ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

International Journal of Engineering Technologies and Management Research
A Knowledge Repository
IJETMR

MULTIDIMENSIONAL ANALYSIS OF ICT INTEGRATION IN SECONDARY MATHEMATICS TEACHING

Youssef Bouchama [*1], Moncef Zaki [*2]
[*1] Doctoral Studies in Didactics of Sciences and Pedagogical Engineering, Sidi Mohammed Ben Abdellah University, Fez, Morocco
[*2] Interdisciplinary Research Laboratory in Didactics of Science and Technology (IRLDST), Sidi Mohammed Ben Abdellah University, Fez, Morocco

Abstract:
This research aims at studying the integration of ICT in mathematics teaching at the junior and high school levels. An experiment was conducted with a sample of 120 Moroccan teachers from Marrakech-Safi, Casablanca-Settat, Rabat-Salé-Kenitra and Fes-Meknes regions. The teachers responded to a questionnaire of 31 modalities, which deal with the knowledge of the institutional aspects of ICT integration in teaching, educational planning, as well as some didactic aspects in the context of ICT integration.

The analysis of the answers was conducted following a multidimensional approach. Thus, thanks to a Factorial Analysis of Multiple Correspondence (FAMC), we were able to identify the most discriminating factors in the integration of ICT and their order of importance. The results of this analysis highlight two factorial axes cumulating an absolute inertia of 76%, respectively representing « Successes and failures of ICT integration in teaching mathematics » and « The success factors in ICT integration».

Keywords: ICT Integration; Secondary teaching; Mathematics; Multidimensional Analysis.

Cite This Article: Youssef Bouchama, and Moncef Zaki. (2018). "MULTIDIMENSIONAL ANALYSIS OF ICT INTEGRATION IN SECONDARY MATHEMATICS TEACHING." *International Journal of Engineering Technologies and Management Research*, 5(10), 137-153. DOI: 10.5281/zenodo.1491918.

1. Introduction

Since the early 2000s' and following the National Charter of Education and Training in 1999, Morocco has undergone a major recast in its secondary and higher education system. Like the international educational systems, Morocco got enrolled in a succession of national programs aiming at the integration of Information and Communication Technologies (ICT) in its educational system. In 2006, the GENIE program was the first action at the national level undertaken by the Moroccan Ministry of Education as part of a reform of the educational system, which aims primarily at the integration of ICT in secondary education. Along with training teachers on the use of ICT, this program was aiming at generalizing the equipment and connection to the Internet network of all public schools. Afterwards, from 2009 to 2012, a second national program entitled "the emergency Plan of the school System" substituted the GENIE program in order to extend and follow the action of integrating ICT in the Moroccan educational system.

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

The impact these national programs have on the Moroccan educational system had been evaluated by the Ministry of Education only from a quantitative approach, in terms of the percentage of computer equipment and Internet connection of schools, or in terms of the number of national training offers for secondary school teachers. Despite these diverse national actions, the question that always arises is the identification of the factors that contribute to (or hinder) the integration of ICT in the Moroccan education system.

Different studies in Morocco are interested in this question through diverse approaches to the integration of ICT. Yet, few among them are interested in this question, specifically for the teaching of Mathematics as we will see in our problematic.

2. Previous Work and Problematic

Our initial research problematic is concerned with identifying the factors that will favor the integration of ICT in mathematics teaching at the Moroccan secondary level. Our research approach is purely exploratory, despite being a priori complementary to other work already carried out in Morocco on the integration of ICT in secondary education. Generally, these work concerned Physics (A. Rasmy and A. Fiévrez, 2015; O. Alj and N. Benjelloun, 2013 and 2016; B. Guennoun and N. Benjelloun, 2016; M. Kaddouri and al, 2017), Biology and Geology (O. El Ouidadi, 2012; A. Benfares, M. Zaki and A. Alami, 2016; A. Tarichen et al, 2017; Y. Nafidi et al, 2018), and rarely concerned Mathematics specifically (M. Oudrhiri, 2016)[1].

One of the first studies (El Ouidadi et al., 2011) which was conducted in Morocco, in Fez-Boulmane region, focused on the integration of ICT in biology-geology in high school. It concluded the inadequacy of the official programs in biology-geology school subject from the look at the official guidelines of the integration of ICT in biology-geology classes in high school, along with the outdated equipments in computer hardware in high schools, as well as the lack of continuous training and education in ICT opportunities for teachers.

Another study (A. Maouni et al., 2014), conducted among students and teachers of Tangier-Tetouan Academy on the integration of ICT in biology-geology in high school, also highlighted the importance and the high demand, of both teachers and students on training in information technology and ICT in general.

