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Analysis of the Teaching-Learning Process of the Molecular Mechanics Concepts at the University Level in D R Congo

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Abstract: This work is achieved within the framework of research into didactic of chemistry. It highlights the impact of the teaching of chemistry, as it is currently practiced over the performance of the students at the university in DR Congo. Two Congolese universities were chosen: the "Université Pédagogique Nationale" (UPN) and the "Université de Kinshasa" (UNIKIN). The teaching-learning approach is considered as an experimental method with three independent variables namely modeling, the conceptualization and the theorization. The observations made one the process of teaching-training show that the student is not in the center of the process. The results of the test which followed these observations show that both modeling and the theorization are the most influential factors on the process of teaching-training in the two universities, while the conceptualization is an influential Factor only at UPN. The success frequencies are of 59.7% at UPN and 63.9 % at UNIKIN for students of the both universities, who are able to identify the symbolic level while responding the test. It is however a representing level of concepts, the one of creation of lower taxonomic level concepts of Bloom. Students then succeed more when recognition and understanding questions are given to them. The students' success frequencies that are able to identify the macroscopic and microscopic while answering questions are of 5.6 % at UPN and 11.3 % at UNIKIN. It can be concluded that the macroscopic, microscopic and symbolic levels of knowledge in Chemistry are not reached by the UPN's and UNIKIN's students while learning notions of molecular mechanics. The teaching of molecular mechanics notions as applied nowadays at the higher education level does not facilitate the learning and the deep understanding in Chemistry.

Keywords: Teaching-learning, modelling, conceptualization, theorization, molecular mechanics.

INTRODUCTION

The learning situations are located between the three constitutive poles of a Didactic triangle: The knowledge, the learner and the teacher. The difficulties which prevent the finalization of the teaching-learning process can generally be explained by the interaction between the three poles. Focusing on this Didactic triangle, the learning difficulties articulate around the three axes: the learner representations, the history and the knowledge nature, and the method of the teacher as well [1-5].

The learner representation is about the image of the concept that one has in his mind, over a phenomenon. This intellectual image is a generalization and an abstraction of an empirical fact. The level of abstraction can be complex or simple. In chemistry models are used, they are an inevitably simplified image of a given thing or phenomenon made in order to facilitate the research of it. Modelling is to build a model according to the objectives of a particular research [5].

The phenomena studied in Physics are in most of the cases of structure and complex forms, difficult to observe and to convey obstacles due to bad conception. During these last decades, the Chemistry development shows that science as namely a descriptive one seems to become a deductive one. Besides experience, the calculation place is constantly growing. However, it is very difficult even impossible to present the quantitative physics field in a linear pedagogy way. Modelling can be conceived to oblige the student to face his/her representations to the scientific theories. It is a privileged tool to overcome obstacles. This use of abstraction recommended in the teaching-learning of physics sciences leads to the risk of discouraging the middle student [1-3, 5].

Because of the phenomena nature studied, teachers and students adopt a dogmatic attitude axed on the transmission of scientific knowledge taken as absolute verities [6]. When a teacher presents chemistry concepts, the slaps between macroscopic, microscopic and symbolic levels are everywhere [8, 9]. At the university, the chemistry teaching combines lecturing and lab sessions which are the front door of macroscopic level and sessions of exercises during which symbolic level dominates. These different activities are taught by different people. A professor generally has one course while assignments are supervised by a group of assistants. So, the three levels of the chemistry representation could also appear as partitioned in front of students.

These difficulties are greatly revealed by the researches done in the chemistry didactics. The results of the works of Houart [7] shows that a half of students are able to identify the macroscopic level in their answers whereas the symbolic level is identified by less of the third party of students and that the microscopic level is identified by less of a quarter.

The concept of transferability of molecular fragments of a molecule to another has raised the implantation of a molecular “mecano” which allows building molecules with the respect of some rules. Molecular models made in balls or/and sticks are this idea. Thanks to the graphic qualities of images obtained on computer, one can display and manipulate the same kind of models, these latter being actually built according to the rules that take into account the forces and interactions between different atoms, these latter being either intra-molecular or inter-molecular [10,11].

