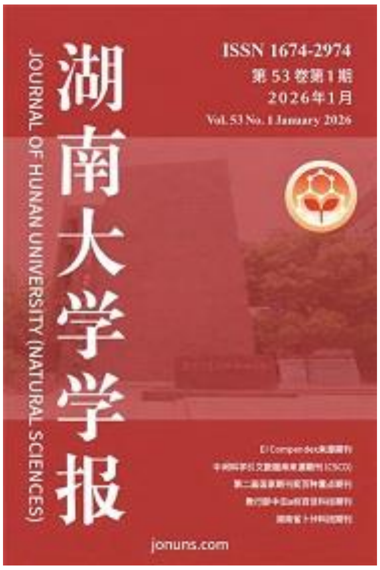

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Difficulties in teaching and learning mathematics in the first year of university: a case study

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Abstract: This study seeks to enhance mathematics teaching and learning by facilitating students' transition from secondary school to university. It provides an in-depth analysis of the mathematics curriculum from primary education through the first year of university, with particular emphasis on equations and related algebraic concepts.

The research adopts a mixed-methods design combining several complementary approaches: (1) a longitudinal analysis of school curricula to examine the progression of mathematical concepts across educational levels; (2) questionnaires administered to university instructors to explore their perceptions of students' learning difficulties and their pedagogical practices, particularly regarding the integration of Information and Communication Technologies (ICT); (3) a student questionnaire aimed at identifying perceived learning obstacles; and (4) a diagnostic test focused on equations to assess first-year students' prerequisite knowledge and competency levels.

The originality of this study lies in its systematic articulation of curricular content across educational stages, revealing discontinuities and conceptual gaps in the progression of mathematical knowledge. To our knowledge, this is the first study conducted in Morocco that integrates curriculum analysis, teachers' and students' perceptions, and an equation-based diagnostic assessment within a unified analytical framework. This comprehensive approach contributes to a deeper understanding of the structural causes underlying students' difficulties in mathematics and proposes concrete strategies to enhance academic achievement.

The findings provide valuable insights into critical learning bottlenecks and offer evidence-based recommendations for improving mathematics instruction and strengthening foundational competencies essential for sustained academic success.

Keywords: mathematics education; transition to university; curriculum analysis; learning difficulties; diagnostic assessment; information and communication technologies (ICT).

大学一年级数学教学与学习中的困难：案例研究

摘要：本研究旨在通过促进学生从中学向大学阶段的过渡，提升数学教学与学习的质量。研究对从小学教育到大学一年级的数学课程进行了系统而深入的分析，重点关注方程及相关代数概念。

本研究采用混合研究方法，综合运用多种互补路径：(1) 对各教育阶段数学课程进行纵向分析，以考察数学概念在不同学段之间的发展与衔接；(2) 通过向大学教师发放问卷，探讨其对学生学习困难的认知以及其教学实践，尤其是信息与通信技术（ICT）的整合情况；(3) 通过学生问卷识别其在学习过程中所感知的主要障碍；(4) 设计以方程为核心的诊断性测试，以评估大学一年级学生的先备知识与能力水平。

本研究的创新性在于系统性地构建不同教育阶段课程内容之间的衔接关系，从而揭示数学知识发展过程中存在的断层与概念性缺口。据我们所知，这是摩洛哥首个在统一分析框架下，整合课程分析、师生认知调查以及基于方程的诊断评估的研究。本研究有助于深入理解数学学习困难的结构性成因，并提出促进学业成功的具体改进路径。

研究结果为识别关键学习瓶颈提供了重要依据，并为优化数学教学与强化学生核心基础能力（以实现持续性学业成功）提供了循证建议。

关键词：数学教育；**大学**过**渡**；课**程分析**；**学**习**困**难；诊**断性**评**估**；**信息与通信技**术（ICT）

1. Introduction

As part of efforts to improve mathematics teaching and learning and promote mathematical and computer science literacy, several initiatives have been undertaken in Morocco by various researchers to identify the difficulties faced by first-year university students and propose remedial measures for a successful transition from secondary to higher education (Zerrour, 2023).

This study follows the same logic, but the originality of the work lies in the analysis of the mathematics curriculum from primary school to the first year of university, focusing on key concepts, in particular equations and related concepts.

This choice is explained by the fact that mathematics is a discipline based on hierarchy and interconnectivity. Moreover, in the mathematics curriculum, concepts are constructed according to a spiral and progressive logic (Eneau and al. 2008).