In physics, a study concerning the difficulties and the obstacles of the integration of ICT within the framework of GENIE program (O. Alj et N. Benjelloun, 2013), was conducted among teachers who benefited from the training GENIE, in these three regions of Morocco (Fes-Boulemane, Rabat-Sale et Tetouan-Tanger). This study has identified a paradox between the high rates of teachers (interviewed) who have an interest (by conviction) in the use of ICT in the pedagogical practices (more than 90%) and the low rates among those (8 %) who integrated ICT effectively in class. The authors justified this paradox by the insufficiency of information technology equipment,

This research was carried out along with the mathematics trainers of the Regional Center of the Professions of Education and [1] Training of Fez, and the author has particularly concluded that these latter were not highly convinced of the interest of digital technology in the pedagogical practices because of neglecting computer equipment in schools and the lack of institutional training

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

the lack of software adapted to the programs being taught, as well as the lack of qualification and training of teachers.

These studies show that there are at least three common factors, independently from the discipline, forming an obstacle to the integration of ICT, namely the lack of equipment, of software (training material) and the training of teachers, or even students, in ICT.

Are they invariants of the integration of ICT? What about mathematics? Does the integration of ICT in mathematics bring in specifications other than those of other scientific disciplines?

Certainly, this previous work have made it possible to identify some elements, in favor of or forming an obstacle to the integration of ICT in their discipline, using some standardized descriptive statics (rate calculations, sometimes with tests of independence of chi2 on two items), were not the object of interest to a quantified hierarchy that would take into account some mutual effects, in terms of binding, between all these different elements.

Furthermore, the great majority of these studies is limited to regional studies, covering only and partially the overall of some Secondary Education academies in Morocco.

On our part, we will be asking the question of the integration of ICT in mathematics in secondary education, examining the situation through a sample covering to a large extent the entire of academies nationwide. The aim is seeking to identify the possible connections between the different elements in favor (or not) of the integration of ICT in mathematics, and to determine a quantified hierarchy (in terms of importance) between the combinations of these elements.

3. Methodological Approach and Experimentation

Our research being exploratory, we have adopted an approach by questionnaire, which we have submitted to a large sample, comparing 120 teachers of mathematics at secondary education. The sample has been extracted in a concern of representativeness and of comprehensiveness, from the Regional Academies of Education and Training (AREF), which are the most representative (in terms of the number of management of secondary schools) on the entire Moroccan territory. The geographical distribution of the sample was done starting from the three AREF, Casablanca-Settat-Rabat-Sale-Kenitra (the center of the kingdom), Marrakech-Safi (south) and Fes-Meknes (north-east), where we have interviewed every time 40 teachers (volunteers) of secondary education (senior high school) and junior high school of mathematics, both in urban and rural areas. The handover of the questionnaire to the teachers, previously submitted for an authorization of the director of each AREF, took on average about thirty minutes. In addition, we have provided a version of questionnaire[2] in Arabic for teachers who would like it, we have also provided deadline of answering of one to two days for those who have submitted the request.

Additionally, we have allocated a code, understood between 1 and 120 to each interviewed teacher, in order to guarantee the anonymity of the people of our sample.

The translation of the questionnaires was validated by university peers, by going from the French text towards the Arabic text[2]

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

Concerning the experimentation, it lasted almost for nine months, from October 2015 to June 2016. This period, comparatively important to the process of the experimentation is particularly due to some institutional factors, sometimes such as expectations that are fairly long for the delivery of the permits by the directors of AREF for the handover of the questionnaires.

In the design of the questionnaire, the choice of some items represents a critical parameter of our methodology of research. In fact, the results which will be established as an outcome of our research will be highly dependent. The review of literature of studies carried on issues similar to ours, especially those of A. Rasmy and A. Fiévez (2015), has led us to enrich the inquiry on the issue of the integration of ICT. Then we have selected three axes that cover at first sight in a comprehensive way the elements that are to be taken into consideration with the topic of the integration of ICT. First, elements related to the institutional aspects of the integration of ICT as they are promoted in the Moroccan teaching (guidelines, projects, and official training). These elements which were taken into account in a very partial way in the previous studies, seemed important to us within the framework of our issue. That is why we have regarded them as a whole in our questionnaire.

Then, some elements related to the educational planning integrating ICT (educational material, computer equipment …) and to techno-educational skills of teachers (initial training in ICT, classroom management…). These are elements that we have found in previous studies (C. Raby et al., 2011; O. El Ouidadi et al., 2011 et 2012; A. Maouni et al., 2014; M. Mastafi, 2014; A. Rasmy et A. Fièvez, 2015). Finally, one last axis dedicated to educational aspects in situation of integration of ICT (digital resources in mathematics, lessons, remedial work, assessment …). These elements here, at the moment of designing the questionnaire, were not taken into account explicitly, or even absent, in the previous work on the integration of ICT in Moroccan secondary schools.

Regarding the analysis of the answers of teachers to our questionnaire, we have thought of it since the beginning multidimensional. In fact, we wanted in our analysis to take into consideration the connections between modalities of different items of the questionnaire, and to extract the most discriminatory factors.

