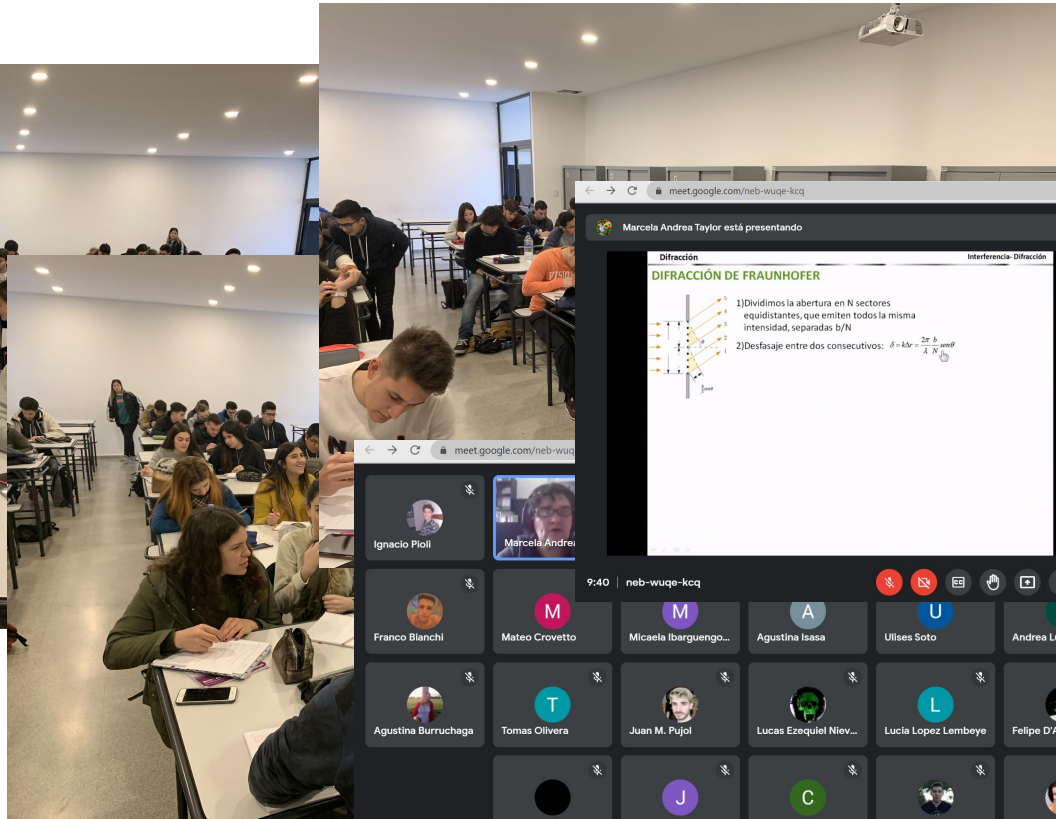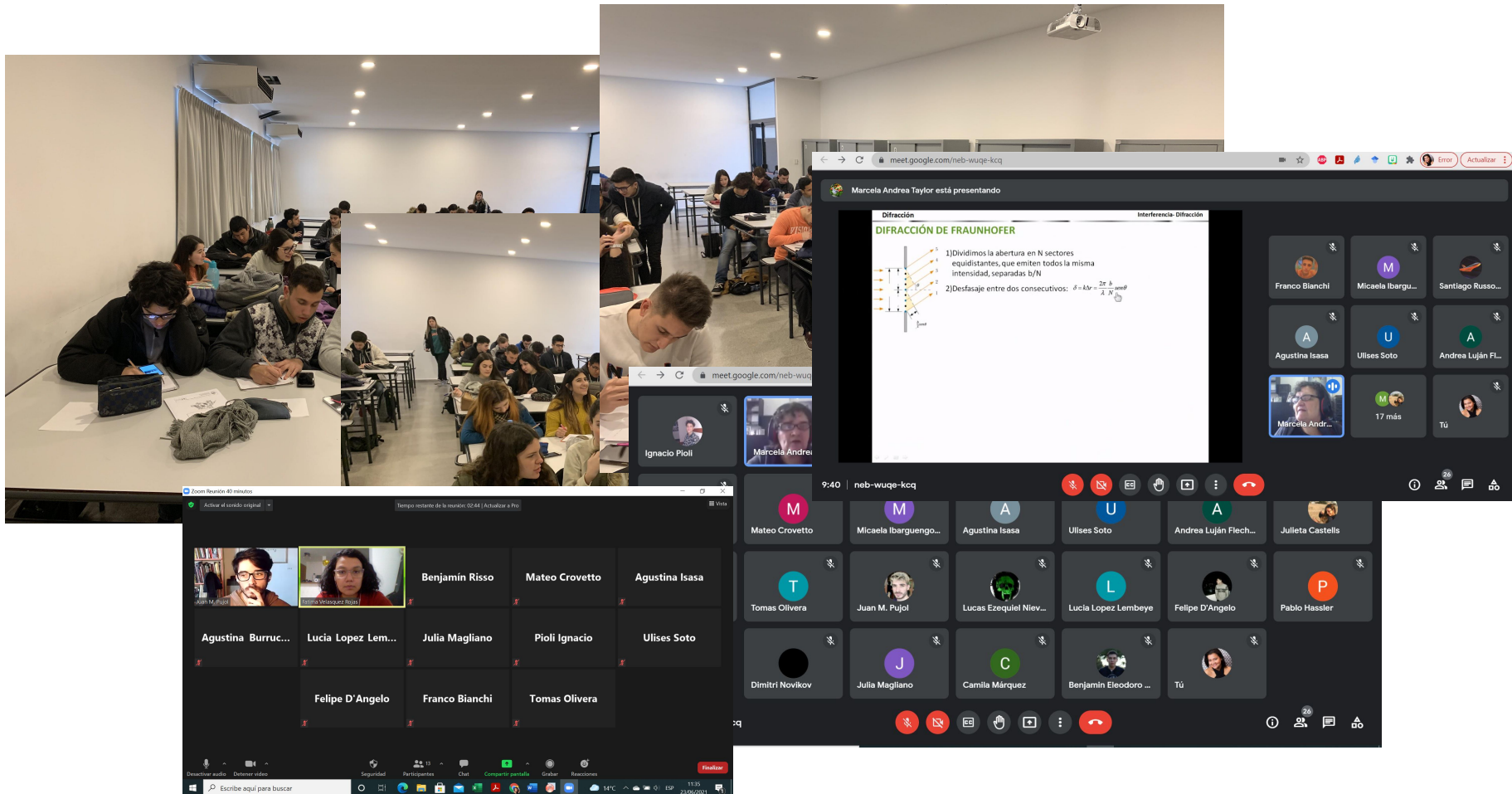# EDUCATIVE CONTEXT

