IOSR Journal of Research & Method in Education (IOSR-JRME)
e-ISSN: 2320–7388,p-ISSN: 2320–737X Volume 7, Issue 3 Ver. III (May - June 2017), PP 65-76
www.iosrjournals.org

Identification of the Types of Reasoning Used By Moroccan Students When Learning the Chemistry of Solutions

ELATLASSI Mohamed[1], TALBI Mohamed[2], KHYATI Abderrahim[3], BOUMAHMAZA Mohamed[3]

[1] *Laboratory of Analytical Chemistry and Physical Chemistry of Materials, Faculty of Sciences Ben M'sik of Casablanca, Morocco*
[2] *Dean of the Faculty of Sciences Ben M'sik, University Hassan 2 in Casablanca, Morocco.*
[3] *Teacher researcher at the normal school superior in Casablanca , University Hassan 2 in Casablanca, Morocco.*

Abstract: *In the context of improving learning methods of the chemistry of solutions, we present here the results of a research we conducted among 282 of second year students of the Moroccan scientific baccalaureate and the first year university students. The objective of this research is to identify the type(s) of participants' reasoning when learning this discipline. We considered the questionnaire as a data collection instrument. The latter contains two parts: the first part contains the three open questions, not modelled ,inspired the Moroccan baccalaureate program for all students (all levels combined) in order to know if the student requires an approach based on a coherent and logical reasoning, and if so, what type of reasoning? And the second part is for students in the first year university with two questions in order to know if changes in ranking of knowledge allow students to involve more and more a model-based reasoning. The results of this study clearly show that our subjects prefer a reasoning based on rules, although this type of reasoning is very long, tiring, linearly reconstructed in a series of connected and logical ideas and often leads to systematic errors and also to spontaneous thoughts and modes (especially undergraduate students) which hinder the construction of scientific reasoning, relying either on the knowledge of elements that are not all accurate according to scientifically accepted theory, or on knowledge studied that was not used in the right situation. Although a positive trend in the hierarchy of knowledge of students was recorded during the first year university, the rate of use of a model-based reasoning by these students as compared to problems that confront students of second year baccalaureate remains low. Consequently, that rate tumbles in front of problems met at the university level.*

Keywords: *Misconceptions, Science reasoning, Chemistry of solutions, the models, the learning of chemistry solutions.*

Résumé : *Dans le cadre d'amélioration de l'apprentissage des méthodes de la chimie des solutions, nous présentons dans cet article les résultats d'une recherche que nous avons menée auprès de 282 étudiants de deuxième année du baccalauréat scientifique marocain et de la première année universitaire, qui vise à identifier le(s) type(s) de raisonnement des participants lors de l'apprentissage de cette discipline. Nous avons envisagé le questionnaire comme instrument de collecte des données. Ce dernier contient deux parties : La première comprend trois questions, inspirées du programme de baccalauréat marocain, destinées à tous les étudiants (tous les niveaux confondus), dans le but de savoir si l'étudiant implique une démarche basée sur un raisonnement logique et cohérent, si oui quel est le type de ce raisonnement ? Et la deuxième est réservée aux étudiants de la première année universitaire, comportant deux questions, dans le but de savoir si l'évolution de la hiérarchisation des connaissances permet aux étudiants d'impliquer de plus en plus un raisonnement basé sur les modèles. Les résultats de ce travail montrent nettement que nos sujets préfèrent plutôt un raisonnement basé sur les règles, même si ce type de raisonnement est très long, fatiguant, reconstruit de façon linéaire dans une logique d'enchainement des idées et mène souvent à des erreurs systématiques. Et aussi à des modes de raisonnements spontanés (particulièrement les étudiants du baccalauréat) qui freinent la construction d'un raisonnement scientifique, s'appuient soit sur des éléments de connaissance qui ne sont pas tous exacts selon la théorie scientifiquement acceptée, soit sur un savoir étudié qui n a pas utilisé dans la bonne situation. Même si une évolution positive de la hiérarchisation des connaissances des étudiants a été constatée durant la première année universitaire le taux d'utilisation d'un raisonnement basé sur les modèles par ces étudiants face à des problèmes du baccalauréat reste faible. Et ce taux dégringole face à des problèmes de niveau universitaire.*

Les mots clés : *Conceptions erronées ; raisonnement en sciences ; chimie des solutions ; les modèles ; l'apprentissage de la chimie des solutions.*

I. Introduction

The learning of science is difficult for students: the concepts are numerous and sometimes complex. This type of learning can be at risk when it relies on unstable foundations mixed with misconceptions. The presence of the latter in the minds of students may impair conceptual understanding, and may lead them to explain scientific phenomena incorrectly and to make inaccurate predictions with scientifically accepted theory (Cormier, 2014). Thus, successful learning is directly linked to a system of coherent and accurate representations according to the scientifically accepted theory. In order to encourage such learning, researchers in science didactics carried out inventories of misconceptions, especially in secondary and college education (Nicoll, 2001; Othman et al., 2008). But actually these catalogues of erroneous designs cannot be easily used by teachers (Talanquer, 2006) because they encounter difficulties in creating educational situations around a voluminous number of conceptions. Currently, researchers propose not only to inventory these conceptions (Duit, 2011), but they propose to study the reasoning process used by learners when solving a scientific task because all the wrong answers Do not come solely from erroneous conceptions: some result from a lack of knowledge, others from an incorrect arrangement of concepts nevertheless correct ... In this work, we agree with the authors on the need to re-examine and identify the types of reasoning favoured by learners before embarking on a process of improving the learning of science. We focus in this work on the Moroccan students of secondary education and the first year of university studies when learning the chemistry solutions. In this article, we present the theoretical framework, then we show the methodology of the research and finally we discuss the results obtained.

1-It is necessary to identify the types of reasoning of learners when solving a task in solution chemistry:

Learning the chemistry of solutions is recognized as difficult by secondary and college students: the concepts are numerous and complex. Even students who successfully complete their chemistry courses may have incorrect ideas well entrenched in their cognitive structures (Driver and Easley, 1978).

Other research in solution chemistry (Cros et al., 1988; Dhindsa, 2002) has shown that after a long academic and even academic course, learners always retain misconceptions. Moreover, students have only a superficial knowledge of the concepts and models of solution chemistry (Boulabiar-Kerkeni, 2004), which prevents their transfer to new problems to solve.