Molecular modelling consists in making clear from calculations, the position of atoms which constitute a molecule in space and energy of the structure so generated. The comprehension of chemical liaison and of its modelling could be achieved only through the help of quantum theory. But the quantum theory uses a mathematical language and very formal basic principles. It is coherent that students refuse to imagine some aspects of the microscopic world [10].

Factors which allow learning the molecular mechanics concepts are numerous among which is the teacher intervention mode. The teaching of the molecular mechanics concepts as it is done today at the university level seems to put at a disadvantage the learning and the comprehension of chemistry.

The present work is achieved in the framework of the Chemistry didactic aims to evaluate the results of learning-teaching of the molecular mechanics concepts in chemistry at the university level in Democratic Republic of Congo (DRC).

METHODOLOGY

A descriptive method was used with two investigations:

- Observation, using an observation grid;
- Content analysis, using as tool, a test questionnaire.

The present method consists in undertaking an investigation without being himself on the ground. It is about seeing how is processed teaching-learning approach of Chemistry notions at the University in the Congo context. A camera then is used by one student within the teaching room, to avoid any subjectivity. The camera will be used to film different verbal behaviors and writings on the blackboard of the teacher during the Molecular Mechanic course. This observation is then supported by a test given just before the end of the Academic year (2016-2017).

The object to be aimed and analyzed in this research is the teaching-learning process. This descriptive study describes a teaching-learning approach. It takes into account a teaching method as an experimental approach. In fact, an distinction between the independent and dependant variables is necessary.

Independent variables are constitutive elements of the teacher speech, of his communication, of his masterly presentation; in short of his intervention to facilitate the modeling, the conceptualization and the theorization (three independent variables) to students.

The teacher facilitates the modeling to different levels. It is about the Bloom taxonomic levels [2, 11-15], of specific goals of the course targeted by the teacher at the beginning. The present taxonomy foresees six levels ordered as follows: recognition, understanding, implementation, analysis, summing up and assessment.

Lower levels (recognition and understanding), middle levels (Implementation and analysis) and higher levels (summing up and assessment) of these specific objectives are modalities of the said independent variable. It is the same for the conceptualization and the theorization.

The modality change of one independent variable involves the variation of student's performance (dependent variables).

To get certain with the orthogonality of independent variables, the comprehensive factorial planning used, organizes a random affectation of experimental conditions to experimental units that are students. The experimental conditions numbers is related to independent variables number and to that of the modalities number in view. Thus, for two modalities by variables which are the lower taxonomic level and higher taxonomic level, the factorial planning organizes 2^3 or 8 experimental conditions [3, 10].

The effects calculation (factors impacts on the expected answer) have been made according to the Yates Algorithm [10] . The students test noted ti and calculated through the formula

$$ti = \frac{|ai|}{si} \quad (1)$$

Where, ai is the calculated value of each effect and si is the estimation of standard deviation

$$si^2 = s^2/8\ ; \quad (2)$$

$$s^2 = \sum ei^2 \quad (3)$$

The uncontrolled factors constitute the miscalculation or the remainder. The Fischer test allows to check if these remainder is minimized. The sum up of the squared deviation noted SCE is calculated as follows:

For the factor: $SCEL = \sum(Y_i - Y_{OBS})^2$ (4)

For the remainder: $SCER = \sum(Y_{OBS\,i} - Y_i)^2$ (5)

Where Yobs is the expected answer in each experiment and Yi, the average answer calculated by the equation of the results treatment model.

The variance value noted S^2 is calculated as follows:

For the factor: $S^2_L = SCEL/ddl$ (6)

For the remainder: $S^2_R = SCER/ddl$ (7)

Where ddl is the degree of freedom

For the factor: ddl=p-1 (8)

For the remainder: ddl = n-1 (9)

Where p is the factors number considered in the model, p=7 and n, the experimental conditions number, n=8.