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National University of La Plata (UNLP), Argentina
School of Engineering
Physics II course
4 semesters, 8 sections (2019 - 2020)
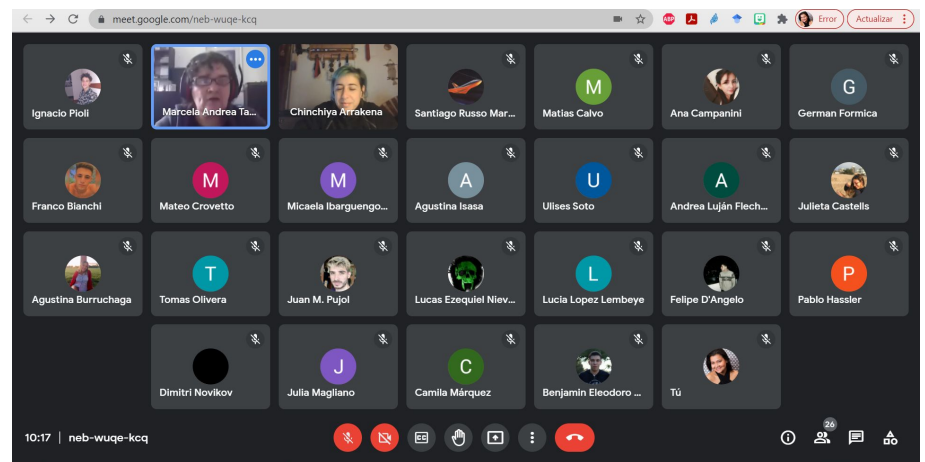*N = 173 students participating in the whole process*

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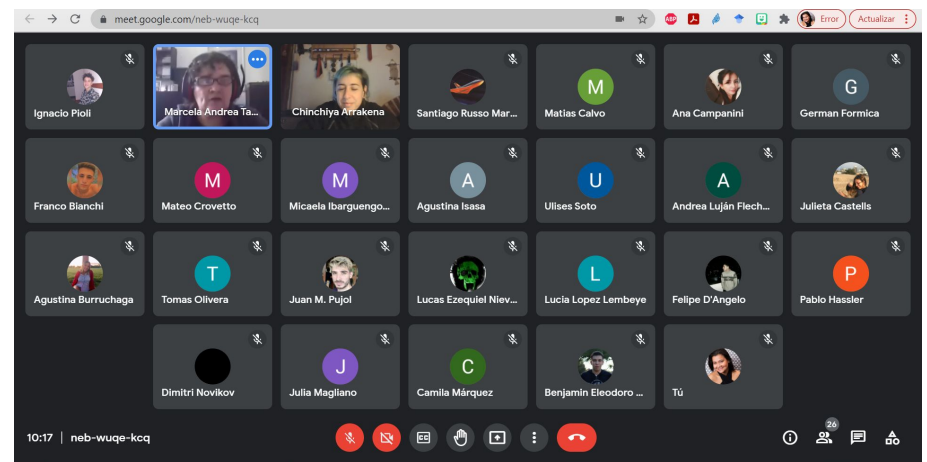
GROUP CLASSIFICATION

- *High-achieving (**HA**) students ($K_f \geq 8$)*

- *Average-achieving (**AA**) students ($6 \leq K_f < 8$)*

- *Low-achieving (**LA**) students ($K_f < 6$)*

BORDOGNA, C. M., AND ALBANO, E. V. Theoretical description of teaching-learning processes: A multidisciplinary approach. *Physical Review Letters* (2001), 118701.