Factorial Analysis of Multiple Correspondence (FAMC) fully meets our approach of analysis; moreover, it represents a method of statistic description that was not used before in the previous studies on the issue of the integration of ICT in the teaching of mathematics in The results promoted by this factorial analysis, are certainly going to supplement those of previous studies which, we would point out, are limited only to statistical descriptions together or even two-dimensional: the uniqueness of FAMC) lies primarily in the multidimensional nature of the description.

ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

4. The Interpretation of Factorial Analysis of Multiple Correspondence (FAMC) Results Analysis

4.1. Factorial Analysis of Multiple Correspondence leading up to the identification of the questionnaire arrangements to high relative contributions

A primary Factorial Analysis Of Multiple Correspondence (FAMC)was formed under SPSS V. 20 *(Statistical Package for the Social Sciences),* statistical processing of data software, on the entire sample (120 individuals), by enabling all the items of the questionnaire, thirty-one items (on twelve questions) each representing an active qualitative variable of the FAMC.

This analysis has initially enabled the identification of the modalities of variables whose relative contributions (contributions to the construction of factorial axes) are so low, and consequently insignificant with regard to relative contributions of the rest of the modalities of the questionnaire. These accumulate respectively the first two factorial axes (with a share of absolute inertia of 50,5% of the first factorial plan), the shares of respective inertia 0,40% and 0.53%, which are each significantly lower to the share of inertia related to the eigenvalue 1 of a variable (an item), 3.22% (achieved by 1/31×100%). Hence, the items related to these modalities are bearing insignificant information with regard to all the information contained n the cloud of points representing the answers of the whole sample. Therefore, the items identified during this first analysis are the following:

Table 1: Relative Contributions to the axes of the first factorial plan of variables (items) removed by the first FAMC

Variables (items)	**Relative Contribution (Dimension 1)**	**Relative Contribution (Dimension 2)**
MASSAR	***0.000***	***0.001***
CITI	***0.037***	***0.022***
Theme “geometry " (assessment)	***0.041***	***0.049***
Theme "function" (assessment)	***0.012***	***0.016***
Theme “trigonometry" (assessment)	***0.036***	***0.076***

This first result is dually interesting: on one hand, it enables minimizing the dimensions in data processing, in accordance with the fundamental principle of minimizing dimensions of factorial analysis, and on the other hand, to identify the items of the questionnaire that almost do not provide information during the analyzing of the answers of individuals.

We note that the implementation of a new FAMC without these items, changes almost nothing in the form of the initial cloud of the entire answers of individuals, and therefore relative contributions of the rest of items. Moreover this operation of disposal of items will be renewed while proceeding to a new succession of FAMC, until the acquisition of an absolute inertia of the first factorial plan representing at least 75% of the whole inertia of the cloud (Cf. J.-P. Benzécri, 1973), because at the end, these are the factors of the first plan of FAMC bearing the essential information contained in the cloud of active variables.

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

Thus, we have proceeded to two other FAMC, which enabled us, according to the same principle described earlier, to dispose of other items of the questionnaire

Table 2: relative contributions to the axes of the first factorial plan of variables (items) disposed of by the second and the third FAMC

Second FAMC, with a share of inertia of the first factorial plan labeled 61,47%			
Variables (items)	Relative Contribution (Dimension 1)	Relative Contribution (Dimension 2)	share of inertia of the first factorial plan
GENIE	**0.220**	**0.077**	**1.14%**
Initial training	**0.017**	**0.186**	**0.78%**
Adequate time	**0.235**	**0.132**	**1.41%**
Cumulation of shares of relatives contributions[3]	**1.81%**	**1.52%**	**3,33%**
Third FAMC, with a share of inertia of the first factorial plan labeled 66.11%			
Variables (items)	Relative Contribution (Dimension 1)	Relative Contribution (Dimension 2)	share of inertia of the first factorial plan
Official directives	**0.037**	**0.263**	**1.30%**
Theme « function » (course)	**0.042**	**0.269**	**1.35%**
Theme « geometry » (course)	**0.025**	**0.241**	**1.16%**
Theme « trigonometry » (cours)	**0.011**	**0.207**	**0.95%**
Cumulation of shares of relative contributions[4]	**0.50%**	**4.26%**	**4.76%**

The problem with the third FAMC is that only nineteen variables (items) out of the thirty-one at the beginning remained active. Thus, a fourth and last FAMC was conducted on the active nineteen variable, and has led to two Eigen values$\boldsymbol{\lambda_1}$ **= 10.214** et $\boldsymbol{\lambda_2}$ **= 4.222**, representing both a share of absolute inertia of **75,98%** for the first factorial plan (achieved by$(10.214 + 4.222)\times 100/19 = 75{,}98\%$)**.** Therefore**,** the inertia accounted for by the first two factorial axes of the last FAMC is higher than 75%, that's why we will limit ourselves to the interpretation of the first two factorial axes achieved by this data analysis.

Furthermore, since λ_1 is higher than λ_2 (Eigen values to the order of simple multiplicity), each one of the two factorial axes will be interpreted separately.

