湖南大学学报（自然科学版）
Journal of Hunan University (Natural Sciences)

第 50 卷 第 2 期
2023 年 2 月

Available online at http://jonuns.com/index.php/journal/index

Vol. 50 No. 2
February 2023

Open Access Article

https://doi.org/10.55463/issn.1674-2974.50.2.23

Teachers' Attitudes toward Integrating ICT in Teaching Chemistry in Morocco: Contribution, Constraints and Perspectives

Abdelouahed Lahlali[1]*, Nadia Chafiq[1,2], Mohamed Radid[2,3], Kamal Moundy[1]

[1] Laboratory of Sciences and Technologies of Information and Education, Faculty of Sciences Ben M'Sick, Hassan II University, Casablanca, Morocco

[2] Observatory of Research in Didactics and University Pedagogy, Faculty of Sciences Ben M'Sick, Hassan II University, Casablanca, Morocco

[3] Laboratory of Physical Chemistry of Materials, Department of Chemistry, Faculty of Sciences Ben M'sick, Hassan II University, Casablanca, Morocco

* Corresponding author: abdelouahed.lahlali-etu@etu.univh2c.ma

Received: December 6, 2022 ▪ Review: January 2, 2023 ▪ Accepted: February 1, 2023 ▪ Published: February 27, 2023

Abstract: Nowadays, Information and Communication Technologies in Education (ICT) have become essential pedagogical tools in any quality education system. While their integration becomes a necessity, especially in the scientific disciplines in general and chemistry in particular, which were the subject of this study. The current article aims to present the attitudes of physics-chemistry teachers of secondary education facing the integration of the information and communication technologies (ICT) in the teaching-learning process during the sessions of chemistry, on the one hand. On the other hand, it highlights the advantages and obstacles to the integration of ICT in the teaching-learning of chemistry, and identifies the conditions that promote the integration of ICT in teachers' practice. For this, we conducted a questionnaire survey with 41 teachers of secondary education from various high schools in the region Casablanca-Settat. The research results suggest that teachers have positive attitudes toward the integration of ICTE into teaching practices, and the majority of teachers emphasize the benefits of ICTE in chemistry lessons. However, the study revealed certain constraints and obstacles that hinder the integration of ICTE, including the lack of computer equipment in schools, overcrowded classrooms, and the absence of educational software adapted to the curriculum. Furthermore, the study proposes some perspectives that would allow for the implementation of a learning environment integrating ICTE in chemistry courses.

Keywords: information and communication technologies, attitudes, ICT integration, theory of reasoned action, theory of planned behavior.

摩洛哥教师对将信息通信技术融入化学教学的态度：贡献、制约因素和展望

摘要：如今，教育信息和通信技术 (信息通信技术) 已成为任何优质教育系统中必不可少的教学工具。虽然它们的整合成为必要，特别是在作为本研究主题的一般科学学科，尤其是化学学科中。目前的文章一方面旨在介绍中学物理化学教师在化学课程中面对信息和通信技术(信息通信技术)在教学过程中的整合的态度。另一方面，突出了信息通信技术在化学教学中的整合优势和障碍，指出了促进信息通信技术融入教师实践的条件。为此，我们对卡萨布兰卡-塞塔特地区各高中的 41 名中等教育教师进行了问卷调查。研究结果表明，教师对将

ICTE 融入教学实践持积极态度，大多数教师强调 ICTE 在化学课程中的好处。然而，该研究揭示了阻碍 ICTE 整合的某些制约因素和障碍，包括学校缺乏计算机设备、教室过于拥挤以及缺乏与课程相适应的教育软件。此外，该研究提出了一些观点，这些观点将允许在化学课程中实施整合 ICTE 的学习环境。

关键词：信息和通信技术、态度、信息通信技术集成、理性行动理论、计划行为理论.

1. Introduction

In recent years, the new information and communication technologies (ICT) are evolving rapidly and are being introduced in all domains and affect remarkably the domain of education. It is during this perspective that the Ministry of Education of Morocco has invested considerably for integrating ICT in its educational system to adapt to the changes governed by globalization on the one hand. On the other hand, the need for change toward ICT is inspired by the national curriculum of education and training.

To improve the quality of teaching and learning, Morocco is among the countries that are adopting a strategy to generalize information and communication technologies in education (ICT) through the Generalization of Information and Communication Technologies in Education program in Morocco (GICTE). This strategy aims specifically at equipping all schools with computer equipment, training teachers, directors, administrative staff, and pedagogical supervisory bodies, acquiring and producing quality digital educational resources adapted to the Moroccan educational context by the management of the engineering program [1].

The field of education must absolutely take advantage of the contribution of these technologies and must be aware that these ICTs provide innovative means, not only for the dissemination of a prodigious amount of knowledge but also to consider new directions to enrich, improve, and even transform certain educational practices [2]. The findings of numerous studies show that the appropriate integration of these technologies in education can bring multiple benefits [3]-[5] internationally and nationally [6]-[10].

The mastery of some basic concepts in chemistry is essential, especially during the cycle of secondary education qualifying of the key and fundamental concepts of chemistry. In addition, numerous studies have shown that some concepts such as chemical bonding, geometry of molecules ... are perceived as difficult concepts to teach and to be acquired by students [11]. Therefore, the integration of ICT is strongly desired in the discipline of chemistry as one of the means to address the most difficult concepts to teach, molecular visualization and allows to move from the microscopic to the macroscopic or from the invisible to the visible [12], the realization of molecular simulations to understand other concepts such as chemical reaction and reaction mechanisms and to reinforce the quality of the pedagogical contents and the approaches used in order to make learning more active and efficient and to enrich scientific concepts.

Nevertheless, the successful integration of ICT has not been an easy task. The results of research that are conducted in the Moroccan context indicate that ICT is little used for pedagogical purposes by teachers [13]-[16], [24].

For this reason, it is critical to question this situation of weak integration of ICT in the classroom despite the massive efforts at the institutional level to generalize the use of these technologies in Moroccan education.

In this respect, the objective of this research is to realize an exploratory study of the attitudes of physics-chemistry teachers toward the integration of the ICT during the sessions of chemistry courses and to bring out the advantages (degree of importance) that the ICT bring to the learning of chemistry, and the obstacles that would present brakes to their integration in the teaching of chemistry at the secondary education in Morocco.