GROUP CLASSIFICATION
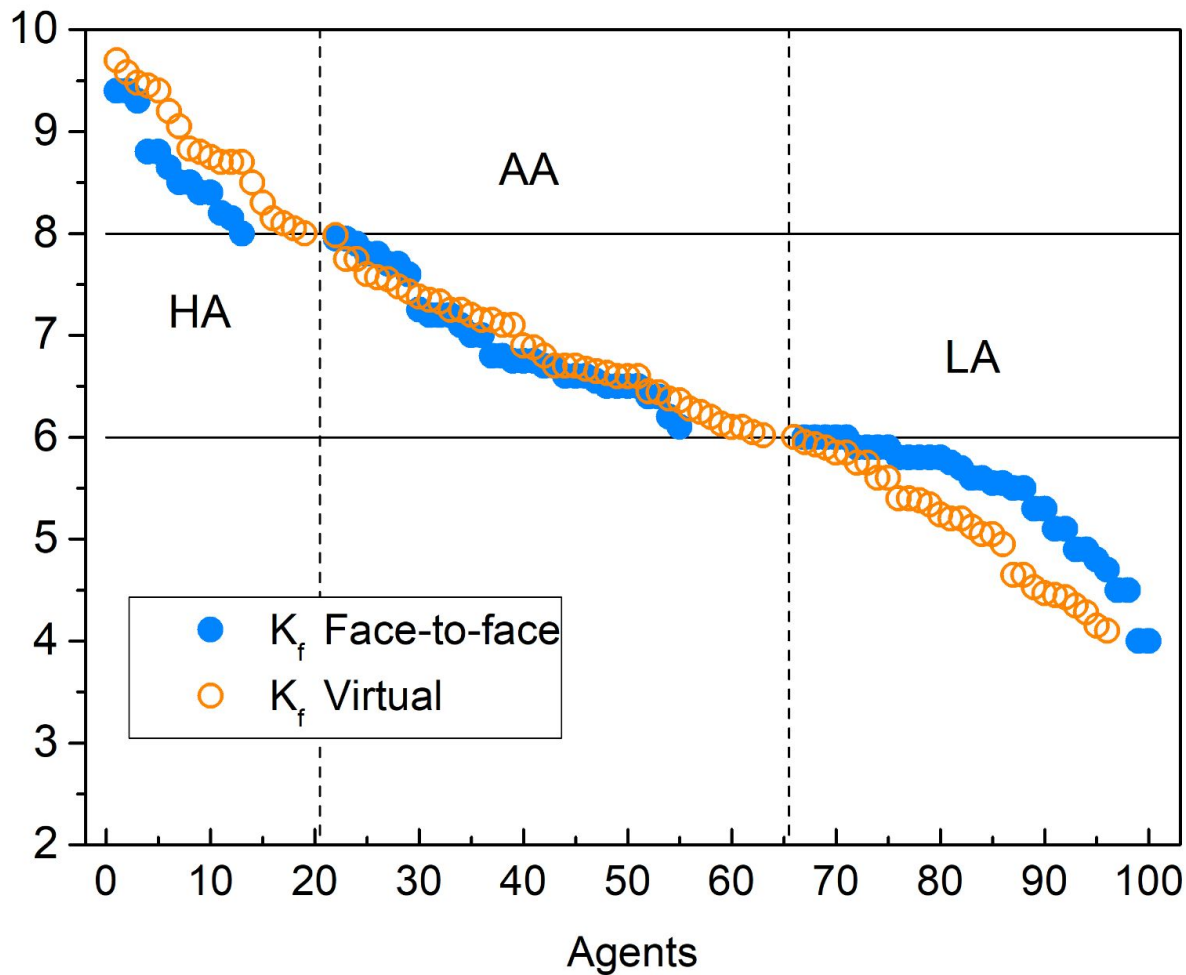
Group Classification of students according to their final grade and context for N = 173.

GROUP CLASSIFICATION

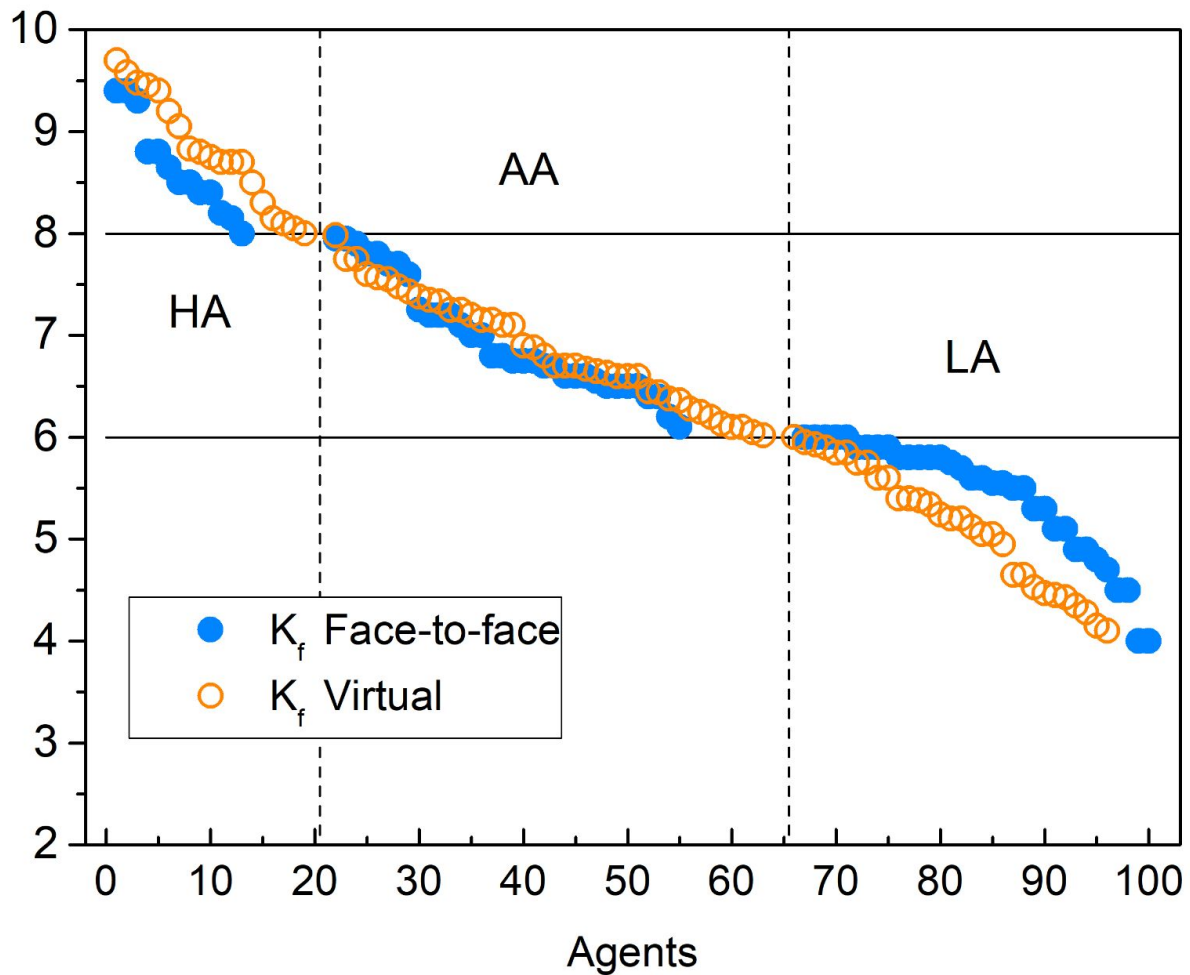|	HA	AA	LA	Total
Face-to-face	13	34	34	81
Virtual	19	42	31	92
Total	32	76	65	173