Analysis factors F is calculated through the following formula:

$$F = S^2_L / S^2_R \quad (10)$$

At the center of the experimental domain, the standard deviation Si is calculated as follows:

$$S^2 = \sum e^2_i \quad (11)$$

$$S^2_i = S^2/n \quad (12)$$

Study sample

The study sample is made of students who attended teachings over the notions of the molecular mechanics. They are from two Universities of Kinshasa in DRC, identified as those which organize the Chemistry department. Both are the "Université Pédagogique Nationale" (UPN) and the University of Kinshasa (UNIKIN). The Fischer test applied on the found result allows to conlude over the reproductibility of these results by an other researcher.

The variance valuer (S^2) is calculated as follows:

$$S^2_{facteur} = SCE_{facteur} / ddl \quad (13)$$

Where ddl = p-1

$$S^2_{résidu} = SCE_{résidu} / ddl \quad (14)$$

Where ddl = n-p where n is the total number of experimental conditions, n=16.

SCE is the of squares of deviations:

For the factor: $SCE_{facteur} = \sum_{i=1}^{p} n_i(\bar{X}_i - \bar{X})^2$ (15)

Where p is the samples number (universities), p= 2 and n_i is the measured number (experimental conditions) in each sample, n_i = 8.

$\bar{X}_i$ is the results average frequency in each university ;

$\bar{X}$ is the general average of frequencies in both universities

For the remainder: $SCE_{résidu} = \sum_{i=1}^{p} \sum_{j=1}^{ni} (X_{ij} - \bar{X}_i)^2$ (16)

Where X_{ij} is the observed frequency in experimental condition in one university.

Variables identified in this research are:

Independent variables

Literature considers three variables namely the chemistry knowledge levels: macroscopic, microscopic and symbolic levels.

These variables are made operational:
- At the macroscopic level: it is the aptitude to the modelling;
- At the microscopic level: it is the aptitude to the theorization;
- At the symbolic level: it is the aptitude to the conceptualization.

Dependent variables

It is the expected answer, i.e. the performance of students. The modalities of independent variables are the taxonomic of Bloom levels of specific objectives of this teaching-learning.

RESULTS AND DISCUSSION

Table-1 & 2 below give experiments in complete plans for the two university, UPN and UNIKIN and the number of students who succeeded (at least 50 %) to the test of the learning the molecular mechanics concepts. Effects calculations (impact of the factors under the study on the expected answer) are carried out according the algorithm of Yates [10].

Legend

Effects from order1: mo: modeling; co: conceptualization; th: theorization

Effects from order 2: moco: modeling X conceptualization; moth: modeling X theorization

coth: conceptualization X theorization;

Effects from order 3: mocoth: modeling X conceptualization X theorization; Yobs: the answer observed in each experience; Y: the average answer calculated with the number of the students from the order 1 and 2 of the linear model associated with the teaching-learning process; ei: estimation of the mistake; ei2: the square of the mistake; ai: value calculated of each effect; ti: the test of student.

Table-1: Experiment plan at UPN

Number of students: 72

N°	Mo	co	th	Moco	moth	coth	mocoth	Yobs	Y	Ei	ei2
1	-1	-1	-1	1	1	1	-1	43	43.25	-0.25	0.063
2	1	-1	-1	-1	-1	1	1	36	35.75	0.25	0.063
3	-1	1	-1	-1	1	-1	1	37	36.75	0.25	0.063
4	1	1	-1	1	-1	-1	-1	25	25.25	-0.25	0.063
5	-1	-1	1	1	-1	-1	1	36	35.75	0.25	0.063
6	1	-1	1	-1	1	-1	-1	14	14.25	-0.25	0.063
7	-1	1	1	-1	-1	1	-1	29	29.25	-0.25	0.063
8	1	1	1	1	1	1	1	4	3.75	0.25	0.063
9	0	0	0					24	28.00	-4.00	16
10	0	0	0					26	28.00	-2.00	4
11	0	0	0					30	28.00	2.00	4
12	0	0	0					28	28.00	0.00	0
13	0	0	0					27	28.00	-1.00	1
14	0	0	0					29	28.00	1.00	1
Ai	-8.25	-4.25	-7.25	-1.00	-3.50	0.00	0.25	28	28.00		0.5
Ti	33	17	29	4	14	0	1	112			
ti center	45.8	23.6	49.3	5.5	19.4	0	1.39	155.5			