We are interested in integrating ICT in chemistry teaching in secondary school because of the very significant lack of rigorous research conducted to better understand the reality of ICT integration in the teaching of this discipline in Morocco. We hope to answer the following main question: To what extent does the integration of ICT enhance the teaching-learning process in chemistry courses?

To answer this question, we go through the following questions:

- What are the attitudes of physics chemistry teachers toward the integration of ICT?
- What are the benefits of the pedagogical integration of ICT in chemistry teaching?
- What are the constraints to the effective and efficient integration of ICT in the teaching-learning process of chemistry?
- What are the conditions for the successful integration of ICT in a secondary school chemistry classroom?

2. Theoretical Framework

2.1. Concept of Attitude

The notion of attitude is a state of mind (sensation, perception, idea, conviction, feeling, etc.), an inner disposition acquired by a person with respect to himself or herself or to any element of his or her environment (person, thing, situation, event, ideology, mode of expression, etc.) that encourages a favorable or unfavorable way of being or acting. In terms of the integration or use of ICT by teachers, we can therefore consider an attitude as a state of mind or an inner disposition that would encourage (or not) the use and integration of ICT in teaching practice [3], [17].

The attitude of an individual has its origin in the environment in which he or she evolves; indeed, it is built on a set of experiences lived or learned throughout his or her life. Thus, several factors participate in the formation of an individual's attitude and thus make it possible to understand how the individual manages to synthesize his beliefs about an object into a global evaluation: physical factors, psychosocial factors, and personal factors [18].

2.2. Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) developed by Ajzen and Fishbein [19], is a psychosocial theory, presents behavior as a variable directly determined by the intention to perform that behavior. In their basic model and as shown in the figure (Fig. 1), Ajzen explains that behavioral intention depends on two basic constructs: attitude toward the behavior and subjective norm [20].

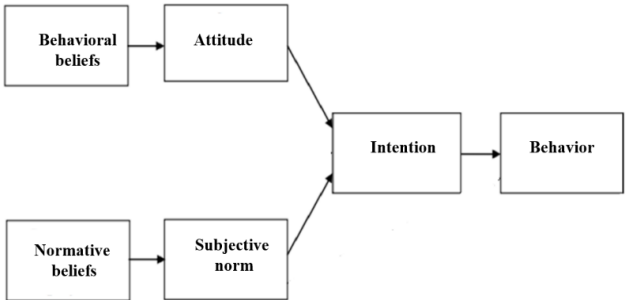

Fig. 1 Theory of reasoned action (TRA) [19]

Therefore, human behavior is a reasoned, thoughtful action being studied resulting, on the one hand, from the internal beliefs of individuals with regard to the action and its consequences and, on the other hand, from the perception of the surrounding environment and its degree of favorability to the realization of said action. Thus, measurement scales have been proposed to anticipate behavioral intention, these scales are presented in the form of confirmation of favorability to statements representative of beliefs and subjective norms regarding a given behavior [17], [20]-[21].

The main criticism of the theory of reasoned action is that only the simplest behaviors are under the control of the will. Perceived behavioral control is then included in the theory of planned behavior to deepen the concept.

2.3. Theory of Planned Behavior (TPB)

The theory of planned behavior is a variant of the theory of reasoned action. It consists of predicting behavioral intention in contexts where the individual does not have total control over a given behavior (in a situation of forced use of an information system, for example); in particular, it studies the relationship between perceived control over the behavior and behavioral intention. Ajzen considers that the more external constraints the individual is subjected to in the performance of a behavior, the less he intends to perform it (Fig. 2).

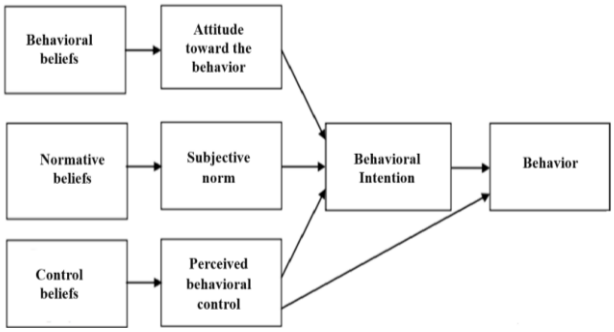

Fig. 2 Theory of planned behavior (TPB) [19]

According to this theory, behavioral intention is jointly related to the individual's attitudes, subjective norms, and perceived control over the behavior. This perception of control reflects the degree to which the individual believes that performing or not performing a behavior is under his or her control and will, lack of control or total control respectively influences the intention to perform or avoid performing a behavior, even if attitudes and subjective norms are favorable [22].

Table 1 represents a synthesis of the theories mobilized to better explain the concept of appropriation and its contribution to the ICT integration process.

Table 1 The synthesis of theories mobilized to explain ICT integration behavior [22]

Item	Proportion
Theory of reasoned action	- Behavior under the control of the will.
	- Directly determining the intention of the behavior.
	- Intention has two antecedents: attitude and subjective norm.
Theory of planned behavior	- Not all behaviors are entirely under control.
	- Many behaviors require opportunities and resources.
	- The perception of control over the behavior influences the intention and directly affects the behavior.

3. Design/Methodology/Approach

3.1. Characteristics of the Sample

We chose a sample of 41 secondary school teachers belonging to the Regional Academy of Education and Training of the Casablanca-Settat region of the Kingdom of Morocco. They are distributed over the different provincial directorates of the region, from the discipline of physics chemistry, and practicing in schools in urban areas.

On the gender side, the teachers who responded to our survey were 38 men (92.7%) and 3 women (7.3%). This difference between the rates for men and women can be explained by the fact that the respondents were selected at random.

On the other hand, the sample of our study is formed mostly by young teachers: the table below (Table 2) shows that 58.5% of the respondents are in the average age between 31 and 40 years, 24.4% are in the average age between 41 and 50 years and only about 9.8% have an age higher than 51 years and 7.3% of the respondents have an age lower than 30 years.

Table 2 Distribution of respondents by age

Age	Percentage
Under 30 years old	7.3%
Between 31 and 40 years old	58.5%
Between 41 and 50 years old	24.4%
Over 51 years old	9.8%

Regarding the teaching experience of the teachers who responded to our questionnaire, 26.8% have more than 21 years of seniority, which shows more experienced teachers in the sample, 29.3% have seniority between 11 and 20 years, a third of the sample (34.1%) have seniority between 6 and 10 years, and only 9.8% have less than 6 years of seniority. This result can be explained by the fact that an electronic questionnaire was used (Table 3).