KNOWLEDGE ACQUISITION MODEL

The Knowledge Acquisition Process from a Complex System Perspective: Observations and Models

Fátima Velásquez-Rojas,[1] Instituto de Física de Líquidos y Sistemas Biológicos La Plata, Argentina, and **María Fabiana Laguna,** Consejo Nacional de Investigaciones Científicas y Técnicas, Bariloche, Argentina

$$K_f^i = \beta_M^X M^i + \beta_T^X T^i + \beta_P^X P^i$$

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Final knowledge acquired by individual i in the course

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Final knowledge acquired by individual i in the course

M: Motivation
T: Interaction with teachers
P: Interaction with pairs
$\square$: Weights for each term

In our study we focus on a specific type of learning, related to classical physics concepts. This is not the only content of value that is learned in the classroom, we simplify the concept of knowledge as a concrete and quantifiable measure.

KNOWLEDGE ACQUISITION MODEL

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Classroom Observations

Surveys

KNOWLEDGE ACQUISITION MODEL

Classroom Observations : *8 Sections (4 Semesters)*
Spatial distribution:
Clusters /Groups

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KNOWLEDGE ACQUISITION MODEL

Classroom Observations : *8 Sections (4 Semesters)*
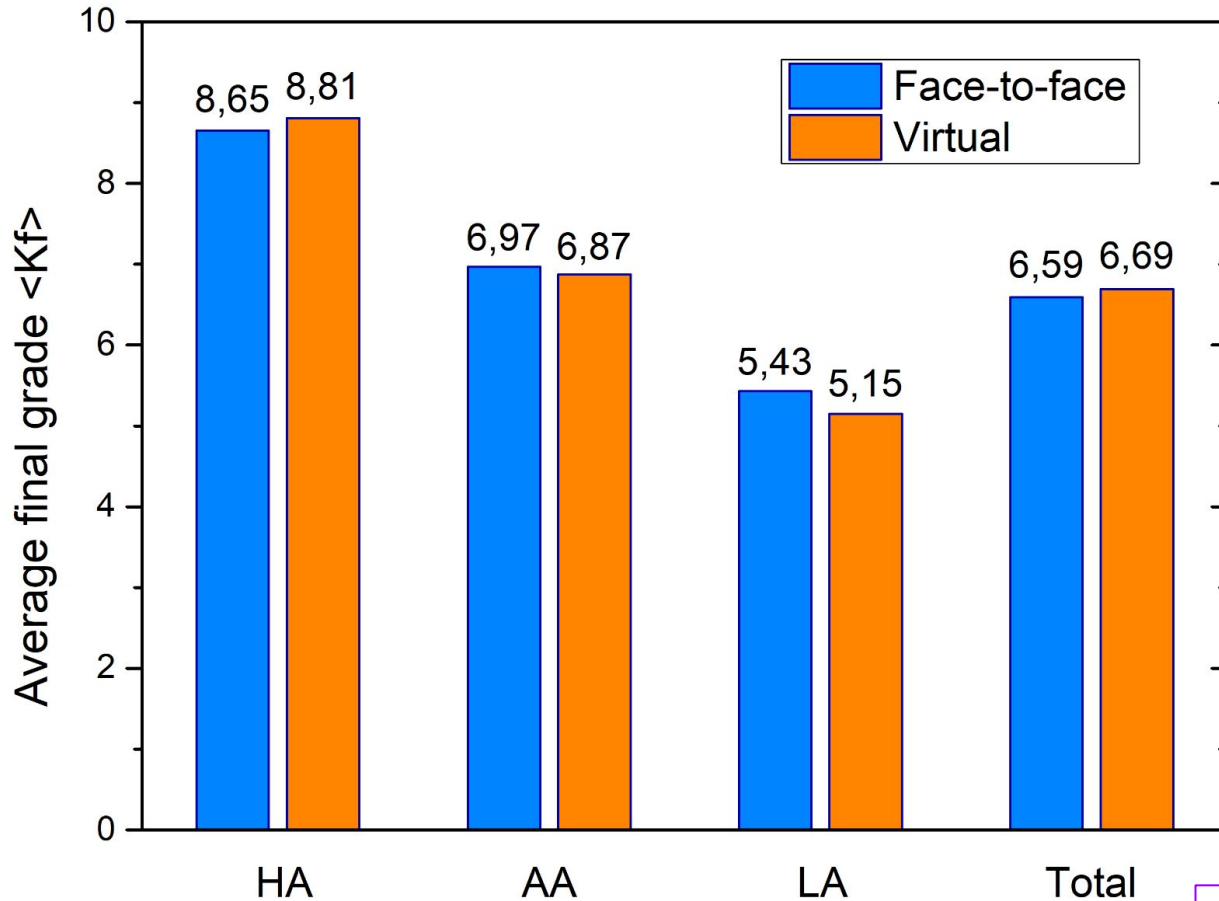*Spatial distribution:*
Clusters /Groups