A large number of didactic works make it possible to identify several difficulties and obstacles during the solution of the tasks in chemistry of the solutions:

- A lack of mastery of fundamental concepts by pupils and students (Laugier and Dumon, 2000, Gauchon, 2008, Schmidt, 1990, Nakhleh and Krajcik, 1993, Naija, 2004, Sheppard, 2006, Stavridou and Solomonidou 2000).
- Interpretation and graphical exploitation are a real difficulty (Maichle 1994, Mokros and Tinker 1987, Nakhleh and Krajcik 1994, Rabier et al 2001, Naija 2004).
- The abstract character and the variety of models on the other hand cause difficulties in mobilizing the "right model" for the right situation (Boulabiar-Kerkeni, 2004).

In addition, a chemistry solution, like all scientific subjects, has a bad reputation among high school students. Indeed, a descriptive study comes from a survey carried out by the Department of Evaluation, Foresight and Performance of the French Ministry of Education in 2005, online with a representative sample of high schools General and technological and vocational schools, shows that:

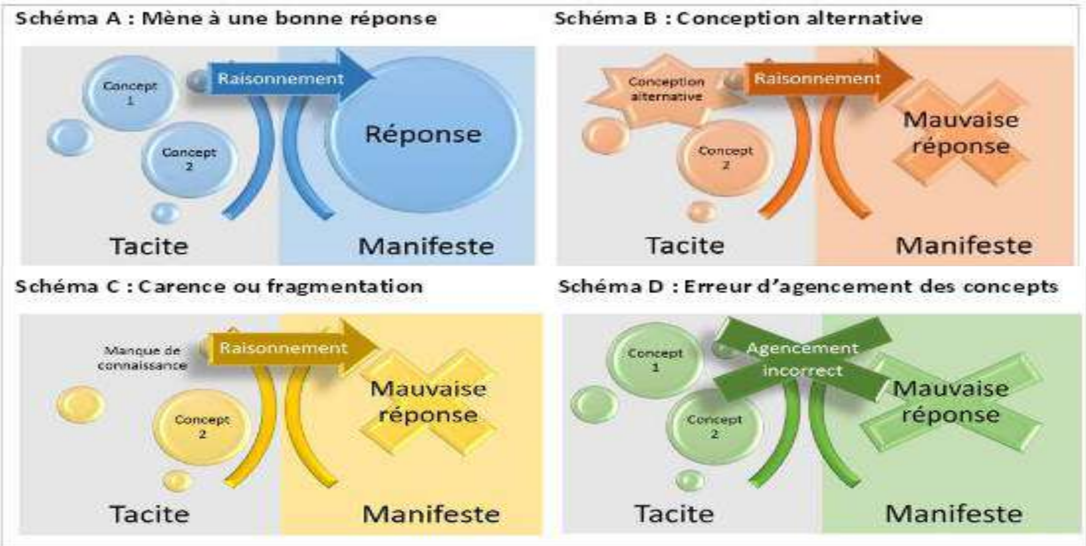
- Students do not choose a path of formation where there is physics-chemistry but a scientific way.
- Chemistry is considered interesting but difficult and less concrete than physics.

With the absence of official Moroccan statistics, a quick navigation in the forums of the students confirms the bad image of this discipline: publication of the dozens of Slogans, commentaries and humorous productions that hate chemistry and scientific subjects in general. Given these constraints, the student tries to find a learning strategy (logical or not) to overcome his difficulties: A study by Boulabiar-Kerkeni (2004), which focuses on the learning of basic concepts in redox and the use of predictive models, shows that French baccalaureate students and first year cycle students Tunisian academic universities use other models, possibly not taught and incorrect according to the scientifically accepted theory, or prefer mainly the symbolic representations of concepts. Another study by Dumas-Carre (1989), which analyzes the types of activities encountered in the secondary education of scientific disciplines in France, shows that most of the resolutions exposed by the teacher (the reasoning reconstructs linearly In a logic of sequence of ideas) incite the student to memorize the steps of the preceding scheme and to reproduce them in a situation that he considers neighbouring without implementing a real scientific approach. Experts, researchers and educational specialists insist on model-based learning because chemistry is a modelling science. In reality, an improvement in the conceptual learning of this discipline requires, in the first phase, an identification of the types of reasoning used by

Moroccan students when learning the chemistry of the solutions. Do Moroccan students favour model-based scientific reasoning when learning this discipline? If not, what is the type of reasoning?

II. The Reasoning

Rationale, in its general definition, is the use of logic to produce a conclusion, inference or judgment (Montminy, 2009), is simply the mechanism by which the establishment and formulation of correct relationships between ideas and concepts. According to Tardif (1997) ideas and concepts are reconstructed in the minds of the people, who make the reasoning, they are implicit. When asked for an answer to a question about these ideas or concepts, the mechanism of reasoning that gives an answer, which is manifest, is triggered. The following are the different variations of the process leading from the mental model to the answer to a question, proposed by Cormier (2014):



In Diagram A: The reasoning process leads to a good response. The latter is obvious, but the concepts are tacit, that is, they are reconstructed in the mind of the person making the reasoning. His mental model is adapted with the scientifically accepted theory. His reasoning is also correct: ideas and concepts are harmonized and organized in a logical way.

Sometimes the answer is not consistent with scientific theory, that is, the student gives a wrong answer.

In Diagram B: This incorrect response originates from the presence of an erroneous conception of mental models. The reasoning used can be logical and solid, but sometimes leads to wrong answers because reasoning relies on elements of knowledge that are not all accurate according to scientific theory.

In Diagram C: Another process may lead to an incorrect response, called "Deficiency or Fragmentation". This process occurs when a student does not have the necessary knowledge to reason. Either this knowledge has never been taught to him, or he has never actually learned it. It is also possible that the student actually has the notions necessary to answer the question, but he cannot invoke them because he does not know that he must use them: the learner does not see an existing relationship between knowledge which must be used and the subject proposed to it.

In Diagram D: The last case also leads to a wrong answer, can be explained in the reasoning process itself, that is, the learner uses just concepts and notions but how they are put In relation to one another, leads to this falsehood. The reasoning is based on incorrect relationships between ideas that are correct. According to Driver and Easley (1978), this may occur when there is a mismatch between the conceptual requirements of a taught content and the degree of reasoning competence of the students to whom the content is taught.