Table 3 Distribution of respondents by the length of time in teaching

Length of time in teaching	Percentage
Under 6 years old	9.8%
Between 6 and 10 years	34.1%
Between 11 and 20 years old	29.3%
Over 21 years old	26.8%

3.2. The Research Process

For the choice of a data collection tool, we opted for a questionnaire. The questionnaire was distributed to 50 teachers belonging to the AREF of Casablanca-Settat. We collected 41 completed and returned questionnaires, which explained a successful response rate of 82%, which we considered very satisfactory.

We developed a questionnaire with several questions following the objectives of the study. The questionnaire was divided into four parts:

The first part entitled "teachers' attitude toward the integration of ICT in chemistry courses".

The second part entitled "the benefits that ICT brings to the learning of chemistry".

The third part entitled "the obstacles to the integration of ICT in the chemistry course".

The last part entitled "the conditions for successful integration of ICT in chemistry teaching".

3.3. Data Analysis

The collected data were coded and analyzed using SPSS 25 and Microsoft Office Excel 2010. Thus, descriptive statistics of the different variables were performed.

The table below shows the results of Cronbach's Alpha reliability test on the questionnaire. The results show that the themes are highly acceptable given that the Cronbach's Alpha values are quite higher than the value of 0.700, which is often considered to be highly correlated (Table 4).

Table 4 Cronbach's alpha values for the three items

Items	Number of items	Cronbach's Alpha
The benefits of integrating ICT into the chemistry course.	13	0.975
Constraints and obstacles to the integration of ICT in the chemistry classroom.	20	0.961
Conditions for supporting improved classroom practices by integrating ICT in the chemistry classroom.	8	0.978

4. Results

4.1. Teachers' Attitudes toward the Integration of ICT in Chemistry Courses

Teachers' attitudes toward the integration of ICT are manifested in the training on ICT integration, the degree of importance of ICT in chemistry courses, the preferred mode of teaching in the classroom, and the degree of ICT integration during chemistry teaching sessions.

4.1.1. Training Specifically Related to the Integration of ICT

The results in Table 5 show that 53.7% of the respondents (physics chemistry teachers) opt for self-training to complete their initial or in-service training related to ICT integration. Additionally, only 29.9% of the teachers were trained during initial professional training in training centers, as well as 24.4% have benefited from in-service training. However, a low rate of 14.6% of respondents who have never received training regarding the integration of ICT in education.

Table 5 Trainings specifically related to the integration of ICT by teachers

Proposals	Percentage	Number of participants
No ICT training	14.6%	6
Basic academic training	22%	9
Continuing education	24.4%	10

(training offered by the GICTE program)		
Initial vocational training	29.3%	12
Self-training	53.7%	22

4.1.2. The Degree of Importance of ICT to the Discipline Being Taught

The results of this test show that 85% (58% very useful and 27% somewhat useful) of the teachers surveyed expressed great interest in integrating ICT into their teaching practices in the subject they teach. However, only 15% of them reject the importance of integrating ICT into classroom practices (Figure 3).

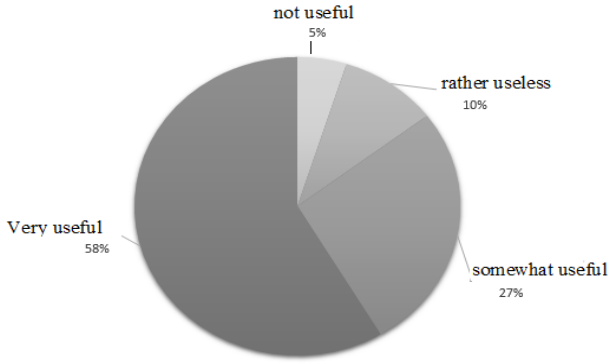

Fig. 3 Degree of the ICT importance for the discipline taught

4.1.3. The Mode of Teaching Preferred in the Classroom by Teachers

Table 6 summarizes the most appropriate teaching mode during chemistry class sessions. The results show that 80.5% of the surveyed teachers opt for alternate teaching integrating several teaching aids (board, handout, ICT). Nevertheless, 19.5% prefer modern teaching based on ICT, and only 7.3% of teachers prefer the traditional process (no integration of ICT).

Table 6 Teachers' views on the most appropriate teaching mode for better learning in chemistry courses

The teaching method adopted	Percentage
Alternate teaching integrating several supports (blackboard, handout, ICT).	80.5 %
Modern teaching based on ICT only	19.5 %
Traditional teaching (no integration of ICT)	7.3 %

4.1.4. The Degree to Which Teachers Integrate ICT in the Classroom

The degree of integration of ICT in the classroom during the chemistry sessions is represented in Table 7. The results indicated that the percentage of ICT integration ranged from 20% to 60%. These results revealed that the percentage of integration of ICT in the teaching-learning process by the surveyed teachers in the classroom remains limited. 29.27% of the respondents stated to integrate ICT in their classrooms with a rate below 20% and 36.59% of the respondents with a rate between 20% and 40%. And 29.27% of respondents with a rate between 40% and 60%.

Table 7 Percentages of physics chemistry teachers integrating ICT in the classroom

Rate of ICT integration	Percentage
Less than 20% of the total	29.27%
Between 20% and 40%	36.59%
Between 40% and 60%	29.27%
Between 60% and 80%	2.44%
More than 80	2.44%

4.2. Benefits of Integrating ICT during Chemistry Sessions

The teachers answered a 13-item questionnaire on the main contributions and benefits derived from the pedagogical integration of ICT in chemistry, each item is represented under a five-point Likert scale ranging from "Strongly disagree" to "Strongly agree".

The following table (Table 8) presents the responses obtained from each item in terms of mean and standard deviation in descending order. The results show that the majority of the teachers opt for all benefits derived from the integration of ICT in chemistry since the means vary between [3.46; 3.98] out of 5. Furthermore, the results show that 4 items out of 13, are considered the most beneficial: these are better visualization of situations (3.98), facilitating the understanding of abstract concepts of the course (3.95), students better understand representations in space such as three-dimensional molecules (3.93) and student motivation (3.93). However, the last three items are less important; they are assimilation and memorization of knowledge, autonomy in learning, and self-evaluation (interactive exercises).