This study attempts to answer the first research question, which aims to identify the mathematical concepts that pose the most problems in the first year of university, as well as teaching practices, particularly those related to the integration of ICT (Nachit and al, 2017).

2. General methodology

Before identifying the difficulties encountered by first-year university students in mathematics, we felt it was essential to analyze the mathematics curricula from primary school to the first year of university to study the evolution of common concepts between the different cycles and streams.

We then developed a questionnaire for a sample of university teachers from the Faculty of Science and the National School of Applied Sciences at Ibn Tofail University in Kenitra. The aim was to identify the internal difficulties in teaching and learning mathematics in the first year of university, as well as their practices, particularly those related to the use of ICT.

In order to find out the views of first-year students on the mathematics teaching process and to identify the difficulties they encounter in learning mathematics, we developed a questionnaire that we administered to a sample group.

The results of the above work guided us in the development of a test on "equations." The objective of this test was to assess the level of the students participating in the experiment and to verify their prerequisites.

The choice of "equations" is motivated by the fact that this concept and the underlying notions are more explicit from middle school onwards and are developed progressively and spirally up to the first year of university.

2.1. Analysis of mathematics curricula:

2.1.1. Methodological elements

The analysis of mathematics curricula for primary school, middle school, and secondary school was based on educational guidelines.

The analysis of first-year university curricula was based on the descriptions of the Mathematical Sciences and Computer Science/Applied Mathematics (SMIA) and Physical and Chemical Sciences (SPC) programs.

2.1.2. Results and discussion:

The distribution of analysis and algebra courses in the first year of university, in the SMI and SPC programs, is presented in the figures below:

- Mathematical Sciences and Computer Science/Applied Mathematics (SMIA) program:

  ➢ First semester:

Table 1. Distribution of first-year university courses for the SMIA program in the first semester (Developed by the authors)

Algebra 1	Algebra 2	Analysis 1
• Logic • Sets • Correspondence and applications • Binary relations, equivalence relations, order relations • Arithmetic in Z • The ring Z/nZ and modular arithmetic	• Algebraic structures • Polynomials with one variable Rational fractions	• Real numbers • Topology of R • Order in R • Numerical functions • Limits of a function • Comparison in the vicinity of a point • Continuity • Differentiability

  ➢ Second semester:

Table 2. Distribution of first-year university courses for the SMIA program in the second semester (Developed by the authors)

Algebra 3	Analysis 2	Analysis 3
• Vector spaces • Generating vector families, free bases • Vector subspaces of IR • Linear equations • Linear applications • Matrices • Determinants	• Riemann integral • Calculation of primitives • Generalized integrals	• Taylor's formula and applications • Limited expansions • Plane parametric curves • Curves in polar coordinates

- Physical and Chemical Sciences (SPC) program:

  ➢ First semester:

Table 3. Distribution of first-year university courses for the SPC program in the first semester (Developed by the authors)

Algebra 1	Analysis 1
• Complex numbers • Polynomials • Rational fractions	• Numerical sequences • Limits and continuous functions • Derivatives of functions and some common functions • Limited developments

  ➢ Second semester:

Table 4. Distribution of first-year university courses for the SPC program in the second semester (Developed by the authors)

Algebra 1	Analysis 1
• Matrices – systems of linear equations • Vector spaces – linear applications • Matrices and linear applications • Determinants and their applications	• Riemann integral • Improper integral • Differential equations • Numerical series

The results of the study of the evolution of the concepts of "numbers, numerical calculations, equations, polynomials, integrals, statistics, functions, vectors, linear systems, powers, remarkable identities, and trigonometry" by year and by cycle, from primary school to university, are shown in the table below:

Table 5. Distribution of Basic mathematical concepts in the Moroccan curriculum and their evolution (Developed by the authors)