Table-2: Experiment plan at UNIKIN

Number of students: 97

N°	mo	Co	Th	moco	moth	coth	mocoth	Yobs	Y	ei	ei2
1	-1	-1	-1	1	1	1	-1	62	61.62	0.38	0.144
2	1	-1	-1	-1	-1	1	1	31	31.38	-0.38	0.144
3	-1	1	-1	-1	1	-1	1	52	52.37	-0.37	0.137
4	1	1	-1	1	-1	-1	-1	23	22.63	037	0.137
5	-1	-1	1	1	-1	-1	1	50	50.37	-0.37	0.137
6	1	-1	1	-1	1	-1	-1	18	17.63	0.37	0.137
7	-1	1	1	-1	-1	1	-1	44	43.62	0.38	0.144
8	1	1	1	1	1	1	1	11	11.38	-0.38	0.144
9	0	0	0					36	36.37	-0.37	0.140
10	0	0	0					37	36.37	0.63	0.400
11	0	0	0					36	36.37	-0.37	0.140
12	0	0	0					36	36.37	-0.37	0.140
13	0	0	0					36	36.37	-0.37	0.140
14	0	0	0					36	36.37	-0.37	0.140
Ai	-15.6	-3.87	-5.62	0.125	-0.62	0.625	-0.37	36.37	36.37		1.125
Ti	4.17	10.32	15.00	0.33	1.67	1.67	1.00	97.00			
ti centre	37.20	9.20	13.40	0.30	1.49	1.49	0.89	86.60			

Legend

Effects from order1: mo: modeling; co: conceptualization; th: theorization
Effects from order 2: moco: modeling X conceptualization; moth: modeling X theorization
coth: conceptualization X theorization;

Effects from order 3: mocoth: modeling X conceptualization X theorization; Yobs: the answer observed in each experience; Y: the average answer calculated with the number of the students from the order 1 and 2 of the linear model associated with the teaching-learning process; ei: estimation of the mistake; ei2: the square of the mistake; ai: value calculated of each effect; ti: the test of student

As it can be seen from these tables, without calculating effects statically, the most influent factors are:

- For UPN: modeling and theorization; conceptualization have a weak influence.
- For UNIKIN, modeling is very influent on the phenomenon studied, conceptualization and theorization have weak influence.

The values of these effects are all negative: the more the teaching method trains on the modeling in both universities or on the theorization at UPN, the more the success frequency reduces. Therefore, students are not prepared for the modeling in both universities and for the theorization at UPN.

The chart of student gives for a risk α = %5 and a freedom degree $\surd$= 8-7= 1, t_{crit}(0.05 ;1)=12.71. The most pertinent factors are therefore modeling and theorization for both universities and conceptualization only for UPN.

The Fischer test allows seeing if the remainder is minimized. Table-3 & 4 give the test of Fischer at UPN and UNIKIN respectively.

Table-3: Test of Fischer at UPN

Variation	SCE	ddl	S^2	F
Factor	1215.5	6	202.58	405.16
Residue	0.5	1	0.50	
$F_{criticism}$	234			

Legend

SCE: sum of gaps squares
S^2 : estimator of the variance
F: is the analysis factor
ddl : degrees of freedom .

Table-4: Test of Fischer at UNIKIN

Variation	SCE	ddl	S^2	F
Factor	2331.5	6	388.58	345.34
Residue	1.1252	1	1.1252	
$F_{criticism}$	234			

Legend

SCE: sum of gaps squares
S^2 : estimator of the variance
F: is the analysis factor
ddl : degrees of freedom .