Table 8 Benefits of ICT integration in chemistry for teachers

Items	Average	SD
1. Better visualization of situations (3D molecules).	3,98	1,172
2. Facilitate the understanding of abstract concepts in this course.	3,95	1,071
3. Students have a better understanding of representations in space (Cram representation).	3,93	1,170
4. Motivate students.	3,93	0,985
5. To make these courses more attractive to my students.	3,83	1,138
6. To save time.	3,83	1,202
7. Reduce difficulties and misconceptions of concepts.	3,80	1,100
8. Richness and diversity of resources.	3,76	1,157
9. To put the student in a meaningful situation.	3,73	1,073
10. Adaptation to the student's rhythm.	3,66	1,063
11. Assimilation and memorization of knowledge.	3,59	1,095
12. Autonomy in learning.	3,51	1,052

4.3. Barriers to the Integration of ICT in Chemistry Courses

The quantitative analysis of the collected data allowed us to identify four main categories of barriers to the integration of ICT in chemistry teaching in Morocco, namely: barriers related to ICT infrastructure and equipment, barriers related to technical support and

professional development, barriers related to the Moroccan educational system, and factors related to psychological and pedagogical barriers (Table 9). Teachers were asked to respond to each item using a five-point Likert scale ranging from "strongly disagree" to "strongly agree". The following table groups the responses obtained for each item according to the mean and standard deviation in the order of priority.

Table 9 Categories of barriers to the integration of ICT in chemistry education

Categories	Items	Average	SD
Barriers related to ICT infrastructure and equipment	Insufficient equipment in these facilities.	4.22	1.255
	The lack of the renewal of technological equipment.	4.17	1.116
	The lack of Internet connections and access difficulties.	4.02	1.275
	The absence of the GICTE room (multimedia) or always closed.	3.93	1.292
	The equipment is unreliable enough, there is always a risk of a breakdown in the presence of the students.	3.80	1.308
	The lack of specialized and adapted software.	3.61	1.302
Barriers to support and professional development	The lack of technical support and maintenance of equipment.	3.85	1.442
	The lack of ICT skills among teachers.	3.49	1.267
	Insufficient training for integrating ICT.	3.44	1.361
	The lack of pedagogical support.	3.27	1.304
Obstacles related to the Moroccan educational system.	The too crowded classes do not favor the integration of ICT.	3.85	1.295
	The ICT integration strategy is poorly translated into the school environment.	3.76	1.392
	The lack of adapted curricula to integrate ICT.	3.73	1.304
	The pedagogical approach not adapted to the use of ICT.	3.05	1.448
Factors related to psychological and educational barriers	Time constraints with a program to complete.	3.63	1.299
	The low motivation of these teachers toward the pedagogical use of ICT in the classroom.	3.51	1.502
	Students are more capable than teachers of using ICT.	3.10	1.546
	Difficulties related to classroom management when integrating ICT.	3.00	1.378
	A sense of fear about the use of ICT.	2.95	1.499

Barriers related to ICT infrastructure and equipment: The analysis of the teachers' results allowed us to divide the barriers related to ICT infrastructure that hinder the integration of ICT in teaching into six main sub-categories. In particular, three factors among them are considered major obstacles that hinder the integration of ICT by the majority of the participants. Indeed, the first factor concerns insufficient equipment in schools (4.22), the second factor concerns the lack of renewal of technological equipment (4.17), and the third factor concerns the lack of internet connections and access difficulties (4.02). Other factors considered less important are the absence of the GICTE room (multimedia) or always closed (3.93), the equipment is unreliable enough (3.80), there is always a risk of breakdown in the presence of students and the lack of specialized and adapted software (3.61).

Barriers to support and professional development: According to most teachers the major obstacles to the integration of ICT in teaching related to support and professional development in order of priority, we find that the first obstacle is the lack of technical support and maintenance of equipment (3.85), the second is the lack of competence of teachers in ICT (3.49), the third factor is the insufficient training for integrating ICT (3.44), and finally the lack of pedagogical support (3.27).

Obstacles related to the Moroccan educational system: According to the responses of the teachers participating in our survey, classes are too crowded (3.85) on the one hand, on the other hand, the strategy of integration of ICT is poorly translated on the school ground (3.76). Moreover, the lack of curricula adapted to integrate ICT (3.73) and the pedagogical approach adopted unsuited to the use of ICT (3.05) constitute real obstacles to the integration of these technologies in teaching.

Factors related to psychological and educational barriers: Concerning the factors related to psychological and pedagogical barriers, the teachers declare time constraints (3.63), and the low motivation of these teachers toward the pedagogical use of ICT in the classroom (3.51) are major obstacles hindering the integration of ICT in education. Similarly, participants believe that students are more capable than teachers to use ICT (3.10). Moreover, participating teachers consider difficulties related to classroom management in case of ICT integration (3.00), and as the last factor, a feeling of fear toward the use of ICT (2.95) constitutes a considerable obstacle to the integration of ICT in Moroccan schools.

4.4. Conditions to Support Improved Classroom Practices by Integrating ICT in the Chemistry Classroom

Conditions for the successful integration of ICT in the classroom, we selected 8 modalities representing the main conditions to support the improvement of classroom practices by integrating ICT. Teachers should respond to each modality using a four-level Likert scale ranging from "unimportant" to "very important". Table 10 groups the responses obtained according to each modality.

Table 10 Conditions to support improved classroom practices by integrating ICT in the chemistry classroom

Items	Unimportant	Quite important	Important	Very important
The periodic implementation of colloquiums (presentations, conferences...) on the need to innovate through the integration of ICT	7.3%	17.1%	31.7%	43.9%
The adoption of specific training for integrating ICT	12.2%	12.2%	26.8%	48.8%
Provide teachers with standardized and indexed digital resources adapted to the curriculum	9.8%	12.2%	31.7%	46.3%
Provision of a bank of appropriate digital practices	4.85%	21.95%	24.4%	48.8%
Encouraging innovative teachers by adopting their digital projects and integrating them into the MEN digital practice system	9.8%	14.6%	19.5%	56.1%
Individual or collective accompaniment of teachers in the experimentation of good digital practices in class	4.9%	14.6%	31.7%	48.8%
Logistical support (equipment, Internet connection)	4.9%	14.6%	19.5%	61%
Establishment of workshops for the exchange and analysis of good digital practices in science education	2.4%	19.5%	14.6%	63.4%

For the conditions that would allow the implementation of learning integrating ICT in the chemistry course, 3 items out of 8 are considered by the teachers as very important, the answers underline the establishment of workshops for exchange and analysis of good digital practices in the teaching of science (63.4%), logistical support (material, Internet connection) (61%), and the encouragement of innovative teachers by adopting their digital projects and their integration in the system of digital practices of the MEN (56.1%).