III. The Four Main Types Of Reasoning Used When Solving A Task In Chemistry

Christian and Talanquer (2012); Ferguson and Bodner (2008); Kraft, Strickland and Bhattacharyya (2010) have shown that there are four types of reasoning used when solving chemistry tasks.

We cite:

3-1-Rules Based Reasoning:

This type of reasoning:

- Involves mainly deductive reasoning.
- Rebuilt linearly in logic of sequence of ideas by memorizing the steps of the resolution.

- Encourages the student to use following a set of rules each corresponding to a small portion of knowledge.
- Is tiring, very long to achieve the right answer.
- Often leads to systematic errors: if a badly carried out or forgotten step leads necessarily to a wrong answer.

3-2- Reasoning Based on Case Experience:

This type of reasoning:

- Involves inductive reasoning.
- Applies when characteristics familiar to the task are recognized by the person making the reasoning.
- Encourages students to use their past experiences or adapt old solutions to new problems.
- May generate incorrect answers: Familiar characteristics may be misleading, and the student may respond to a task in light of the characteristics of another irrelevant task that he / she considers to be neighbouring without using a scientific approach.

3-3- Model Based Reasoning:

This type of reasoning:

- Is the most common and the most beloved in science: it is based both on detailed knowledge allowing to explain the scientific phenomena and a shortened reasoning allowing to predict them.
- Scientific reasoning is named in several articles (A. Dumas-Carré et al 1989, J.-L. Closset, 1992, L. Viennot, 1992 ...) because it is a paper-pencil transposition of the practices of researchers.

3-4-Reasoning based on symbols:

The latter type:

- Draws on the manipulation of chemical symbolism.
- Is used especially by students who attempt to circumvent the need to understand the reason for chemical processes.
- Students rely solely on the symbolic surface characteristics of the problems to be solved.
- Is not very effective and does not help to mobilize the studied knowledge.

Note: We must not confuse the reasoning based on the symbols with that based on the models because the latter can rely on symbols to represent an idea or to connect concepts ... On the other hand, the other mode of reasoning Takes symbols as much as a basis of reasoning.

IV. Research Methodology

4-1-Topics:

Our first data collection was carried out during the months of April and May 2015, concerning only the students of the second year of the Moroccan baccalaureate section "Physical Chemistry (PC)" and section "Science of life and earth (SVT)". We conducted a second data collection in the spring of 2016 to increase our sample, this time involving students in the first year of the scientific university section "Science of Chemical matter (SMC)" and second year students of Baccalaureate science. Our sample consists of 282 students, between 2015 and 2016, in all disciplines.

Branch	Number of students	Percentage%
Baccalaureate students section « PC »	122	43,3
Students of the Baccalaureate section «SVT»	93	33
First-year university students Section 'SMC'	67	23,7

4-2-Instrumentation:

To meet our objectives, participants were asked to respond to a questionnaire in three parts:

- ✓ An introduction containing a presentation of the survey and its objectives, an incentive to complete the questionnaire, instructions for filling, instructions and acknowledgments.
- ✓ Part of identification of the person participated: age, sex...
- ✓ Part of the production of the questionnaire, which is divided into two:
- The first part of the questionnaire production contains three questions: the latter are inspired by the Moroccan baccalaureate program, with the aim of knowing if the student implies a logical and coherent approach, if so what is the type of this reasoning?
- The second is reserved for students in the first academic year, with two questions in order to know if the evolution of the hierarchy of knowledge allows the students to imply more and more a reasoning based on the models.

4-3-Data processing and analysis:

Our method of processing and analyzing results contains five steps:

- ✓ Step 1: Students' answers are typed on the Excel file and analysis of the data in fact just after the collection. The age, sex and degree of the students are also valid for each apprentice.

- ✓ Step 2: we benchmark the justifications and the resolutions adopted by the students for each answer and then we selected results, attribute attributed to erroneous conceptions to those attributable to other causes, based on mental- Answers used by students.
- ✓ Step 3: We separate the spontaneous answers that are based either on the wrong conceptions or on a studied knowledge that has no relation with the proposed questions.
- ✓ Step 4: After determining the percentage of spontaneous responses of each question, we subsequently initiated analysis of other responses based on a specific grid. The latter is a matrix that lists the necessary knowledge and stages of solving the student's study for each question and compared to the actual activity of the student.

In order to establish this grid, the questionnaires were sent to five chemistry teachers with all the essential data in their waste treatment application according to four types of reasoning (inductive, deductive, model-based and based on Symbols and units). The answers obtained and the characteristics of all the main types of reasoning in chemistry will serve us later in this famous grid.

- ✓ Step 5: Finally, we count the answers for each question and we do the calculation of the percentage of each type of reasoning used.

V. Analysis Of The Results:

5-1-Analysis of open-ended questions inspired by the Moroccan baccalaureate program:

5-1-1-Analysis of the question-1-:

- **The statement of the question -1-:**

In a practical session, a student wishes to perform a titration of an acetic acid solution, initially at pH = 3, with a sodium hydroxide solution, using a pH indicator.

Which pH indicators are available; help him choose the appropriate indicator for this titration?

Acid-Base indicators	Turning area
Methyl orange	3,2 ↔ 4,4
Bromophenol blue	3,4 ↔ 4,6
Methyl Red	4,2 ↔ 6,2
Yellow of nitrazine	6,0 ↔ 7,0
Phenolphthalein	8,2 ↔ 10

- **Data:**
- pKa (CH3COOH / CH3COO-) = 4.76.
- The relationship between pKa and pH: pH = pKa + Log ([A -] / [AH])

➢ **The results obtained:**

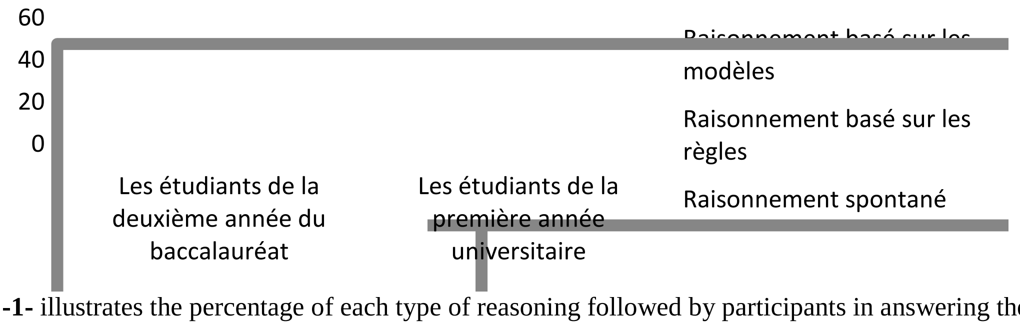


Figure -1- illustrates the percentage of each type of reasoning followed by participants in answering the first question.