It should be noted that for the second FAMC , only twenty-sis variables remained active, and that in this case the Eigen value [3] 1 (corresponding to a variable) represents 1/26×100 = 3.84% of the absolute inertia. Moreover, it appears that accumulation of shares of relative contributions of some disposed of variables (items), as well for the first factorial axe than for the second, are far below 3.84%.

As for the third FAMC, only twenty-three variables (items) remained active, and here again, it appears that the accumulation of [4] shares of relative contributions of the disposed of variables (items), as well for the first factorial axe than for the second, are far below the share of inertia corresponds to the Eigen value 1(a variable) being 1/23×100 = 4.34%.

ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

4.2. Interpretation of The First Factorial Axis

The FAMC has led to an absolute inertia of 53,80% for the first factorial axe. This value represents more than the half of the entire inertia of the cloud corresponding to the overall of active variables, which reflects an important share of the entire processed information. The variables that have contributed the most to the forming of this first factorial axe are the following:

Table 3: variables with strong relative contributions to the construction of the first factorial axis

Titles of variables (items)	**Coding**	***Relative Contribution to the axe 1***
MOS	**MOS**	**0. 360**
NAFIDA	**NA**	**0. 526**
Institutional formations	**FI**	**0. 338**
Software	**LOG**	**0. 787**
Platforms	**PF**	**0. 880**
websites	**SI**	**0. 880**
Magnetic supports	**SM**	**0. 880**
Personal work	**TP**	**0. 880**
Official formations	**FO**	**0. 328**
Interest of ICT (outside class context)	**IH**	**0. 767**
Interest (inside class)	**IC**	**0. 767**
Pedagogical advantages	**AVP**	**0. 708**
Institutional advantages	**AVI**	**0. 708**
Didactic advantages	**AVD**	**0. 708**

On the one hand, the first factorial axis opposes, regarding positive components, the modalities **NA_O, MOS_O, FI_O, LOG_O, PF_O, SI_O, SM_O, TP_O, FO_O, IH_exi, IC_exi**, **AVP_exi, AVI_exi, AVD_exi**. On the other hand, it opposes their opposites, regarding negative components (see figure 1).

This perfect opposition, regarding the first factorial axis between the modalities representing the presence (yes) or absence (no) of the variables with strong relative contribution, allows at a first instance to conclude that the questionnaire which we have elaborated to explore the question of integrating ICT in the teaching of mathematics is generally well-constructed and very coherent with respect to this problematic.

Given the nature of the modalities of this opposition, the first factorial axis gets naturally interpreted as being the axis of the **"successes and failures of the integration of ICT in the teaching of mathematics",** or by order of importance, the personal investment of the teachers, the availability of digital resources (LOG, PF, SI, SM) and the conviction of the teachers of pedagogical, didactic and institutional interests (IH, IC, AVP, AVD, AVI) for such integration, representing very important criteria for the success (or not) of the integration of ICT in teaching mathematics.

Besides, the first factorial axis shows that the institutional actions (NA, MOS, FI, FO) will be, to a lesser extent, factors contributing to this integration (with relative contributions representing systematically less than half of those related to other modalities that constructed the first factorial

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

axis), by being clearly placed in the second plan of the success criteria of integrating ICT in teaching mathematics.