In both universities, F is greater than $F_{criticism}$. Therefore the gap between the obtained experimental value and the value calculated from the model is minimized.

To confirm this linearity of the studied behavior, some experiences are done in the center of the experimental field. At UPN, one has S_i=0.18 and at UNIKIN one has S_i=0.42

At UPN as at UNIKIN, pertinent effects in middle (t in center) are the same as those of each model. Therefore the model results are near to those observed.

Among the three factors on which depend the learning notions in chemistry (modeling, conceptualization and theorization) only modeling and theorization are not well adapted to students of the two universities.

The test of Fischer used for the obtained results permit to conclude on the re-productivity of these results by another researcher. These results in percentage (frequencies) are mentioned in the following chart:

Table-5: Frequencies of success in % in each experimental condition

N°	YobsUPN	YobsUNIKIN	EXPERIMENTAL CONDITIONS		
1	59.7	63.9	-1	-1	-1
2	50.0	31.9	1	-1	-1
3	51.4	53.6	-1	1	-1
4	34.7	23.7	1	1	-1
5	50.0	51.5	-1	-1	1
6	19.4	18.5	1	-1	1
7	40.3	45.4	-1	1	1
8	5.6	11.3	1	1	1
$\bar{X}_i$	38.89	37.5			
$\bar{X}$	38.18				

Legend

$\bar{X}_i$:is the frequency of the average success in each university;

$\bar{X}$: is the general average of the frequencies in both universities.

The results of the test of Fisher are mentioned in the following table-6:

Table-6: The results of the test of Fisher for the re-productivity

variation	SCE	ddl	S^2	F
Factor	7.9806	1	7.9806	0.023
Residue	4827.8	14	344.84	
$F_{criticism}$	4.6			

According to the results of this test, the factor of the analysis F is inferior to $F_{criticism}$, therefore the variability factor namely "university" separates the population from students in identical groups. However, the results are re-producible.

Moreover, this table shows well that when asking questions which not of superior level, the success frequency is 59.7 % for UPN and 63.9 %for UNIKIN. When asking one question of the superior level out of three, the success frequency is reduced to 50.46 % at UPN and to 45.66 % at UNIKIN. For two questions of the superior level out of three, the frequency becomes 31.46 % at UPN and 29.2 % at UNIKIN. When asking only questions of the superior level, the success frequency falls to less than 5.6 % for UPN and 11.3 % for UNIKIN. The figure below indicates the students's success frequencies to questions of higher level of bloom taxonomy.

Figure 1 shows that success frequencies is higher at UNIKIN (63.9%) than at UPN (59.7%) but success frequencies for both universities are higher than 50% . These frequencies which reflect the conceptualization level, that is to say, the one of concepts representation (symbolic level), are furthermore higher to the one of Houart [7] (less than 1 out of 3 or less than 33.3%). However, it is about lower taxonomic level knowledges of Bloom.

Moreover, for the same level of concepts representation, the comparison between the both Universities shows that students of UPN are weaker than those from UNIKIN. In fact, among the factors from which depend the learning-teaching of molecular mechanic notions, the conceptualization is the most significative factor at UPN only.

For questions of lower level, students succeed better than when one asks recognition and understanding questions. Indeed, when there are only questions of higher level, success frequency is of 5.6% at UPN and of 11.3% at UNIKIN. These frequencies which reflect modeling and theorization levels or macroscopic and microscopic levels are weaker than those obtained by Houart [7] (almost more than 50% for the macroscopic level and less than 25% for the microscopic level).

The delineating factors identified above, that is, modeling and theorizing in both universities, are therefore dependent on higher-level issues, namely, questions of synthesis and judgment.

The analysis done above is supported by following observation:

Implementation

In this process of teaching-learning, teachers have presented well pedagogic objectives and their utilities. The required knowledge is recalled. However, the teaching-learning of the molecular mechanics concepts do raise neither interest, nor curiosity to the students while the notions taught are from a highest abstraction level.