➢ **Interpretation of results:**

According to the answers, students are well aware that the determination of the equivalence point is the most important step in titration and the value of the pH_E at equivalence must belong to the area of the pH indicator turn. But to determine this value of pH_E, students followed four types of reasoning:

- A minority chose reasoning based on the experience of the case. They chose the yellow of nitrazine as a suitable pH indicator with this titration, justified their response that there is complete disappearance at the equivalence of the base and the acid and the medium becomes neutral (pH = 7). Our subjects tried to adapt the characteristics of the strong acid titration to a strong base with the proposed situation: During a strong acid titration by a strong base, there is complete neutralization at the equivalence of the acid and from the base and the medium becomes neutral. On the other hand, when a weak acid is dosed by a strong base (our case), there is a complete disappearance at the equivalence of the titrated and titrating solutions and at the same time the appearance of another weak base (The CH3COO- ions) and thereafter the medium becomes basic and the pH_E is greater than 7.

- 30.7% of Baccalaureate students (**BM)** and a minority of First-year university students (**CUS)** is reported that there was no suitable indicator for this titration and justified their response that the pH of the solution did not belong to any turning zone of the pH indicators quoted in the statement. They replied spontaneously without giving the time necessary to reformulate the proposed situation: they did not distinguish between the initial pH of the solution to be dosed and the pH_E at equivalence.
- Half of the students in all disciplines used rules-based reasoning. Our subjects then used a set of rules, each corresponding to a small portion of knowledge: They began their reasoning by writing and filling the progress table. Subsequently, they tried to apply a set of rules to arrive at a relationship between pH_E and pKa. Unfortunately, MB students are stuck because they do not possess the necessary knowledge to reason: the pH of a weak base did not include in the Moroccan baccalaureate program.
- Only a small number of participants used model-based reasoning. These students have the model of the chemical reaction of the assay and they easily determined the desired pH indicator.

5-1-2-Analysis of the question-2-:

➢ **The statement of the question -2-:**

"Hydrogen peroxide is an aqueous solution of hydrogen peroxide H_2O_2, which is often used as a cosmetic for lightening hair".

In a beaker containing a volume V_1 = 10 ml of a solution of H_2O_2 (colorless) hydrogen peroxide with a concentration C_1 = 0.06 mol / l, a volume V_2 = 20 ml of a violet solution of permanganate of potassium (K^+, MnO_4^-) acidified with a concentration C_2 = 0.01 mol / l. What is the color of the mixture? Justify your answer?

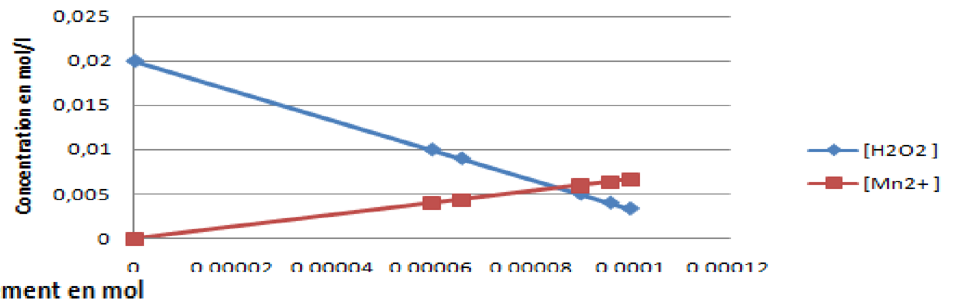
Colorless	Purple	Light violet	Dark purple	Other

➢ **Data:**

- Progress table:

	$2MnO_4^-{}_{(aq)}$	$+ 6H^+{}_{(aq)}$	$+ 5H_2O_{2(aq)}$	$2Mn^{2+}{}_{(aq)}$	$+ 8H_2O_{(l)}$	$+ 5\ O_{2(g)}$
Etat initial					excès	
Etat intermédiaire					excès	
Etat final					excès	

- The graphical evolution of $[H_2O_2]$ and $[Mn^{2+}]$ concentrations as a function of the progress of the reaction.



➢ **The results obtained:**

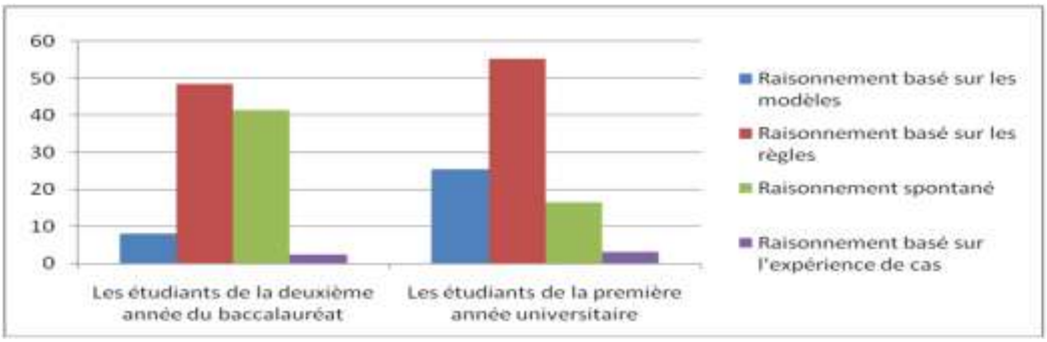


Figure -2- illustrates the percentage of each type of reasoning used by participants to answer the second question

➢ **Interpretation of results:**

According to the answers, students are well aware that determining the limiting reagent is the most important step in helping them determine the color of the mixture. But to determine this color, they followed four types of reasoning:

- A minority chose reasoning based on the experience of the case. These students chose the correct answer but the reasoning followed is wrong, they justified their answer that the quantity of matter of the oxygenated water is higher than that of the permanganate ions. It appears that our subjects tried to adapt the characteristics of an acid-base reaction to the proposed situation: in an acid-base reaction, the stoichiometric coefficients of the reagents are generally the same and equal to one. Of an oxidation-reduction reaction, these coefficients are often different. In reality, the total disappearance of the reagents does not mean that the initial material amounts of the latter are equal.
- Almost half of the BM participants and 16.4% of CUS responded spontaneously, they do not call the principles and the basic notions of this discipline: they believe that the mixture becomes purple. This incorrect answer is due to the presence of an erroneous conception of the mental models: Most in his daily life that a mixture of two solutions, one colorless and the other violet automatically gives a violet solution. This is true, in the absence of a reaction between the two solutions.
- More than half of the students in all disciplines used rules-based reasoning. Our subjects used a long approach, based on a set of sequenced rules, each corresponding to a small portion of knowledge: They began their reasoning by writing and filling the progress table, then they determine the limiting reagent and thereafter the color of the solution. Unfortunately, this reasoning often generates systematic errors (20% of these BM participants made mathematical errors when calculating the limiting reagent).
- Only a minority of participants used model-based reasoning. They found the answer with good justification. They clearly determined the reagent limiting the evolution of the concentrations of [H2O2] and [Mn2 +] as a function of the progress of the reaction, and they easily indicated the color of the solution.

5-1-3-Analysis of the question-3-:

➢ **Statement of the question -3-:**

"Ammonia NH_3 is a chemical substance used primarily in the manufacture of fertilizers to fertilize the soil or as a raw material in the pharmaceutical industry.

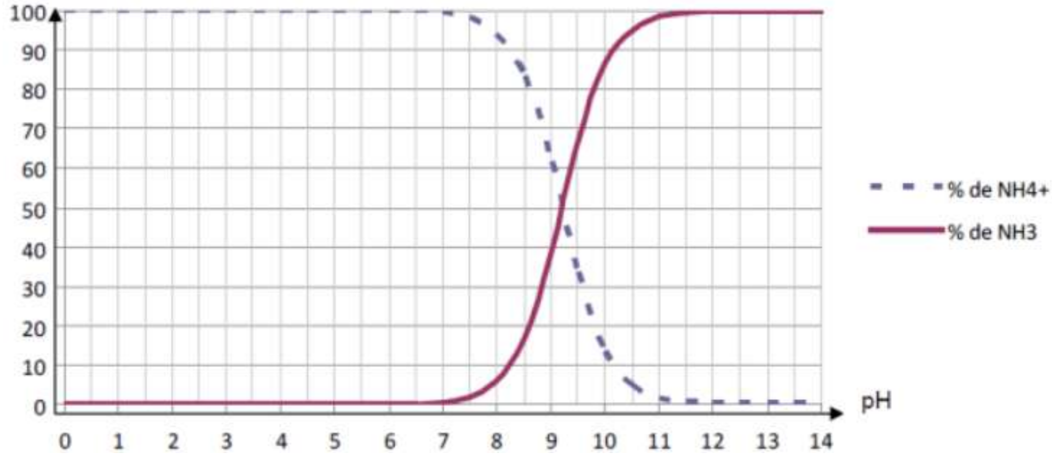
The ammonia reacts partially with water according to the following reaction:

$NH_{3\,(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + HO^-{}_{(aq)}$ (the equilibrium constant K = 1.58.10-5).

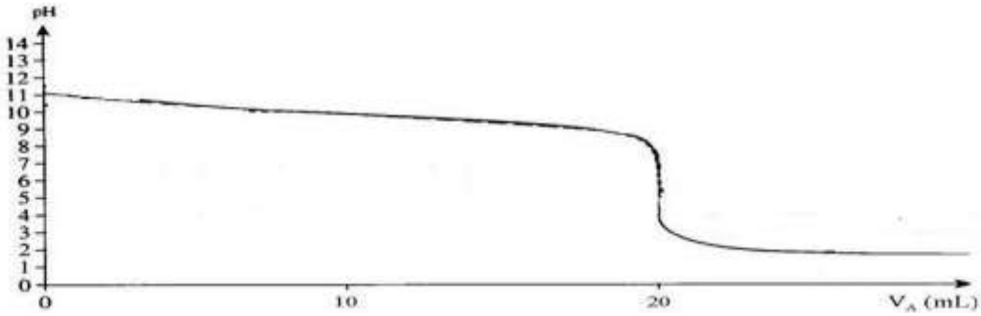
From an aqueous solution of ammonia NH_3, with initial concentration $C_b = 1.10^{-1}$ mol.L^{-1} and pH = 11.1, determine the acidity constant pKa of the couple NH_4^+ / NH_3?

➢ **Data:**

- The relationship between pKa and pH: pH = pKa + Log ([NH3] / [NH4 +])
- The half-equivalence of an assay is reached when half the volume of the titrant solution has been poured which makes it possible to obtain the equivalence. At this point the pH = pKa.
- Concentration of the species presents [NH3] and [NH4 +] as a function of pH:



- The shape of the titration curve of an ammonia solution of concentration C_b with a hydrochloric acid solution of concentration $C_a = 1.10^{-1}$ mol.L^{-1}.



➢ **Students' results:**

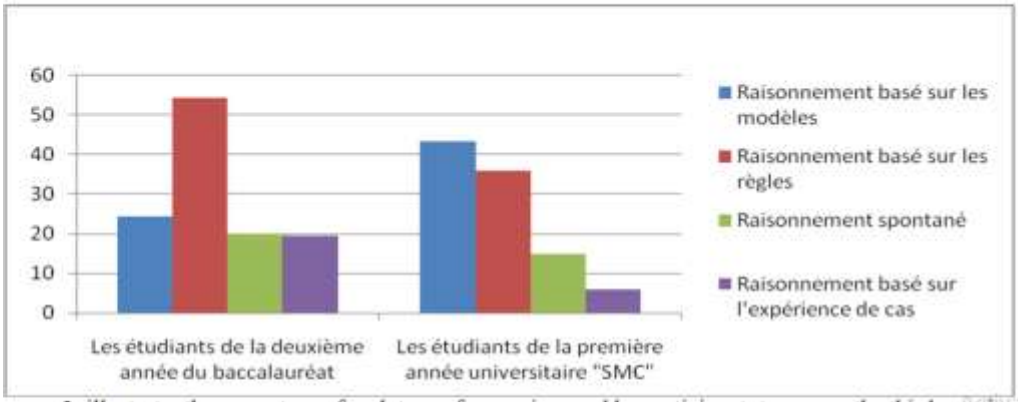


Figure -3- illustrates the percentage of each type of reasoning used by participants to answer the third question.