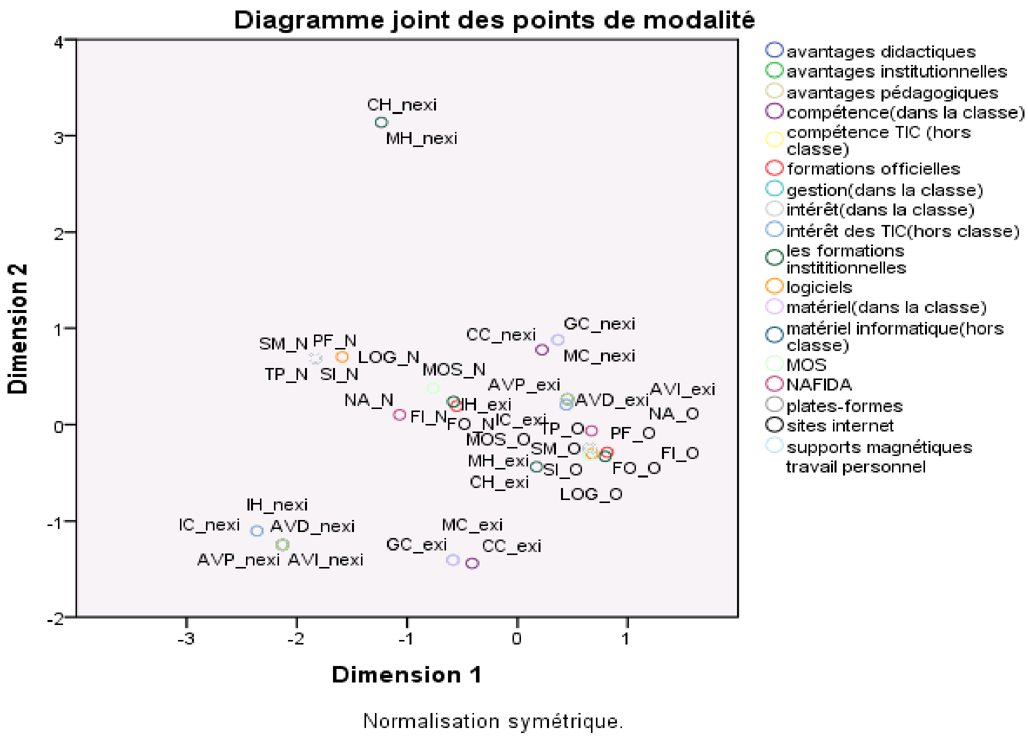

Figure 1: diagram of variables' modalities in the first factorial plan

4.3. Validation of First Factorial Axis

The projection of the interviewed individuals on the first factorial plan (see figure 2) confirms the interpretation of the first factorial axis.

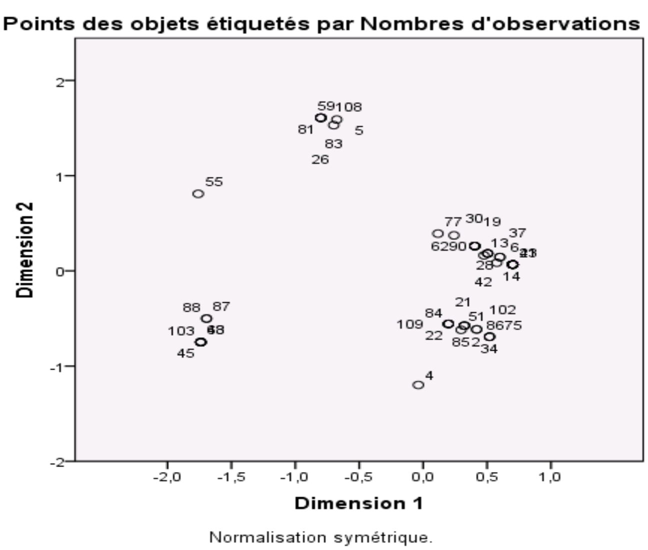

Figure 2: projection of individuals on the first factorial plan

ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

Actually, the identification of the individuals that possess the highest relative contributions to the first factorial axis, and that oppose each other regarding the first factorial axis, has led to the following results:

Table 4: individuals with high relative contribution to the first factorial axis

Individuals	Relative contribution	Coordinates related to 1st axis
55	**0.074**	**-1.760**
118-104-103-68-45-43	0.072	-1.740
88-87	0.060	-1.694
26	0.015	-0.801
14	**0.012**	**0.701**

Thus, we can notice in table 4 that the individuals “55” and “14” are those that represent an opposition regarding the first factorial axis with the highest contributions. The analysis of these two individuals’ profiles shows that “55” responded with “no” to all items in the questionnaire, while “44” responded with “yes” to all the items. The profile of “55” belongs, therefore, to an extreme teacher who disallows any integration of ICT in teaching, while the profile of “14” belongs to an innovative teacher who is open to the idea of ICT integration in teaching.

These two profiles totally confirm the interpretation held for the first factorial axis, which is the “successes and failures of integrating ICT in teaching mathematics”.

4.4. Non-Discriminating Factors in the Success of ICT Integration

The reduction of dimensions that was carried out along this factorial analysis has permitted the elimination of different modalities (see tables 1, 2) highlighting that some institutional parameters like initial training on the use of ICT in teaching, or the official directives relative to the integration of ICT I teaching mathematics look like presenting some parameters that have almost no significant effect on the success or not of ICT integration. In addition to that, we can add other parameters, mainly pedagogical, like the remediation or evaluation in class, making use of tools related to ICT.

The ultimate AFCM that led to an absolute inertia of 53,80%concerning the first factorial axis has shown that the lack of skills among teachers with respect to data processing or to the use of ICT (inside or outside class), the lack of equipment (inside and outside class), or the lack of participation in official trainings on the use of ICT, are all factors of secondary priority in the construction of the first factorial axis. Thereby, these factors represent secondary criteria in the success of ICT integration in mathematics, and this is what will be confirmed through the interpretation of the second factorial axis.

4.5. Interpretation of the Second Factorial Axis

For the second factorial axis, the AFCM led to an absolute inertia of 22, 22%. Note that this absolute contribution first represents almost half of that relative to the first factorial axis. This important gap between the absolute contributions of the two first factorial axes fully justifies resorting to an individual interpretation of the second factorial axis in opposition with the

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

interpretation of the whole first factorial plan[5]. Thus, the items, which will contribute to the construction of the second factorial axis, will represent a part of information complementary to that given by the first factorial axis. Yet, it should be relativized in terms of importance to a second plan compared to the one provided by the first factorial axis.