Number	Numbers are the first concept taught in mathematics in the first year of elementary school. They are linked to digits, counting, and other related concepts. In elementary school, students learn the numbers from 0 to 9, then to 99, then to 999, and finally to 99,999. Next, students learn about fractions and continue to study them through middle school, where they study relative numbers for the first time in the first year. They then could study rational numbers in the second year of middle school and are introduced to relative numbers, which are covered in more detail in the third year. In the core curriculum, students could study sets (N, Z, D, Q, and R) in a more theoretical way, and in the second year of the scientific baccalaureate, they learn about set C. Finally, at university, students in the SMA program study complex analysis.
Numerical calculation	This concept combines operations and proportionality. Primary school students first learn addition, then addition with carrying, then subtraction, then multiplication, and finally division. Thus, they are exposed to proportionality from the fifth year of primary school through the first year of secondary school.
Equations	Learners were implicitly exposed to equations without being given the name of the concept during primary school through problems, until they reached the first year of secondary school, where they learned about first-degree equations with a single unknown, which they studied throughout the cycle, as well as inequalities and systems. They continued in the qualifying cycle to learn about first-degree equations with two unknowns, second-degree equations, and differential equations. At the university level, SMA/I and SPC students continue to study matrix equations and polynomial equations of degree greater than 2 (approximation or numerical method).
Polynomials	Polynomials are the general case of equations. As mentioned above, students are already familiar with this concept, having studied literal calculation in their first year of middle school, but it remains implicit until their first year of high school. At university, SMA/I and SPC students continue to study this concept in algebra in their first year (solving p(x)=0 using numerical methods).
Integrals	The integral is related to surface area. Primary school students learn how to measure length and surface area, as well as their units and how to calculate perimeters and surface areas, up to the first year of middle school. In high school, students encounter this concept for the first time in their second year of high school and continue to study it in college, along with improper integrals and holomorphic functions.
Statistics	In elementary school, there are four math modules, including data organization and processing. Students learn how to organize data in a table and plot curves. In the first year of middle school, through the core curriculum, they learn how to do calculations in this area. In college, there are descriptive statistics, even two-dimensional statistics, and inferential statistics... depending on the course of study chosen.
Functions	This concept is studied from the third year of college through the second year of university as a function study. In their first year of university, students revisit this concept in detail. They learn about functions with multiple variables, holomorphic functions, and limited development.
	From the second year of middle school through the core curriculum, students study vector calculus and scalar products. In the first year of high school, they learn about barycenters, scalar products, and

Vectors	geometry in space. In the second year of high school, they continue to study scalar products and vector products. In college, they continue to learn about vector spaces and affine geometry.
Lenear Systems	From elementary school through the second year of high school, students only learn about equations (see previous lines). In the third year of high school, they encounter this concept for the first time and learn how to solve them up to the core curriculum. In college, students learn about linear systems.
Powers	Learners are exposed to this concept throughout middle school and continue to use it in the core curriculum and in subsequent years as a prerequisite.
Remarkable identities	From the first year of middle school through to the core curriculum, students learn this concept. In the first year of high school in the mathematics track and in the second year of high school in the other tracks, students study the identity $(a+b)^n$ in enumeration.
Trigonometry	This concept is taught from the second year of middle school through the first year of high school. In college, students learn trigonometric and circular functions.

3. Views and practices of university teachers

3.1. Target audience:

The target respondents are mathematics teachers who have taught or are still teaching first-year university students. The sample consists of 25 teachers from the Faculty of Science (FSK) and the National School of Applied Sciences at Ibn Tofail University in Kenitra (ENSAK).
The characteristics of the sample are shown in the table below:

Table 6. Characteristics of the sample of participating teachers (Developed by the authors)

Attributes	Characteristics	Workforce
Age group	30-40 years old	4/25
	41-50 years old	13/25
	51-65 years old	8/25
Seniority	Under 5 years old	3/25
	Between 5 et 10 years old	5/25
	Between 11 and 16 years old	10/25
	More than 17 years old	7/25
Home institution	FSK	20/25
	ENSAK	5/25

Most teachers who responded to the questionnaire work at the Faculty of Sciences in Kenitra.
Half of the sample belongs to the 41-50 age group, followed by the 51-65 age group. A minority of teachers are between 30 and 40 years old.
In terms of seniority, more than half of the teachers who responded have more than 11 years of experience.

3.2. Data collection tools:

The questionnaire distributed to teachers electronically consists of three items with a total of seven semi-open questions.
The first item includes two questions that focus on teachers' views on the level of first-year students in mathematics and the difficulties they encounter in the learning process.
The second item consists of four questions concerning teaching practices related to learning assessment methods and the use of ICT in education, and the last item is dedicated to teachers' suggestions for overcoming difficulties in learning mathematics.

3.3. Results:

As illustrated in the figure below and in response to the first question in the questionnaire, 37% of respondents consider the level of new high school graduates to be passable, and 23% consider it to be low. While 3% say that the level of these students is excellent, 10% consider it to be good, and 27% consider it to be fairly good.