➢ **Analysis of results:**

According to the answers, the students followed four types of reasoning:

- A minority chose reasoning based on the experience of the case. Our subjects tried to adapt the specific characteristics of the acid and project them into the proposed situation. Indeed, when a reaction of an acid with water, the acidity constant Ka and the equilibrium constant K are identical. On the other hand, in the case of a base, these constants are not equal and the relation becomes: Ka = Ke / K with Ke: the ionic product of the water.
- 20% of BM participants and 14.9% of CUS responded spontaneously: They have determined the pH_E at equivalence by the tangent method. But, they did not differentiate between pH at half equivalence and half the pH at equivalence.
- More than half of MB participants and over one-third of CUS students used rules-based reasoning. Our subjects used following a set of rules corresponding to a small portion of knowledge: in our case, the student must write the relation of the acid constant Ka according to the concentrations of the species present in solutions and fill correctly the reaction progress table. Then, using the table, it must determine the concentrations of the species present in the solution as a function of the pH and calculate the acidity constant Ka and subsequently the pKa.
- Only 1/5 of BM participants and 1/3 of CUS used model-based reasoning. They found the answer with good justification. They followed two approaches: the first, the students directly recorded the value of pKa from the graph of the concentrations of the species as a function of the pH and the second; they determined the volume of the base paid to equivalence and then readily read the pH at half equivalence.

6-1-Analysis of open-ended questions inspired by the program of the first academic year "MSC" section:

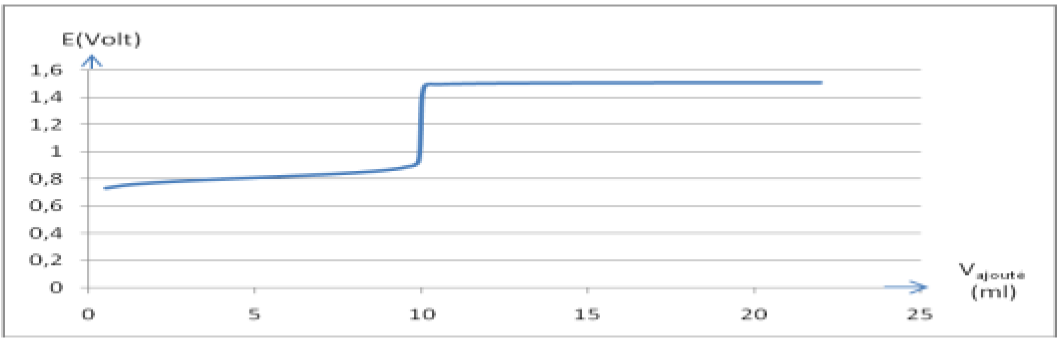
6-1-1-Analysis of the question-1-:

➢ **The statement of the question -1-:**

Determining the value of the standard potential E^0 (Fe^{3+} / Fe^{2+}) from a potentiometric titration of a solution of Fe^{2+} ions of concentration C_1 with a solution of potassium permanganate (MnO_4^-; K^+) with a concentration C_2.

➢ **Data:**

- Nernst formula: E (Ox / red) = E0 (Ox / red) + (0.06 / n) × log ([Ox] / [Red]) with n the number of electron exchanged.
- The theoretical plot of the evolution of the redox potential of the pairs in the equilibrium solution E as a function of the volume of the MnO^{4-}



➢ **Student results:**

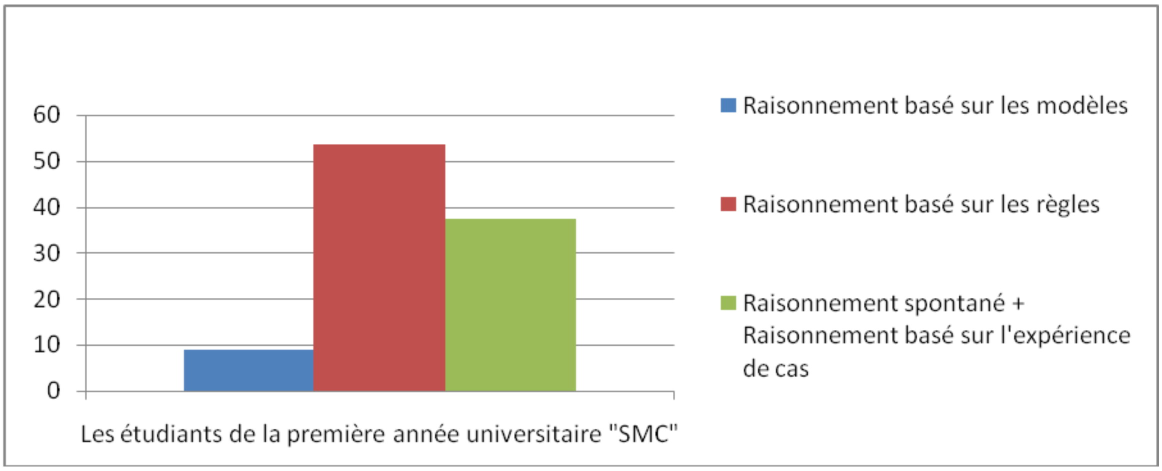


Figure 4- illustrates the percentage of each type of reasoning used by students in the first year academic section "SMC" to answer the first question.