Surveys : *We collected the aforementioned factors in 3 different moments*

These results were compared with the final grade obtained: "Final knowledge".

$$K_f^i = \beta_M^X M^i + \beta_T^X T^i + \beta_P^X P^i$$

$$X = HA, AA, LA$$

CHANGES OBSERVED BETWEEN CONTEXTS

Each group's performance changed differently with context:
- For HA students, *<Kf>* increased during virtual context.
- For those in groups AA and LA, performance decreased.
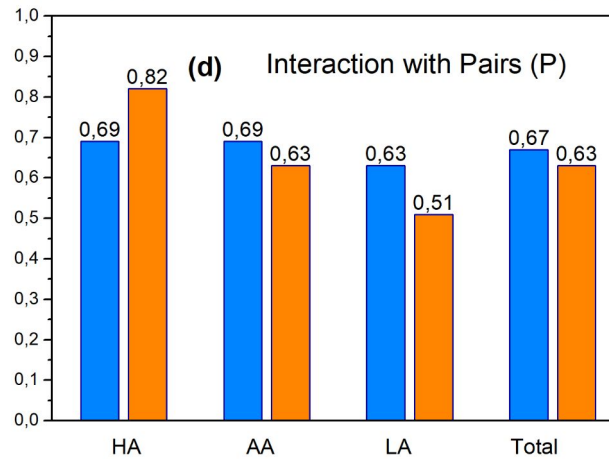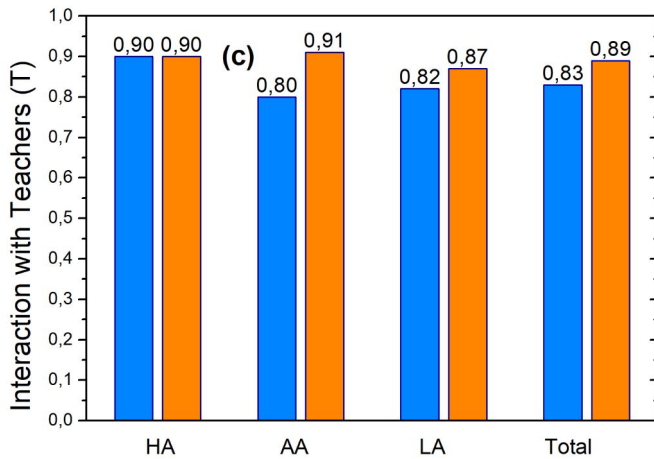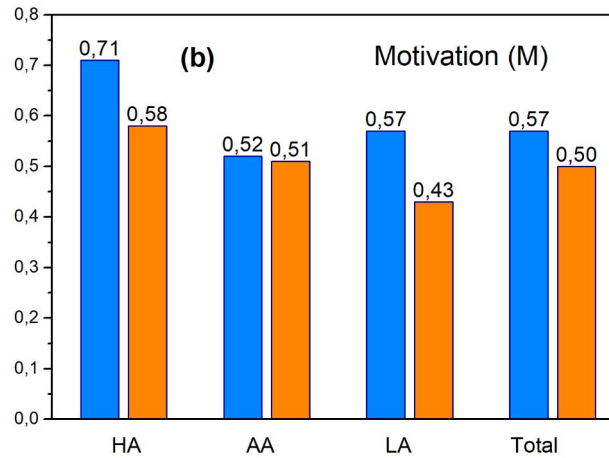
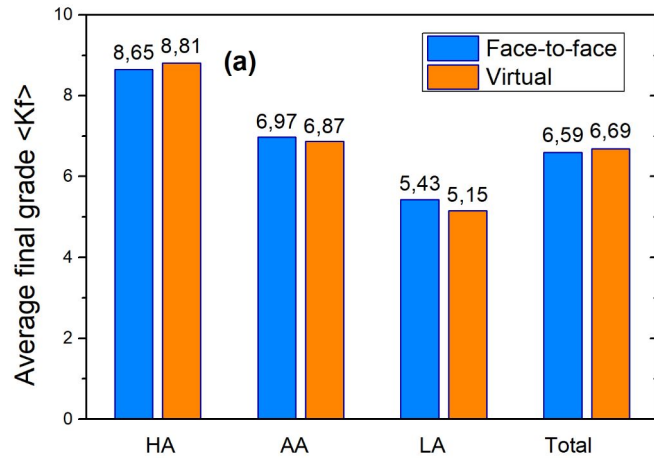$$K_f^i = \beta_M^X M^i + \beta_T^X T^i + \beta_P^X P^i$$