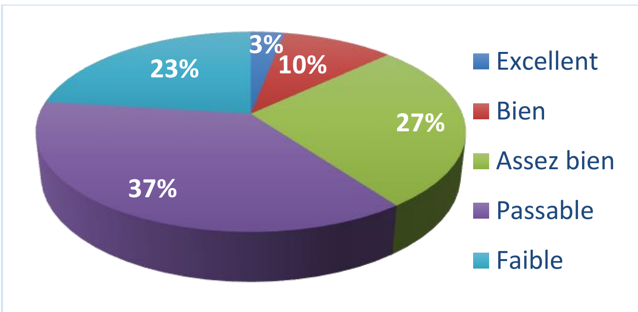

Figure 1. Opinions of participating teachers regarding the level of students (Developed by the authors)

Most teachers consider the level of first-year university students to be fair to poor.
Regarding the nature of the difficulties students encounter in learning mathematics, the results presented in the figure below, based on respondents' statements,

indicate that the majority of difficulties stem from prerequisite knowledge. Twenty-four percent of teachers believe that students have difficulty applying their knowledge. Fourteen percent cited a lack of autonomy, and 9% cited difficulty understanding instructions.

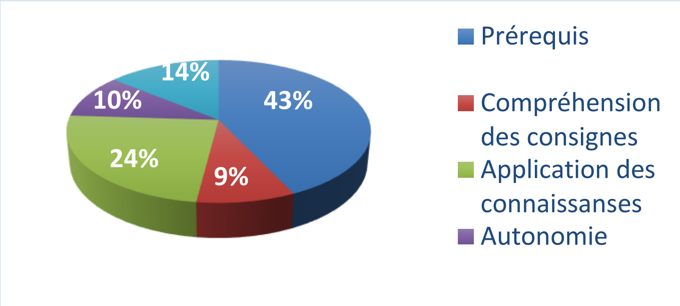

Figure 2. Causes of student weaknesses in relation to the modules studied (Developed by the authors)

Admittedly, a low level of prerequisites taught in secondary school and a limited level of taxonomy in terms of knowledge can only hinder the construction of new learning and the development of concepts already covered. Added to this is the problem of understanding instructions, autonomy, and motivation.

When asked about how they assess learning, 97% of respondents reported relying on written exams, 1% use project-based learning, 1% use multiple-choice questions, and 1% use presentations.

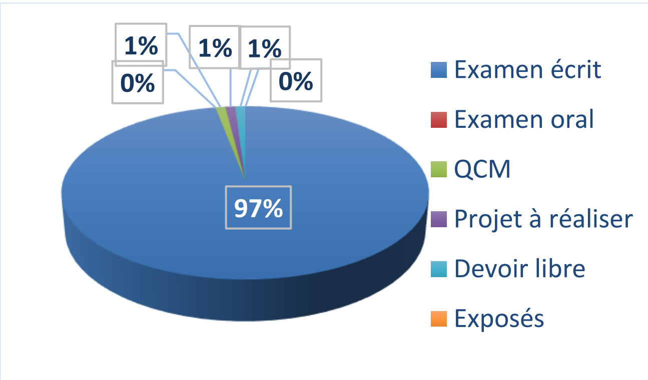

Figure 3. Assessment methods used by participating teachers (Developed by the authors)

This type of summative assessment does not promote an effective teaching and learning process in the absence of diagnostic and formative assessment. Moreover, in a context of mass effect, ICT could support teachers in these assessment processes.

Regarding teaching practices related to the integration of ICT in education, 57% of respondents say they do not use them in mathematics teaching:

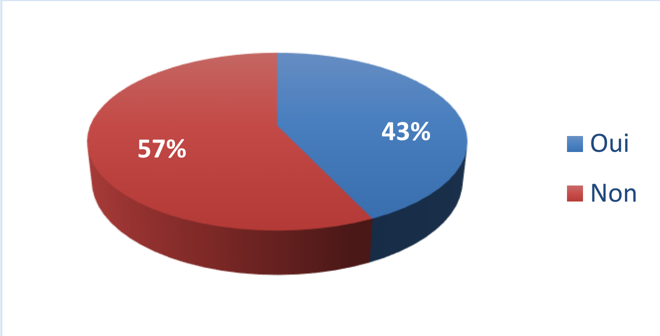

Figure 4. Distribution of teachers regarding the use of ICT in education (Developed by the authors)