➢ **Analysis of results:**

According to the answers, the students followed four types of reasoning:

- Only a minority of participants chose model-based reasoning. They have exploited the notion of half-equivalence and the Nernst relation and have directly extracted the value of the standard potential of the couple Fe^{3+}/Fe^{2+} ($E_{1/2\ éq} = E^0_{(Fe3+/\ Fe2+)}$) directly from the graph.
- More than half of the participants chose rules-based reasoning. Indeed, the students know well, from the formula of Nernst, that the determination of a relation between the Fe^{3+} and Fe^{2+} ions is the most important step. They began their reasoning by writing and filling the progress table and thereafter they tried to find a relationship between the iron ions before the equivalence as a function of introduced quantities. In the absence of numerical data, most of these students are blocked. However, 19% of these participants thought of equivalence: MnO4- and Fe2 + ions were mixed in stoichiometric proportions where $n_0(Fe^{2+}) = 5\ n_{eq}(MnO_4^-)$, that is to say $C_1V_1 = 5C_2V_{eq}$ and thereafter the relationship of iron ion concentrations becomes $[Fe^{3+}]/[Fe^{2+}] = V_2/(V_{eq}-V_2)$. This type of reasoning is essentially based on a set of chained rules, if a badly performed step automatically leads to a wrong answer.
- More than one third of students followed two types of reasoning at the same time, such as:

✓ Spontaneous reasoning: Students did not distinguish between standard potential and equivalence potential.

✓ Case-based reasoning: To determine the potential for equivalence, they used the tangent method, which often used in acid-base assay curves. In our case, it cannot be applied because the curve is not symmetric, because of the stoichiometric coefficients of the equations.

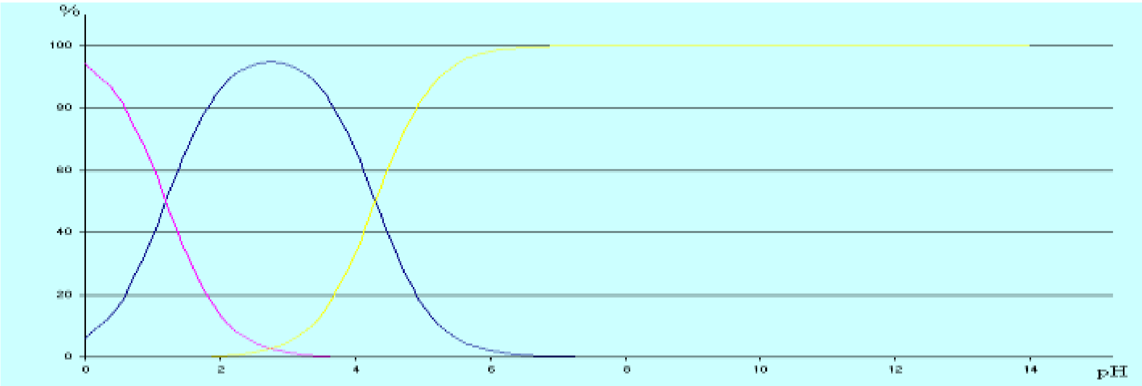
6-1-2-Analysis of the question-2-:

➢ **The statement of the question -2-:**

Determine the concentrations of all carbonaceous species in a solution of oxalic acid $H_2O_4C_2$ initially at 10^{-2}mol.L-1 and brought to pH = 3 with the aid of soda, without variation of volume.

➢ **Data:**

- PKa1 (H2C2O4 / HC2O4-) = 1.4; PKa2 (HC2O4- / C2O42-) = 4.3;
- Acid constant Ka: Ka = ([base] × [H3O +]) / [acid]
- Diagram of distribution of the addition of soda to a solution of oxalic acid



➢ **Student results:**

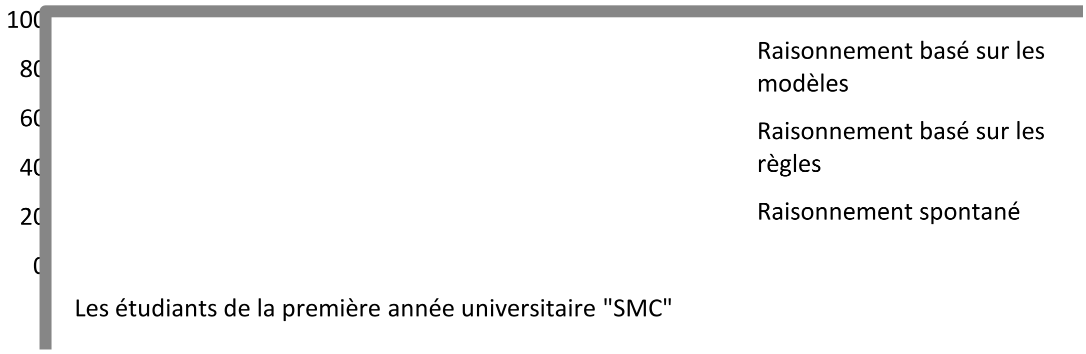


Figure 4- illustrates the percentage of each type of reasoning used by students in the first academic year section "SMC" to answer the second question.

➢ **Analysis of results:**

According to the answers, the students followed three types of reasoning:

- Only a minority of participants chose model-based reasoning. They exploited the diagram well and easily determined the percentage of each species in the solution and subsequently its concentrations.
- The majority of the participants chose reasoning based on the rules. Our subjects used following a set of rules corresponding to a small portion of knowledge: in our case, the student must take a very long approach, he must begin by writing the equation of conservation of matter And the acidity constants of two acid-base pairs and thereafter to extract the expressions of $[HC_2O_4^-]$ and $[C_2O_4^{2-}]$ concentrations from the acidity constants and replace them in the conservation equation of The material. Then, it must calculate the value of Concentration of oxalic acid $[H_2C_2O_4]$ at pH = 3. This value allows the student to first determine the concentration of $[HC_2O_4^-]$ from Ka1 and secondly the concentration of $[C_2O_4^{2-}]$ from Ka2.
- The rest chose spontaneous reasoning. Indeed, these students did not differentiate between the initial concentration of oxalic acid C and the concentration of this acid at pH = 3.

VI. Conclusion

The results of this modest work clearly show that learning the methods of solution chemistry, as it was taught at the Moroccan high school, could not convince the majority of students to follow a strategy based on reasoning based On the models. Rather, they prefer rules-based reasoning, even if this type of reasoning is very long, tiring, reconstructed linearly in a logic of chaining ideas (each rule must be used, one after another to find The correct answer), and often leads to systematic errors (ie, a poorly performed or forgotten step leads to a wrong answer). And also to spontaneous modes of reasoning which hamper the construction of scientific reasoning, are based either on knowledge elements which are not all accurate, according to the scientifically accepted theory (question 2), or on a studied knowledge which Did not use in the right situation (questions 1 and 3). Probably our subjects confuse concepts and notions of this discipline or they do not give sufficient time to reformulate the statement of problems.