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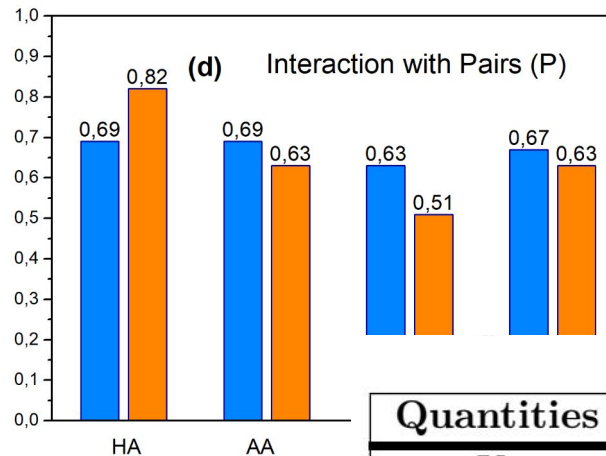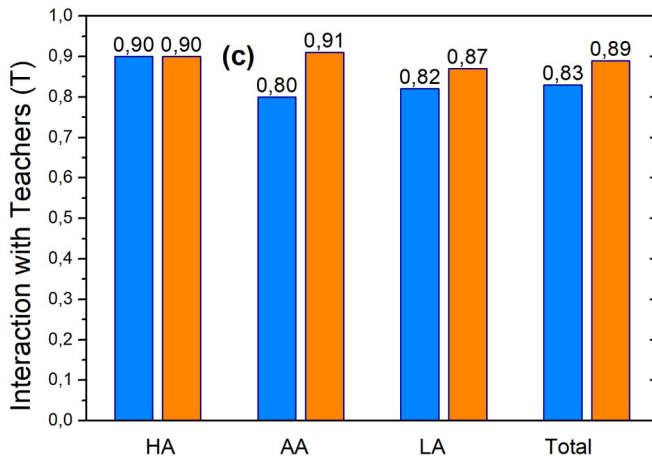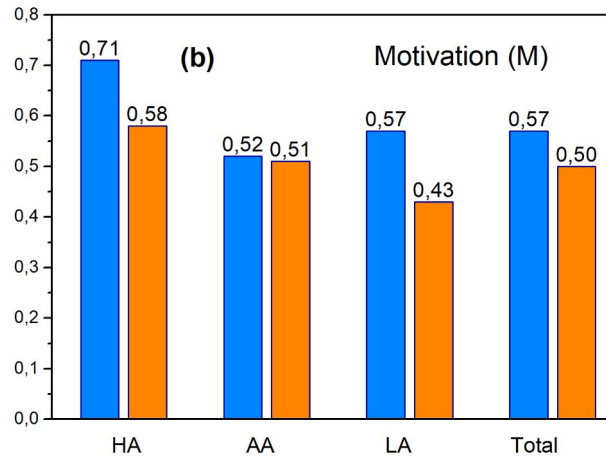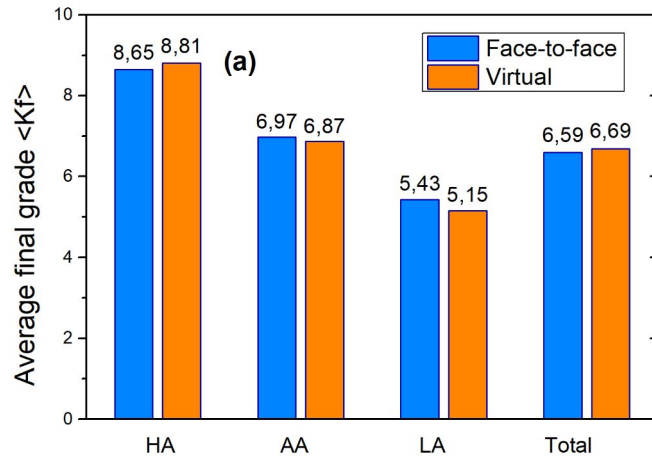$$K_f^i = \beta_M^X M^i + \beta_T^X T^i + \beta_P^X P^i$$

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$$K_f^i = \beta_M^X M^i + \beta_T^X T^i + \beta_P^X P^i$$

CHANGES OBSERVED BETWEEN CONTEXTS

$X = HA, AA, LA$

(a) — Average final grade $\langle K_f \rangle$: Face-to-face / Virtual — HA 8,65 / 8,81; AA 6,97 / 6,87; LA 5,43 / 5,15; Total 6,59 / 6,69

(b) Motivation (M) — HA 0,71 / 0,58; AA 0,52 / 0,51; LA 0,57 / 0,43; Total 0,57 / 0,50

(c) Interaction with Teachers (T) — HA 0,90 / 0,90; AA 0,80 / 0,91; LA 0,82 / 0,87; Total 0,83 / 0,89

(d) Interaction with Pairs (P) — HA 0,69 / 0,82; AA 0,69 / 0,63; LA 0,63 / 0,51; Total 0,67 / 0,63

- Decreased motivation in all groups
- Change in the way students interacted with teachers and other students

Quantities	relative change (%)			
	HA	AA	LA	Total
K_f	1.8	-1.5	-5.1	1.5
M	-17.5	-2.2	-23.7	-12.3
T	-0,1	12.8	5.9	7.1
P	17.8	-8.5	-19.7	-5.8

NETWORKS OF INTERACTION BETWEEN STUDENTS

Context	Isolated students			In groups		
	HA	AA	LA	HA	AA	LA
Face-to-face	3	12	15	10	22	19
Virtual	2	11	11	14	30	22