Experimentation

The teaching-learning of the molecular mechanics concepts is not carried out with manipulations in lab.

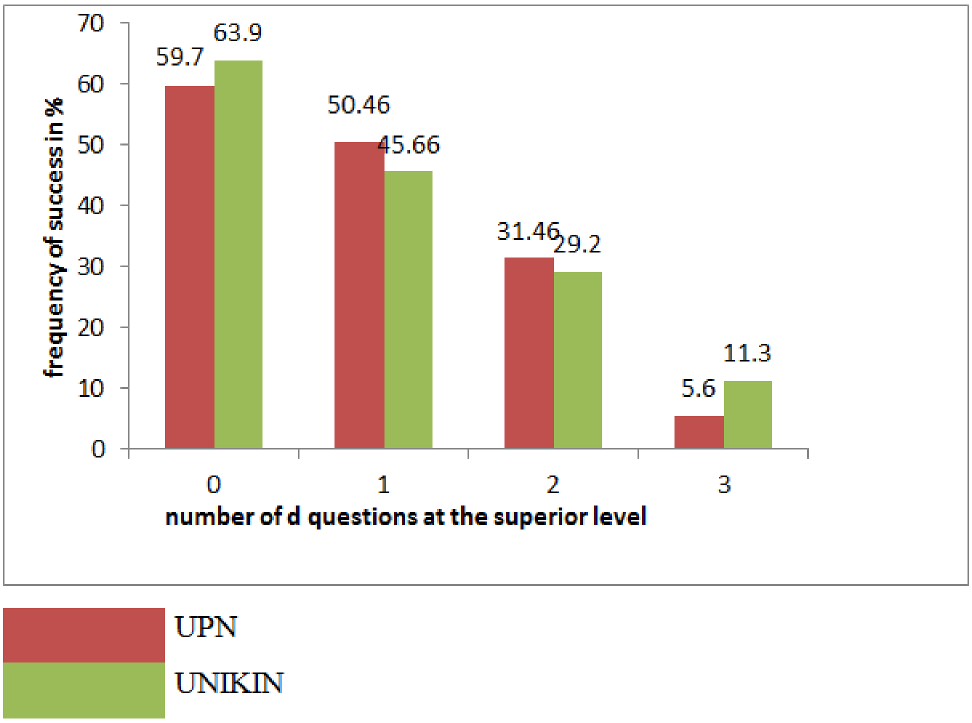

Fig-1: Frequency of success in function of the questions at the superior level

Objectivization

In this process, teachers do not allow students to present their results on the comprehension of concepts in order to get the unique one.

The abstract of information is given to the students in a handout. The teacher tries to reproduce molecules structures on the board for a collective discussion.

Reinvestment

The reinvestment activity does not need the same process because the student goes from a representation of concepts in classic mechanics to a representation of concepts in quantum mechanics.

Global characteristics

In this process, the teaching-learning does not allow to the student noticing quickly his/her successes, failures and progresses.

So, according to observations done at UPN as at UNIKIN, the student is not put in the center of this teaching-learning process.

CONCLUSION

The present study was undertaken in the framework of the research in Chemistry Didactics, considering the Chemistry teaching impact as it is nowadays practiced over the students' performance at the University. The most influential factors on the quality of learning the concepts of geometric variables notions used in molecular mechanics had to be identified.

The description of a teaching-learning method taken as an experimental method revealed three independent variables namely modeling, conceptualization and theorization these are the levels of knowledge likely to be identified by a student during the teaching-learning process.

Observations made show that the student is not put at the center of the teaching-learning process. Modeling and theorization are the most influential factors on the teaching-learning process in both universities while conceptualization is an influencing factor only at the UPN.

The success rates of students who are able to identify macroscopic and microscopic levels in their responses are 5.6% at the UPN and 11.3% at the UNIKIN. For the symbolic level these frequencies are 59.7% at the UP N and 63.9% at the UNIKIN. However, this success is dependent on questions of level of recognition and understanding, lower levels in Bloom's taxonomy.

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