Although a positive evolution in the prioritization of students' knowledge was observed during the first academic year, the rate of use of model-based reasoning by first-year university students faced with a baccalaureate problem remains low (It does not exceed 37.5% for all proposed questions). And this rate plummeted against problems of university level. In fact, it is clear that the majority of Moroccan students, at all levels, prefers rules-based reasoning before a learning situation. This is because students do not have the capabilities of representations of problems and reasoning sufficient to solve conceptual problems. This type of reasoning leads students only to solve algorithmic problems that require only the application of stored procedures without necessarily conceptual understanding. This research has been limited to acid-base and redox dosing, but it opens up avenues for other research such as mechanics, electricity, organic chemistry, etc.

Bibliography

[1] Boulabiar-Kerkeni, A. (2004). Notions et modèles fondateurs de la connaissance des élèves et des étudiants en oxydoréduction. Thèse de doctorat. Université lumière de Lyon 2.

[2] 18

[3] Christian, K., et Talanquer, V. (2012). Modes of reasoning in self-initiated study groups in chemistry. Chemistry education research and practice, 13, 286-295.

[4] Closset , J-L. (1992). Raisonnement en électricité et en hydrodynamique. Aster n0 14, p.144-155.

[5] Cormier, C. (2014). Etude des conceptions alternatives et des processus de raisonnement des étudiants de chimie du niveau collégial sur la molécule, la polarité et les phénomènes macroscopiques. Thèse de doctorat. Université de Montréal.

[6] Cros, D et al. (1986). Conceptions of first-year university students of the constituents of matter and the notions of acids and bases. European Journal of Science Education. Vol.8, p.305-313.

[7] Dhindsa, H.S (2002). Pre-service science teacher's conceptions of pH. Australian Journal of Education Chemistry, 60, 19-24.

[8] Driver, R. & Easley, J. (1978). Puplisand paradigms : A review of literature related to concept development in adolescent science students. Studies in science education, 5, p. 61-84.

[9] Duit, R. (2011). Symposium – Distinguished Contributions in research. Communication présentée à NARST 2011 International Annual Conference, Orlando, FL.

[10] Dumas-Carré, A., Caillot, M., Martinez Torregrossa, J. & Gil, D. (1989). Deux approches pour modifier les activités de résolution de problèmes en physique dans l'enseignement secondaire : une tentative de synthèse. Aster, n0 8, p. 135- 160.

[11] Ferguson, R. L. & Bodner, G-M. (2008). Making sense of arrow- pushing formalism among chemistry majors enrolled in organic chemistry. Chemistry education research and practice, 9, p. 102-103.

[12] Gauchon, L. (2008). Comprendre les titrages : Représentations d'élèves de premières et terminales scientifiques et effets de quelques variables. Thèse de doctorat. Université de Paris Diderot-Paris 7.

[13] Johnstone, A. H. (1993). The development of chemistry teaching : A changing response to changing demand. Journal of chemical education. Vol. 70 (9), p. 701-705.

[14] Kraft, A., Strickland, A- M,. & Bhattacharyya, G. (2010). Reasonable reasoning : Multi-variate problem-solving in organic chemistry. Chemistry education research and practice, 11, p. 281-292.

[15] Laugier, A. & Dumon, A. (2000). Practical works and representation of chemical reaction in the macroscopic and microscopic level, chemistry education: Research and practice in Europe. Vol(1), p. 61-75.

[16] Maichle, U. (1994). Cognitive processes in understanding line graphs, in W.Schnotz & R.W.Kulhavy, Comprehension of graphics, Elservier.

[17] Mokros, J. & Tinker, R. (1987). The impact of microcomputer-based labs on children's ability to interpret graphs. Journal of Research in Science Teaching, 24, p. 369-384.

[18] Montminy, M. (2009). Raisonnement et pensé critique : Introduction à la logique informelle. Montréal, QC : les presses de l'université de Montréal.

[19] Nakhleh, M-B & Krajcik, J-S. (1993). A protocol analysis of the influence of technology on student's actions, verbal commentary, and through process during the performance of acid-base titrations. Journal of research in science teaching, 30(9), p. 1149-1168.

[20] Nakhleh, M-B & Krajcik, J-S. (1994). Influence of levels of information as presented by different technologies of student's understanding of acid, base and PH concepts. Journal of research in science teaching, 31(10), p. 1077-1096.

[21] 19

[22] Niaja, R. (2004). Apprentissage des réactions acido-basique : mise en évidence et remédiations des difficultés des étudiants lors d'une séquence d'enseignement expérimental. Thèse de l'Université lumière, Lyon 2.

[23] Nicoll, G. (2001). A report of undergraduates' bonding misconceptions. International Journal of Science Education, 23(7), p. 707-730.

[24] Othman, J., Treagust, D.F., et Chandrasegaran, A.L. (2008). An investigation into the relationship between students' conceptions of the particulate nature of matter and their understanding of chemical bonding. International Journal of Science Education, 30(11), p. 1531-1550.

[25] Rabier, A.,Venturini, P. & Terisse, A. (2001). Etude didactique sur l'utilisation des modèles d'acido-basicité par les étudiants et les élèves de terminale. In Skhole, n0 hors série, IUFM de Marseille.
[26] Schmidt H-J. (1990). Secondary school student's strategies in stoichiometry. International journal of science education, 12, 457-471.
[27] Sheppard, K. (2006). High school student's understanding of titrations and related acid-base phenomena. Chemistry education research and practice, 7(1), p. 32-45.
[28] Starvidou, H. et Solomonidou, C. (2002). Représentations et conceptions des élèves grecs par rapport au concept d'équilibre chimique. Didaskalia n01, p. 107-134.
[29] Talanquer, V. (2006). Commonsense constraints and learning progressions: The case of "structure of matter". International Journal of Science Education, 33(2), p. 179-195.
[30] Tardif, J. (1997). La construction des connaissances 1. Les consensus pédagogique collégiale, 11(2), p. 14-19.
[31] Viennot, L. (1992). Raisonnement à plusieurs variables : Tendances de la pensée commune. Aster n0 14, p. 127-141.