FACE-TO-FACE
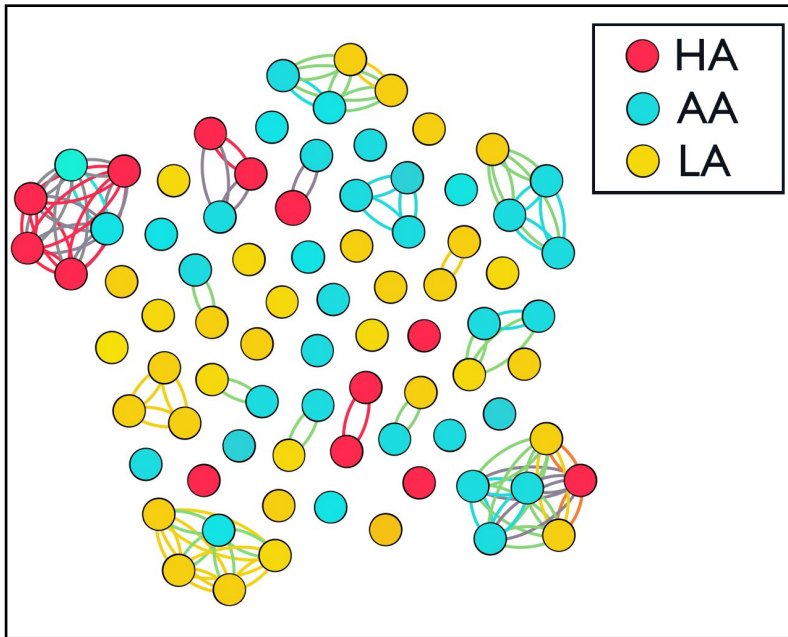
VIRTUAL
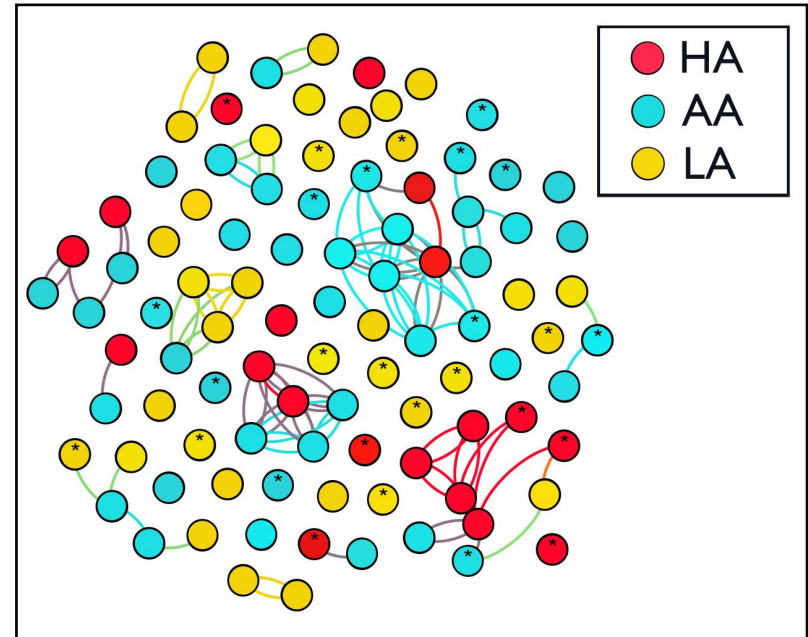
Similarities: *presence of highly connected clusters, as well as isolated students.*

Differences: *the virtual network has nodes that connect two different clusters, acting as "bridges". New form of relationship between students?*

KNOWLEDGE ACQUISITION MODEL

$$K_f^i = \beta_M^X M^i + \beta_T^X T^i + \beta_P^X P^i$$

$$X = HA, AA, LA$$

Final knowledge acquired by individual i in the course

Find the weights:
- *Artificial neural networks*
- *Multiple Linear Regression Method*

METHOD 1: Single Layer Perceptron (SLP) network

Inputs   Weights   Net input function   Suppressed activation function

x_1, M w_1, β_M

x_2, T w_2, β_T Σ Output

x_3, P w_3, β_P
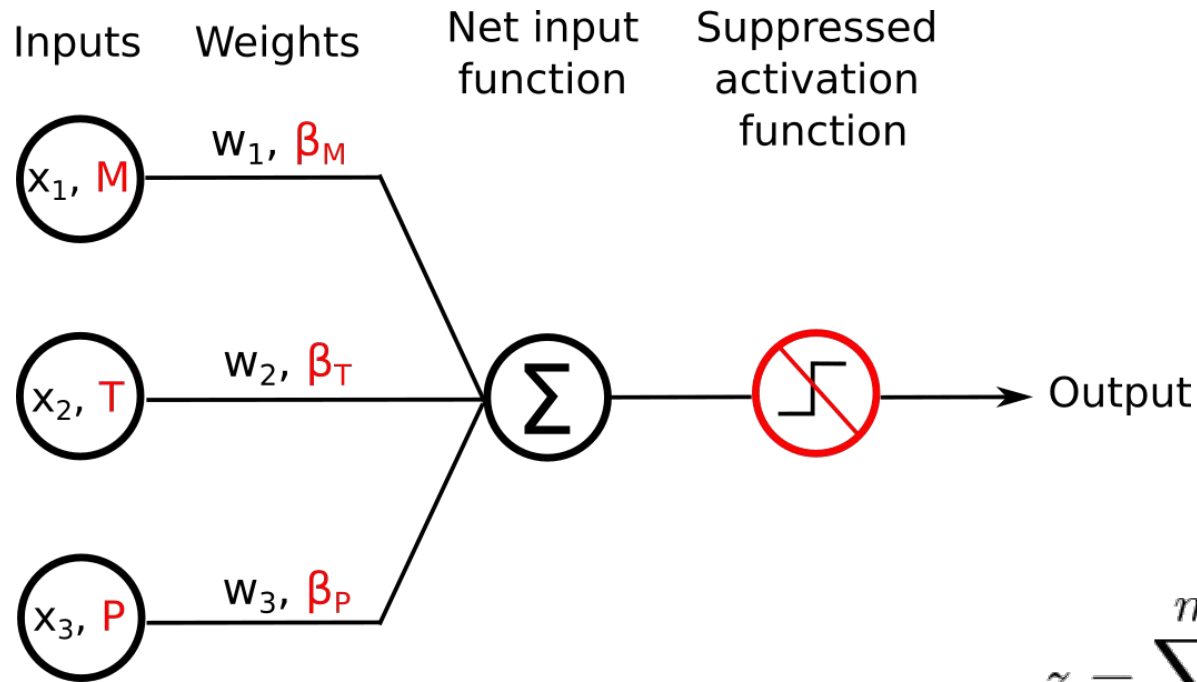
$$z = \sum_{j=1}^{m} x_j w_j = \mathbf{w}^{\mathbf{T}}\mathbf{x}$$

$$K_f^i = \beta_M^X M^i + \beta_T^X T^i + \beta_P^X P^i$$

METHOD 1: Single Layer Perceptron (SLP) network

	Face-to-face			Virtual		
	HA	AA	LA	HA	AA	LA
β_M^X	3,2	3,1	2,2	3,3	3,1	2,2
β_T^X	4,2	3,9	3,3	4,3	3,9	3,7
β_P^X	3,2	2,7	1,8	3,2	2,7	1,3