The secondary conditions that would allow the implementation of the integration of ICT in education for teachers are the individual or collective support of teachers in experimenting good digital practices in the classroom (48.8%) and the adoption of specific training for integrating ICT (48.8%) and provision of a bank of appropriate digital practices (48.8%).

Finally, we find the periodic implementation of colloquiums (presentations, conferences...) on the need to innovate through the integration of ICT (43.9%) and provide teachers with standardized and indexed digital resources adapted to the programs taught (46.3%).

5. Discussion

The research confirmed that most teachers interviewed expressed great interest in the integration of ICT in teaching-learning during the chemistry course. Moreover, most of the teachers of physics chemistry testify that they have not benefited from solid initial or continuous training in the field of ICT. However, the integration of ICT in the teaching of chemistry remains insufficient as specified by [7], [13]-[15], [23], [24], this paradox between the interest and integration of ICT in the pedagogical activity of the teacher is due to several constraints that we have detected in this work.

All item averages are between 3.46 and 3.98, these results showed positive attitudes of teachers toward the integration of ICT in chemistry courses and has several advantages for most teachers of secondary education and that they can improve the quality of teaching and learning.

Indeed, the integration of ICT has a positive impact on teaching and can strengthen the motivation of students. This result is consistent with the results of international studies [1], [3], [25]-[26], which showed that the integration of ICT can promote student learning in science. In addition, Moroccan researchers confirmed that the integration of ICT has a positive impact on student learning [1], [5]-[6], [8], [27]-[28], thus saving time [26].

The integration of ICT in education is a complex process that encounters several obstacles even within Western countries [23]. Indeed, several studies have been conducted to identify and classify these obstacles into two main categories or three. The results of our research reveal many barriers to the integration of ICT in the chemistry classroom in four categories:

The first category of barriers is that of insufficient technological equipment. This result is consistent with findings that confirm that the lack or inadequacy of technological equipment and the availability of Internet access are among the most significant constraints to the successful integration of ICT in education [29]-[33].

The second category of barriers is that related to support and professional development, some research conducted around the world has concluded that the lack of teacher training in ICT is a major obstacle to the integration of technology into teaching practices [25], [29], [33]-[34]. Similarly, the lack of technical support to help teachers overcome the difficulties that accompany the use of ICTs is an obstacle to the integration of ICTs into educational practices [35]and

the lack of in-service training for teachers in the integration of ICTs into their practices [36].

The third category of obstacles related to the Moroccan education system. Particularly overcrowded with students per class, this problem makes the integration of ICT difficult, if not impossible in learning and evaluation situations. Other constraints that are related to working conditions, the lack of curricula adapted to integrate ICT, in some levels of education at the secondary level, and the incompatibility of some pedagogical approaches with successful integration of ICT, could hamper the effective use of ICT in education [3], [15], [35].

The fourth category of barriers corresponds to psychological and pedagogical barriers, negative attitudes among teachers, such as a feeling of fear toward the use of ICT (lack of self-confidence), fear of failure in front of students (students are more capable than teachers to use ICT), and low motivation of teachers toward the pedagogical use of ICT in the classroom. This result is in line with the results [25], [37] that point out that among the frequent obstacles are the management of teaching time and the overload of work required by the intensive preparations of the ICT session [38].

The most important conditions indicated by the respondents of our survey are mainly, on the one hand, the exchange of experiences and good digital practices in science teaching with colleagues in the workshops, on the other hand, logistical support (hardware equipment should be sufficient) can help and encourage teachers to integrate ICT [39]. In addition, teachers must have the basic knowledge in the use and operation of educational software for this it is necessary to adopt specific training for integrating ICT [2], [13], [41]-[42], then the respondents insist on encouraging innovative teachers by adopting their digital projects and their integration into the system of digital practices of the MEN [39]-[40] expressed to make available to teachers standardized and indexed digital resources adapted to the programs taught [30], [39].

The survey of Moroccan physics and chemistry teachers revealed several advantages that could be derived from the integration of ICT into the learning process of chemistry courses. These results are similar to those obtained by national [1], [6], [8], [27]-[28] and international [3], [25]-[26] studies. Furthermore, our investigation allowed us to identify the main factors hindering teachers' successful integration of ICT, which is consistent with research [23], [25], [29], [33], [34], [36].

Finally, there are other factors that can encourage the use of ICT in education: individual or collective support for teachers in experimenting with good digital practices in the classroom and provision of a bank of appropriate digital practices.

While this research has produced important results, it has its limitations. Indeed,

- The study focused on teachers working in schools in only one regional education and a training academy was selected for data collection,
- Only a minority of teachers responded to the questionnaire,
- One limitation of the current study is that it focuses on the opinions of teachers only.
- Another limitation of the current study is that it focuses on teachers who practice in public schools with very high percentages.

6. Conclusion

This study aimed at identifying the attitudes of the physics-chemistry teachers in secondary education toward the integration of ICT in the teaching-learning process.

The main results of this study show that the integration of ICT constitutes indispensable tools in the pedagogical practice of chemistry courses. Additionally, there is a positive impact of the integration of ICT on the teaching of chemistry to strengthen the understanding of abstract concepts, motivate students, and make the courses more attractive to students.

Also, the results of the research show the existence of many obstacles mentioned by the teachers interviewed. As a result, four categories of obstacles are identified, namely: obstacles related to ICT infrastructure and equipment, obstacles related to the support and professional development of teachers, obstacles related to the Moroccan educational system, and obstacles related to psychological and pedagogical obstacles.

Based on the results of the study, curriculum developers should consider teachers' attitudes when preparing content and ensure the essential conditions for the successful integration of ICT in the chemistry classroom.

In the light of the results obtained, it can be said that the integration of ICT are indispensable tools for learning chemistry in the secondary cycle in Morocco, however, in this work there are limitations to be taken into consideration, the study focuses on the opinions of teachers only, the sample size that responded to the questionnaire is limited, and the study to focus on the opinion of teachers practicing in public schools and only one regional academy of education and training in Morocco were selected for data collection among 12 academies.