The variables with most contribution to the forming of this second factorial axis are as follows:

Table 5: Variables with high relative contributions for the construction of the second factorial axis

Variables' title (items)	***Coding***	***Relative Contributionto axis 2***
ICT competence (outside class)	**CH**	**0,651**
Hardware (outside class)	**MH**	**0,651**
Competence(in class)	**CC**	**0,528**
Material(in class)	**MC**	**0,585**
Gestion (in class)	**GC**	**0,585**

The very nature of the items with high contribution to the second factorial axis makes it possible to give an immediate interpretation of this axis that can be naturally entitled **"factors of success of ICT integration in teaching"**. These factors refer primarily to the teachers' skills in ICT, and to the availability of the hardware outside as well as in class context. Additionally, they refer to an important pedagogical criterion; being able to manage the class while integrating ICT. Thus, these are the necessary and fundamental factors of the success of ICT integration.

As for the term "success" which we have inserted in the title of the second factorial axis' interpretation, it is justified through the fact that the modalities "yes" of the items CH, MH, CC, MC and GC are all in opposition with their respective modalities "no" by this axis (see figure 1).

4.6. Validation of the Second Factorial Axis

The projection of individuals interviewed on the first factorial plan (see figure 2) also confirms the interpretation of the second factorial axis.

Thus, the individuals with the highest relative contributions to the second factorial axis that oppose each other concerning this axis are as follows:

Table 6: individuals with high relative contribution to the second factorial axis

Individuals	**Relative contribution**	**Coordinates related to 2nd axis**
26	**0.096**	**1.608**
5	0.094	1.589
83	0.087	1.530
4	**0.053**	**-1.198**

In table 6, the individuals "26" and "4" are the ones representing an opposition regarding the second factorial axis, with the highest contributions. The analysis of these two individuals' profiles

This is initially confirmed by means of the gap between the two first proper values of the AFCM.[5]

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

shows that "26" responded by "no" to all the items of high contribution to factorial axis 2 (table 5), while "4" responded by "yes" to the same items. The profile of "4", thus, belongs to a teacher having ICT skills, having hardware inside and outside class, and successful in managing a class with ICT integration, while "26" presents a profile that is opposite to the previous one.

These two profiles totally confirm the interpretation held for the second factorial axis, namely **"factors of success of ICT integration in teaching"**.

5. Conclusions, Discussions and Research Perspectives

Along this research, the exploration of the question of integrating ICT in teaching mathematics in high school has been achieved using a questionnaire that takes into consideration three aspects; the institutional aspect, the pedagogical aspect and the didactic aspect. The multidimensional analysis of the collected corpus provides two complimentary factors representing the absolute cumulated inertia of 76%. The relative importance of each of these factors has been clearly established through the factorial analysis of the multiple correspondences (AFCM) thanks to the hierarchy between the two factors where the absolute inertias represent 53,80% and 22,22% respectively.

The first factorial axis is concerned with the "successes and failures of ICT integration in teaching mathematics". This factor clearly shows that the institutional actions, especially in terms of ICT training as it is provided, had no significant effect on the success of ICT integration in teaching mathematics in high school. This result nuance certain results of other researchers that has been conducted in other disciplines like Biology and Geology (S. Benfares et al., 2016; A, Maouni et al., 2014)), or Physics (O. Aljand N. Benjelloun, 2013 et 2016) in which the authors generally highlight the lack of ICT training for teachers. Concerning this research, the major elements in ICT integration highlighted by the first factorial axis are primarily related to the personal investment of the teacher, and then to the availability of the pedagogical resources, and finally to the teacher's conviction of the pedagogical, didactic as well as institutional interests of ICT integration in teaching mathematics. This represents, in one way or another, a specialty of teaching mathematics. The fact that the Mathematics teacher's personal investment is an essential condition in the success of ICT integration implies a priori institutional action targeting teachers, especially in terms of trainings. These latter have to be a kind of support to the specific needs both didactic and pedagogical for the success of teaching with ICT.

Concerning the pedagogical resources suggested by the first factorial axis, they actually refer to the digital resources having to do with mathematical contents. It is about a didactic aspect here that deserves a whole study.

Actually, in the light of this work, we wanted to extend our discovery beginning a study on the issue of digital resources in mathematics teaching in secondary level. The results concerning this issue are still in progress.

The second factorial axis, complementary to the first, represents the "factors of success of ICT integration in teaching". These factors refer first to the teachers' skills in ICT, and to the availability of hardware inside as well as outside the class. These elements are necessary for the

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

integration of ICT, and are mentioned in almost all previous work. They also refer to the purpose of the institutional actions itself ("GENIE" program and "Emergency Plan") that are carried out by the ministry of National Education. Are these factors enough for the success of ICT integration?

A third factor highlighted by the second factorial axis, and not least, is the one concerned with the mastery of class management in an ICT integration situation. This factor, which is rather of a pedagogical nature, is has not been raised in previous national work, while it is clearly highlighted in our factorial analysis. We think that this does not represent specificity in the teaching of mathematics. This question deserves being explored in the light of other disciplines, especially those with scientific content (Physics, biology and geology). This factor directly affects the aspect of training teachers.