➤ Generality of the coefficients in both contexts

➤ Preponderance of the term of teachers

$$K_f^i = \beta_M^X M^i + \beta_T^X T^i + \beta_P^X P^i$$
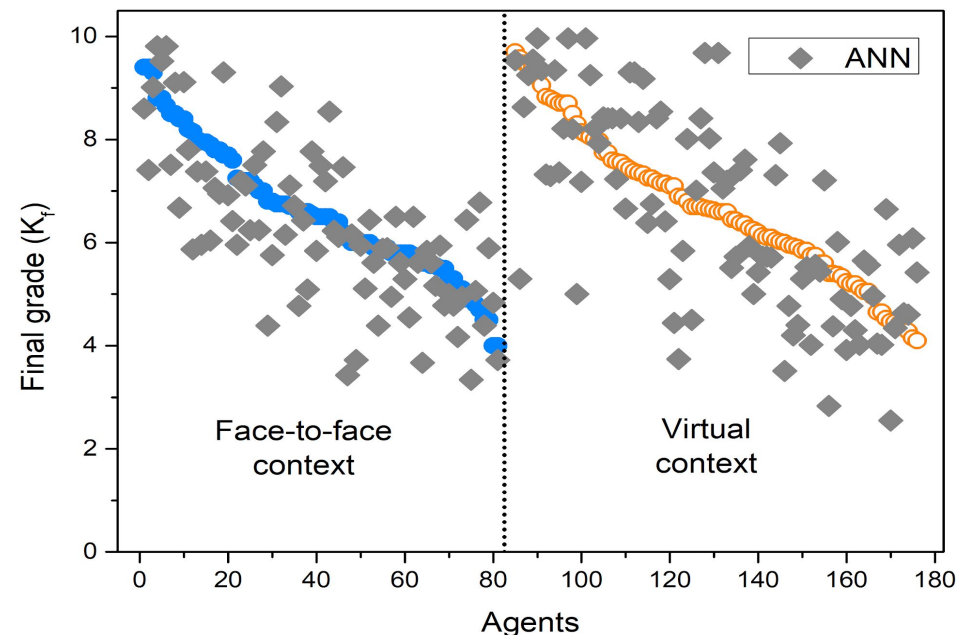
METHOD 2: Multiple Linear Regression (MLR)

$$K_f = \beta_M M + \beta_T T + \beta_P P + \gamma_{HA} G_{HA} + \gamma_{LA} G_{LA} + \alpha_C C_P + \varepsilon$$

METHOD 2: Multiple Linear Regression (MLR)

$$K_f = \beta_M M + \beta_T T + \beta_P P + \gamma_{HA} G_{HA} + \gamma_{LA} G_{LA} + \alpha_C C_P + \varepsilon$$

	β	SE	p-value
M	2.2776	0.3768	1.00e-08
T	4.6893	0.3063	< 2e-16
P	1.4660	0.2308	12.09e-09
Student group according to their final achievements K_f (Reference → AA)			
HA	1.9131	0.2664	2.43e-11
LA	-1.0585	0.2136	1.81e-06
Context (Reference → Virtual context)			
Face-to-face context	0.7424	0.1902	0.000139

Adjusted R-squared	0.9664
p-value	< 2.2e-16

preponderance of the term teachers (higher weight β_T)

The p-values obtained indicate that all the regression coefficients are statistically significant.
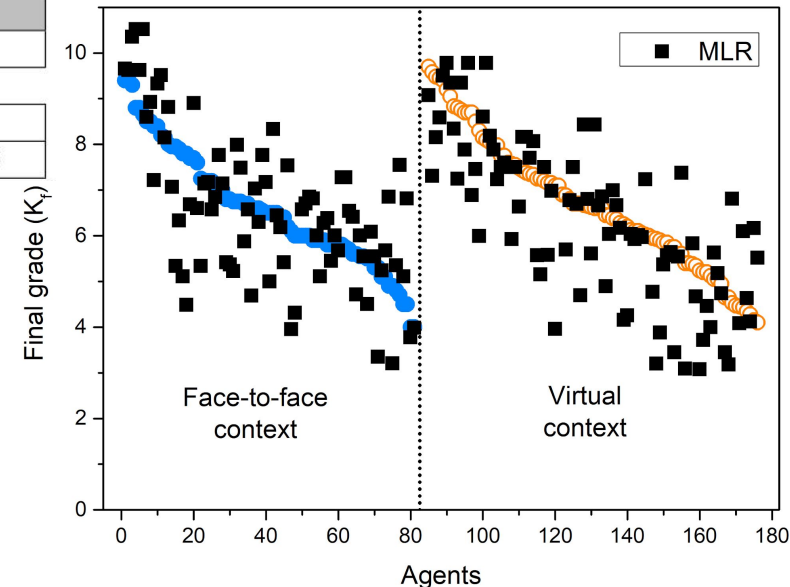
IN SUMMARY:

- *We analyze various quantities that participate in the knowledge acquisition process in face-to-face and virtual contexts for a specific case study.*

- *We develop an analytical model based on data consisting of a series of surveys and observations that are contrasted with information on academic performance.*

- *The shift to virtuality reflected a lack of motivation to learn and a change in the way students interact with pairs and teachers.*

- *The emerging network of contacts built from the interaction between pairs reveals different structures in both contexts.*

- *We explore two methods to know the weight of the different factors considered. In both contexts the weights are similar.*

- *In all cases, interaction with teachers is of utmost importance in the process of acquiring knowledge.*

Thank you for your attention!!!
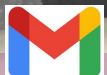
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