In view of the results obtained, it appears that the successful integration of information and communication technologies into classroom practices requires the improvement of the conditions for integrating educational technologies and an awareness of the didactic and pedagogical aspects of ICTE integration.

Finally, it seems very relevant to us to continue

researching this topic, in a further, more in-depth study, aimed at a better understanding of these attitudes, among school headmasters, educational inspectors, and students, and to study the impact of ICT on the understanding or assimilation of microscopic concepts of chemistry among apparent.

References

[1] MESSAOUDI F, and TALBI M. Réussir l'intégration des TICE au Maroc: regard sur le déploiement de la stratégie nationale GICTE, 2012, *Revue EpiNet*, 143: 10, http://www.epi.asso.fr/revue/articles/a1203e.htm

[2] NAFIDI Y, ALAMI A, ZAKI M., et al. L'intégration des TIC dans L'enseignement des Sciences de la Vie et de la Terre au Maroc: Etat des Lieux et Défis à Relever. *European Scientific Journal*, 2018, 14(1): 97-121. http://dx.doi.org/10.19044/esj.2018.v14n1p97

[3] BARIU T N, and CHUN X. Influence of teachers' attitude on ICT implementation in Kenyan universities, *Cogent Education*, 2022, 9(1): 1-22. http://doi.org/10.1080/2331186X.2022.2107294

[4] POYET F. Impact des TIC dans l'enseignement: Une alternative pour l'individualisation? *Dossier d'actualité du Service de Veille scientifique et technologique*, 2009: 1-10.

[5] RABY C, KARSENTI T, MEUNIER H, and VILLENEUVE S. Usage des TIC en pédagogie universitaire: point de vue des étudiants. International *Journal of Technologies in Higher Education*, 2011, 8(3): 6-19.

[6] AHAJI K, EL HAJJAMI A, AJANA L, et al. Analyse de l'effet d'intégration d'un logiciel d'optique géométrique sur l'apprentissage d'élèves de niveau baccalauréat sciences expérimentales, *Revue Électronique de l'EPI*, 2008, 101.

[7] EL OUIDADI O, ESSAFI K, ABOUTAJDYNE M, et al. Analyse des attitudes et des besoins des enseignants Marocains dans le domaine des TICE. Cas de L'Académie (AREF) de FES-Boulemane, Maroc. *Radisma*, 2011, 7.

[8] DROUI M, EL HAJJAMI A, BOUKLAH M, and ZOUIRECH S. Impact de l'apprentissage par problème sur la compréhension conceptuelle de la mécanique newtonienne. *Revue Électronique de l'EPI*, 2013, 157.

[9] ALJ O, and BENJELLOUN N. Étude comparative des résultats de quelques recherches sur l'intégration des TIC dans l'enseignement des disciplines scientifiques au sein du programme GICTE Maroc. *Revue Électronique de* l'EPI, 2016.

[10] COUR A, and BELMOUDENE A. Analyse des besoins de formation en technologies éducatives chez les enseignants du secondaire au Maroc. *Revue Électronique de l'EPI*, 2021.

[11] JOKI J, and AKSELA M. The challenges of learning and teaching chemical bonding at different school levels using electrostatic interactions instead of the octet rule as a teaching model. *Chemistry Education Research and Practice*, 2018, 19(3): 932–953. https://doi.org/10.1039/C8RP00110C

[12] CHAVENT M, BAADEN M, HÉNON E, and ANTONCZAK S. Bientôt dans votre amphithéâtre, la chimie fera son cinema. *L'actualité chimique*, 2012, 363.

[13] BIAZ A, BENNAMARA A, KHYATI A, and TALBI M. Intégration des technologies de l'information et de la communication dans le travail enseignant, état des lieux et perspectives. *Revue Électronique de l'EPI*, 2009, 120.

[14] ALJ O, and BENJELLOUN N. Intégration des TIC dans l'enseignement des sciences physiques au Maroc dans le cadre du programme GICTE: difficultés et obstacles. *International Journal of Technologies in Higher Education, 2013,* 10(2): 49-65.

[15] EL MADHI Y, CHIAHOU B, BELGHYTI D, et al. Les contraintes liées à l'intégration du TIC dans l'enseignement des sciences de la vie et de la terre au Maroc. *European Scientific Journal*, 2014, 10(34):143-153.

[16] BENFARESS S, ZAKI M, and ALAMI A. Analyse Multidimensionnelle des Facteurs D'intégration des Tice: Etude de Cas à Travers Le Programme GICTE Marocain. *European Scientific Journal*, 2016, 12(19): 164-180. http://dx.doi.org/10.19044/esj.2016.v12n19p164

[17] OUELLET A. Analyse du concept attitude: du concept théorique au concept opératoire. *Revue des sciences de l'éducation*, 2009, 4(3), 365-374. https://doi.org/10.7202/900085ar

[18] MRANI C A, and EL HAJJAMI A. L'innovation techno-pédagogique chez l'enseignant des sciences physique-chimie du cycle secondaire marocain: les représentations, les attitudes et les comportements. *Revue Électronique de l'EPI*, 2019.

[19] FISHBEIN M, and AJZEN I. *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley, 1975.

[20] MATOUSSI, F., and SIMONNEAUX, L. Attitudes des enseignants face à l'intégration des TIC: Cas de l'enseignement secondaire tunisien. TICEMED, 2008: 1-8.

[21] KARSENTI T, SAVOIE-ZAJC L, and LAROSE F. Les futurs enseignants confrontés aux TIC: Changements dans l'attitude, la motivation et les pratiques pédagogiques, *Éducation et francophonie*, 2021, 29(1): 86–124, https://doi.org/10.7202/1079569ar.

[22] AHMIMID A. *Proposition d'un modèle d'analyse des déterminants de l'acceptation de l'usage des dispositifs de télédéclaration fiscale au Maroc*. Doctoral thesis in Management Sciences. Universite de Nantes, 2018.

[23] MASTAFI M. Intégration et usages des TIC dans le système éducatif marocain: Attitudes des enseignants de l'enseignement primaire et secondaire. Adjectif.net, 2013. http://www.adjectif.net/spip/spip.php?article228

[24] MAOUNI A, MIMET A, KHADDOR M, et al. L'intégration des TIC dans l'enseignement des SVT au Maroc: réalité et attentes. *Radisma*, 2014, 10(27).