Finally, the institutional trainings must actually respond to the needs of teachers, both didactic and pedagogical, in order to follow them up during their teaching activities in a context of ICT integration. We can manage these trainings in the form of regional internships, under the supervision of the regional academies of education, taking into account content that responds to the teachers' effective needs. Concerning managing these trainings, it might be provided by peers having experience (aggregates and certified teachers) in high schools like what is being done in France for instance.

References

[1] -Alj, O. et Benjelloun, N. (2013) Intégration des TIC dans l'enseignement des sciences physiques au Maroc dans le cadre du programme GENIE : difficultés et obstacles, Revue internationale des technologies en pédagogie universitaire (RITPU) 10(2), 49-65. http://www.ritpu.org/IMG/pdf/RITPU_v10_n02_49-pdf.pdf

[2] Alj, O. et Benjelloun, N. (2016) Etude comparative des résultats de quelques recherches sur l'intégration des TIC dans l'enseignement des disciplines scientifiques au sein du programme GENIE marocain, Association EPI. https://www.epi.asso.fr/revue/articles/a1601c.htm

[3] Benfares, N., Zaki, M. et Alami, A. (2016) Analyse multidimensionnelle des facteurs d'intégration des TICE: étude de cas à travers le programme GENI marocain, European Scientific Journal Vol. 12 N°19, pp. 164-180.

[4] Benzécri, J.-P. (1973) L'analyse des données : L'analyse des correspondances, Dunod.

[5] El Ouidadi, O. ,Essafi, K. ,Aboutajdyne, M. , Sendide,K. et Depiereux, E. (2011) Analyse d'attitudes et de besoins d'enseignants marocains en TICE : cas de l'académie (AREF) de FES-Boulemane, Maroc,Revue africaine de didactique des sciences et des mathématiques (RADISMA), 7. http://www.radisma.info

[6] El Ouidadi, O. (2012) Etat des lieux et enjeux de l'implémentation des TICE dans le système scolaire marocain: Profils des enseignants et étude d'impact en SVT. Thèse de Doctorat. Formation Doctorale « Didactique des Sciences et Ingénierie Pédagogique ». Université Sidi Mohammed Ben Abdellah, Fès. Maroc.

[7] Kaddouri, M., Benali, M. et Azzimami, T. (2017) Technologies de l'Information et de la Communication (TIC). Quels profils d'usage chez les lycéens marocains? http://www.adjectif.net/spip/spip.php? article426

[8] Maouni, A., Mimet, A., Khaddor, M. , Madrane, M. et Moumene, M. (2014)L'intégration des TIC dans l'enseignement des SVT au Maroc : réalité et attentes, Revue africaine de didactique des sciences et des mathématiques (RADISMA)Numéro 10. http://www.radisma.info/document.php?id=1424

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

[9] Mastafi, M. (2014) Obstacles à l'intégration des technologies de l'information et de la communication (TIC) dans le système éducatif marocain. www.frantice.net/index.php?id=870
[10] Ministère de l'Éducation Nationale du Maroc (MEN) (1999) Charte nationale d'éducation et de formation. Espace III: amélioration de la qualité de l'éducation et de la formation. Levier 10: utiliserles nouvelles technologies de l'information et de la communication (art. 119, 120, 121). http://www.men.gov.ma
[11] Nafidi, Y., Alami, A., Zaki, M., El Batri, B. et Afkar, H. (2018) Impacts of the use of digital simulation in learning earth sciences (the case of relative dating in high school), Journal of Turkish Science Education Vol. 15, Issue 1, pp. 89-107.
[12] Oudrhiri, M. (2016) De l'usage pédagogique du numérique dans l'enseignement des mathématiques au Maroc, Association EPI. https://www.epi.asso.fr/revue/articles/a1605c.htm
[13] Raby, C., Karsenti, T., Meunier, H. et Villeneuve, S. (2011) Usage des TIC en pédagogie universitaire : point de vue des étudiants, International Journal of Technologies in Higher Education 8(3), pp. 6-19.
[14] Rasmy, A. et Fièvrez, A. (2015) Les usages et obstacles liés à l'intégration des technologies par les enseignants du secondaire au Maroc, Association EPI. https://www.epi.asso.fr/revue/articles/a1512b.htm
[15] Tarichen, T., Zerhane, R. et Janati-Idrissi, R. (2017) Utilisation des TIC par les enseignants de SVT du cycle secondaire dans l'enseignement de l'immunologie, Association EPI. https://www.epi.asso.fr/revue/articles/a1705c.htm

Annex A
Questionnaire

A1) Have you consulted the official directives on the integration of ICT in teaching mathematics?

Yes☐ No ☐

- If yes, which ones do you implement in class?

A2) Do you know any project launched by the ministry to encourage the integration of ICT in teaching?

Yes☐ No ☐

- If yes, which ones ?

A3) Have you ever participated in official training sessions on the integration of ICT in teaching?

Yes ☐ No ☐

If yes, specify the people entitled to these training sessions, their length, the targeted competencies.