[25] UNDI V, and Hashim H. The Demands of 21st Century Learning: A Study on Primary School Teachers' Attitudes towards Using ICT in English as a Second Language (ESL) Classrooms. *Creative Education*, 2021, 12, 1666-1678. https://doi.org/10.4236/ce.2021.127127.

[26] BIBEAU R. Les Technologies de l'Information et de la Communication peuvent contribuer à améliorer les résultats scolaires des élèves. *EpiNet*, 2007, 94.

[27] GUENNOUN B, and BENJELLOUN N. Regards des étudiants sur l'intégration des TIC dans l'enseignement supérieur scientifique. *International Journal of Technologies in Higher Education*, 2016, 13(1): 64–94. https://doi.org/10.18162/ritpu-2016-v13n1-05.

[28] TAOUFIK M, ABOUZAID A, and MOUFTI A. Les Activités Expérimentales dans L'enseignement des Sciences Physiques: Cas des Collèges Marocains. *European Scientific Journal*, 2016, 12(22): 190-212.

[29] PELGRUM W J, and LAW N. *Les TIC et l'éducation dans le monde: tendances, enjeux et perspectives.* UNESCO: Institut international de

planification de l'éducation, 2004.
[30] BIBEAU R. Les TICE à l'école: proposition de taxonomie et analyse des obstacles à leur integration. *Revue Électronique de l'EPI*, 2005.
[31] TEYSSEDRE G. *Quels obstacles à l'intégration des TICE dans l'enseignement élémentaire? Une étude anthropo-didactique auprès d'enseignants des cycles 2 et 3*. Doctoral thesis in Societies, Politics, Public Health. Université Bordeaux Segalen, 2012.
[32] UNAL S, and OZTURK I H. Barriers to ITC integration into teachers' classroom practices: Lessons from a case study on social studies teachers in Turkey. *World Applied Sciences Journal*, 2012, 18(7): 939-944.
[33] GIL-FLORES J, RODRÍGUEZ-SANTERO J, and TORRES-GORDILLO J J. Factors that explain the use of ICT in secondary-education classrooms: The role of teacher characteristics and school infrastructure. *Computers in Human Behavior*, 2017, 68: 441–449.
[34] TAYLOR N, and CORRIGAN G. New South Wales primary school teachers' perceptions of the role of ICT in the primary science curriculum – A rural and regional perspective. *International Journal of Science and Mathematics Education*, 2007, 5(1): 85–109.
[35] MASTAFI M. Obstacles à l'intégration des technologies de l'information et de la communication (TIC) dans le système éducatif marocain. Frantice.net, 2014: 50–65. http://dx.doi.org/10.18162/fp.2015.294
[36] CHEKOUR M, LAAFOU M, and JANATI-IDRISSI R. Les facteurs influençant l'acquisition des concepts en électricité. Cas des lycéens marocains, Adjectif.net, 2015. http://www.adjectif.net/spip/spip.php?article354
[37] BECTA. A review of the research literature on barriers to the uptake of ICT by teachers, 2004. https://dera.ioe.ac.uk/1603/1/becta_2004_barrierstouptake_litrev.pdf
[38] RIZZA C. *Les TICE dans la formation initiale des enseignants en France: Etude de cas national*, 2009. https://www.oecd.org/france/46103639.pdf
[39] HEER S, and AKKARI A. Intégration des TIC par les enseignants: premiers résultats d'une enquête Suisse. *International Journal of Technologies in Higher Education*, 2006, 3(3): 38-48.
[40] KOH J H L, and CHAI C S. Teacher clusters and their perceptions of technological pedagogical content knowledge (TPACK) development through ICT lesson design. *Computers & Education*, 2014, 70: 222–232.
[41] LEE Y, and LEE J. Enhancing pre-service teachers' self-efficacy beliefs for technology integration through lesson planning practice. *Computers & Education*, 2014, 73: 121–128.
[42] CARUGATI F., and TOMASETTO, C. Le corps enseignant face aux technologies de l'information et de la communication: un défi incontournable. *Revue des sciences de l'éducation*, 2002, 28(2), 305–324. https://doi.org/10.7202/007356ar

参考文:

[1] MESSAOUDI F 和 TALBI M. 摩洛哥 ICTE 整合的成功：国家捷信战略部署一瞥，评论外网，2012，143：10，http://www.epi.asso.fr /期刊/文章/a1203e.htm
[2] NAFIDI Y、ALAMI A、ZAKI M. 等人。摩洛哥将信息通信技术融入生命与地球科学教学：现状和面临的挑战。欧洲科学杂志，2018，14(1)：97-121。http://dx.doi.org/10.19044/esj.2018.v14n1p97
[3] BARIU T N, CHUN X. 教师态度对肯尼亚大学信息通信技术实施的影响，有说服力的教育，2022, 9(1): 1-22. http://doi.org/10.1080/2331186X.2022.2107294
[4] POYET F. 信息通信技术对教育的影响：个性化的替代方案？科技观察社时事档案, 2009: 1-10.
[5] RABY C、KARSENTI T、MEUNIER H 和 VILLENEUVE S. ICT 在大学教学中的应用：学生的观点。国际高等教育技术杂志, 2011, 8(3): 6-19.
[6] AHAJI K、EL HAJJAMI A、AJANA L 等人。分析集成几何光学软件对本科阶段实验科学学生学习的影响，EPI 电子杂志, 2008, 101.
[7] EL OUIDADI O、ESSAFI K、ABOUTAJDYNE M 等。摩洛哥教师在 ICT 领域的态度和需求分析。摩洛哥 FES-布莱曼学院(区域参考基金)的案例。辐条, 2011, 7.
[8] DROUI M、EL HAJJAMI A、BOUKLAH M 和 ZOUIRECH S. 基于问题的学习对牛顿力学概念理解的影响。EPI 电子评论, 2013, 157.
[9] ALJ O 和 BENJELLOUN N. 比较研究在捷信摩洛哥计划内将信息通信技术整合到科学学科教学中的一些研究结果。个人防护装备电子评论，2016。
[10] COUR A 和 BELMOUDENE A. 摩洛哥中学教师教育技术培训需求分析。个人防护装备电子评论，2021。
[11] JOKI J 和 AKSELA M. 使用静电相互作用而不是八位位组规则作为教学模型在不同学校级别学习和教授化学键合的挑战。化学教育研究与实践, 2018, 19(3): 932–953. https://doi.org/10.1039/C8RP00110C
[12] CHAVENT M、BAADEN M、HÉNON E 和 ANTONCZAK S。很快，在您的圆形剧场中，化学将成为电影。化工新闻, 2012, 363.
[13] BIAZ A、BENNAMARA A、KHYATI A 和 TALBI M。信息和通信技术在教学工作、清单和观点中的整合。EPI 电子评论，2009，120。
[14] ALJ O 和 BENJELLOUN N. 在捷信计划的框架内将信息通信技术整合到摩洛哥的物理科学教学中：困难和障碍。国际高等教育技术杂志, 2013, 10(2): 49-65.
[15] EL MADHI Y、CHIAHOU B、BELGHYTI D 等。在摩洛哥将信息通信技术整合到生命和地球科学教学中的制约因素。欧洲科学杂志，2014，10(34):143-153。
[16] BENFARESS S、ZAKI M 和 ALAMI A。信息通信

技术集成因素的多维分析：摩洛哥捷信项目的案例研究。欧洲科学杂志，2016，12(19)：164-180。http://dx.doi.org/10.19044/esj.2016.v12n19p164

[17] OUELLET A. 态度概念解析：从理论概念到操作概念。教育科学杂志，2009，4（3），365-374。https://doi.org/10.7202/900085ar

[18] MRANI C A 和 EL HAJJAMI A. 摩洛哥中学物理化学科学教师的技术教学创新：表现、态度和行为。EPI 电子评论，2019。

[19] FISHBEIN M 和 AJZEN I. 信念、态度、意图和行为：理论与研究导论。马萨诸塞州雷丁：艾迪生卫斯理，1975。

[20] MATOUSSI, F. 和 SIMONNEAUX, L. 教师对信息通信技术整合的态度：突尼斯中等教育案例。中美，2008：1-8。

[21] KARSENTI T、SAVOIE-ZAJC L 和 LAROSE F. 未来教师面临信息通信技术：态度、动机和教学实践的变化，教育和法语国家，2021，29(1)：86–124，https://doi.org/10.7202/1079569ar。

[22] AHMIMID A. 关于在摩洛哥接受使用电子纳税申报系统的决定因素的分析模型的建议。管理科学博士论文。南特大学，2018。

[23] MASTAFI M. 信息通信技术在摩洛哥教育系统中的整合和使用：中小学教师的态度。Adjectif.net，2013。http://www.adjectif.net/spip/spip.php?article228

[24] MAOUNI A、MIMET A、KHADDOR M 等人。信息通信技术在摩洛哥 SVT 教学中的整合：现实与期望。辐射，2014，10(27)。

[25] UNDI V 和 HASHIM H. 21 世纪学习的需求：小学教师对在英语作为第二语言(英语)课堂上使用信息通信技术的态度的研究。创意教育，2021，12 日，1666-1678。https://doi.org/10.4236/ce.2021.127127。

[26] BIBEAU R. 信息和通信技术有助于提高学生的学业成绩。外网，2007，94。

[27] GUENNOUN B 和 BENJELLOUN N. 学生对信息通信技术在高等教育中的整合的看法。国际高等教育技术杂志，2016，13(1)：64-94。https://doi.org/10.18162/ritpu-2016-v13n1-05。

[28] TAOUFIK M、ABOUZAID A 和 MOUFTI A. 物理科学教学中的实验活动：摩洛哥大学案例。欧洲科学杂志，2016，12(22)：190-212。

[29] PELGRUM W J 和 LAW N. 世界各地的信息通信技术和教育：趋势、问题和观点。教科文组织：国际教育规划研究所，2004。

[30] BIBEAU R. 学校信息通信技术：提议的分类法和对其整合障碍的分析。EPI 电子期刊，2005。

[31] TEYSSEDRE G. 信息通信技术融入基础教育的障碍是什么？与第 2 周期和第 3 周期的教师进行的人类教学研究。社会、政治、公共卫生领域的博士论文。波尔多塞加伦大学，2012。

[32] UNAL S 和 OZTURK I H. 国际贸易委员会融入教师课堂实践的障碍：土耳其社会研究教师案例研究的经验教训。世界应用科学杂志，2012，18(7)：939-944。

[33] GIL-FLORES J、RODRÍGUEZ-SANTERO J 和 TORRES-GORDILLO J. 解释中等教育课堂中信息通信技术使用的因素：教师特征和学校基础设施的作用。人类行为中的计算机，2017，68：441–449。

[34] TAYLOR N 和 CORRIGAN G. 新南威尔士小学教师对信息通信技术在小学科学课程中的作用的看法——农村和区域视角。国际科学与数学教育杂志，2007，5(1)：85-109

[35] MASTAFI M. 在摩洛哥教育系统中整合信息和通信技术(信息通信技术)的障碍。Frantice.net，2014，50–65。http://dx.doi.org/10.18162/fp.2015.294

[36] CHEKOUR M、LAAFOU M 和 JANATI-IDRISSI R. 影响电力概念习得的因素。摩洛哥高中生案例，Adjectif.net，2015。http://www.adjectif.net/spip/spip.php?article354

[37] 贝塔。关于教师采用 ICT 的障碍的研究文献回顾，2004。https://dera.ioe.ac.uk/1603/1/becta_2004_barrierstouptake_litrev.pdf

[38] RIZZA C. 法国初始教师培训中的信息通信技术：国家案例研究，2009。https://www.oecd.org/france/46103639.pdf

[39] HEER S 和 AKKARI A. 教师对 ICT 的整合：瑞士调查的初步结果。国际高等教育技术杂志，2006，3(3)：38-48。

[40] KOH J H L 和 CHAI C S. 教师集群及其对通过信息通信技术课程设计开发技术教学内容知识(TPACK)的看法。计算机与教育，2014，70：222–232。

[41] LEE Y 和 LEE J. 通过备课实践增强职前教师对技术整合的自我效能信念。计算机与教育，2014，73：121-128。

[42] CARUGATI F. 和 TOMASETTO, C. 面对信息和通信技术的教学机构：不可避免的挑战。教育科学杂志，2002，28（2），305-324。

https://doi.org/10.7202/007356ar