	Training 1	**Training 2**	**Training 3**
Entitled people			
Date and the length			
Competencies targeted			

ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

B) Lesson planning using ICT and techno pedagogical competencies.

B1) To prepare your lessons outside class, what ICT means do you regularly use? (Software, platforms, Websites, Magnetic medium with mathematical content…)

B1.1.) Software (Latex, scientific word, Math type, geogebra, powerpoint, word, excel,…)

B1.2) platforms

B1.3) websites

B1.4. Magnetic medium with mathematical resources (lessons / exercises stored on CD, USB flash drive, removable disk…)

B2) the use of these ICT means has been developed thanks to:

- Auto-learning
- Official training sessions

People entitled to the training sessions	**Their length**

B3) During your first training at ENS, CPR or at CRMEF, have you taken any course or module relevant to the preparation for an ICT-based teaching?

Yes☐ No ☐

- If yes, specify the centre where you received the initial training and briefly describe the courses and the modules you had taken therein.

B4) during your continuous training, have you taken any courses or modules relevant to the preparation for an ICT-based teaching?

Yes ☐ No ☐

If yes, mention the institutions which ensured your continuous training (ministry of national education, public schools, private schools, associations ….) et briefly describe the courses and the modules you took during your continuous training:

B5) if you don't use any ICT means outside class, tick the items corresponding to your situations:

Items	
Your ICT competencies (computer, websites, platforms…) are limited.	
You have little competency in information science (software, spreadsheet….)	
You have no information technology material	

ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

You think there is no point in using ICT means	
You have no time to use ICT means	

Other reasons to mention:

C) didactic aspects of the integration of ICT in teaching:

C1) have you ever used ICT (softwares, internet, platforms, IWB, tablet, overhead projector,……) in class with your students?

Yes☐ No ☐

- If yes, complete the following chart and eventually another similar chart in case you have another activity to mention.

Activity 1:

Theme and level of teaching	
ICT meansused	
Objectives	
Description of the activity	
Description of the activity	

- Otherwise, check the items corresponding to your situation:

Items	
You are not trained to pedagogically use ICT in class.	
You don't have information technology material in class	
You have no access to the internet in class.	
You have personal problems using information technology material	
The use of ICT demands a lot of preparation time	
You don't have adequate mathematical situations to integrate ICT in class.	
You think there is no point in using ICT in class	
The use of ICT in class is a waste of time.	
The use of ICT doesn't involve students in class.	
Class time span doesn't allow room to easily integrate ICT tools.	
The use of ICT doesn't involve students in class	
Class management becomes difficult during the use of ICT	
Multimedia rooms are not often sufficiently free.	

Other reasons to mention:

C2) have you ever used ICT as didactic support to remedy students' weaknesses?

Yes ☐ No ☐

If yes, mention the situations you have practiced in class and which yielded good results

Theme	
ICT tools used	
Problems to overcome	

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

Activity description	
Results attained after remedial work	

- If not, why ?

C3) have you ever used ICT as a didactic support during the evaluations of the students?

Yes☐ No ☐

- If yes, describe the kind of evaluation you have practiced with the students and mention the one that met better your expectations in terms of students' evaluations.

kind of evaluation summative, normative, formative	
ICT toolsused	
Mathematical content, The content measured	
The importance and advantage of integrating ICT	

- If not, why ?

C4) According to you, how will be the integration of ICT in teaching mathematics benefial?

Annex B

Results of the AFCM

Summary of models

Dimension	Cronbach Alpha	Explained variance		
		Overall (proper value)	Inertia	Percentage of explained variance
1	,952	10,214	,538	53,759
2	,806	4,222	,222	22,223
Total average		14,437	,760	
Moyenne	,909[a]	7,218	,380	37,991

a. La valeur Alpha de Cronbach moyenne est basée sur la valeur propre moyenne.

ISSN: 2454-1907
DOI: 10.5281/zenodo.1491918

Measures of discrimination

	Dimension		Moyenne
	1	2	
MOS	,360	,056	,208
NAFIDA	,526	,003	,265
Institutional Trainings	,338	,037	,188
Software	,787	,099	,443
platforms	,880	,080	,480
Websites	,880	,080	,480
Magnetic support	,880	,080	,480
Personalwork	,880	,080	,480
Official trainings	,328	,026	,177
ICT skills (outside class)	,157	,651	,404
Hardware (outside class)	,157	,651	,404
ICT interests (outside class)	,767	,108	,437
Skill (inside class)	,067	,528	,297
Materials (inside class)	,157	,585	,371
Management (inside class)	,157	,585	,371
Interest (inside class)	,767	,108	,437
Pedagogicaladvantages	,708	,156	,432
Institutionaladvantages	,708	,156	,432
Dacticadvantages	,708	,156	,432
Total assets	10,214	4,222	7,218
Percentage of explained variance	53,759	22,223	37,991

*Corresponding author.
E-mail address: youssefbouchama@ hotmail.fr/ zaki.moncef@ yahoo.fr