Of the 43% who use ICT in education, almost all (96%) rely on PowerPoint presentations, and Data show 2% use the platform or a website, 1% use dynamic geometry software, and 1% use digital resources:

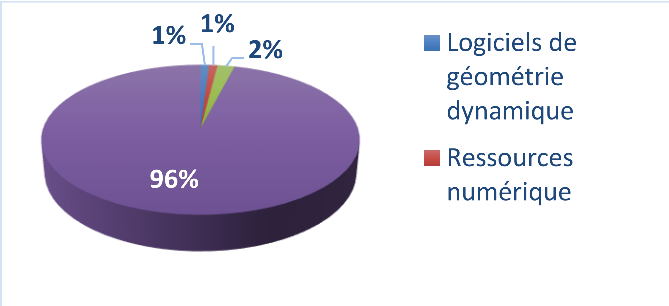

Figure 5. Types of technologies used by teachers (Developed by the authors)

Almost all respondents limit themselves to using presentation software, specifically Microsoft PowerPoint, and a video projector.

The use of dynamic geometry software and digital resources is virtually non-existent.

However, as shown in the figure below, 89% of teachers are aware of the benefits of integrating ICT in education to overcome difficulties in learning mathematics.

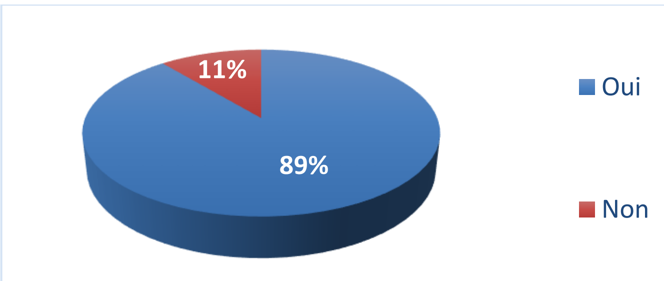

Figure 6. Teachers' opinions on the use of ICT in education (Developed by the authors)

In order to overcome the difficulties encountered in teaching and learning mathematics, 41% of respondents suggest revising teaching methods in the cycles prior to university. 30% call for a strengthening of prerequisites. 17% recommend increasing the number of hours allocated to modules, and 16% recommend organizing support and remedial sessions before the exam period.

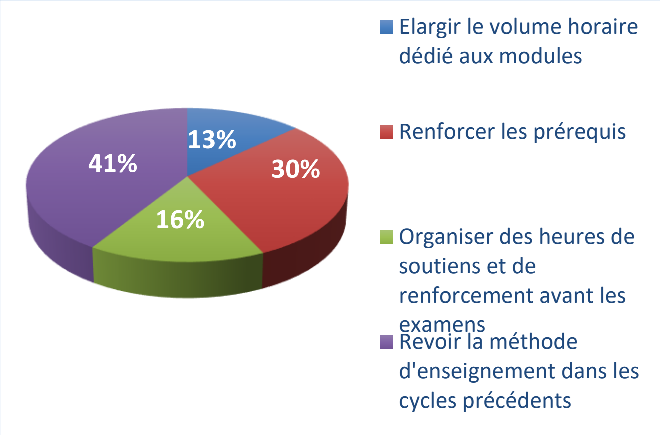

Figure 7. Teachers' suggestions for overcoming students' difficulties (Developed by the authors)

4. Students' views on the program

Teaching practices and difficulties in learning mathematics from the students' point of view.

4.1 Target audience

This study involved 100 first-year students at Ibn Tofail University in Kenitra, in the Mathematical Sciences and Computer Science/Applied Mathematics (SMIA) and Physical and Chemical Sciences (SPC) programs. 70% study at the Faculty of Sciences and 30% at the National School of Applied Sciences.
Characteristics of the sample:
As shown in the table, the majority of respondents are aged 17-18, 12% are aged 19, and 9% are aged 20.
Distribution of students by program:
The majority of study participants (68%) belong to the mathematical and computer science/applied sciences field. Meanwhile, 32% belong to the physical sciences field.

Table 7. Characteristics of the sample of participating students (Developed by the authors)

Attribut	Caracteristics	Percentage
Age	17 years old	11%
	18 years old	68%
	19 years old	12%
	20 years old	9%
field of study	Mathematical Sciences and Computer Science/Applied Mathematics (SMIA)	68%
	Physical and Chemical Sciences (SPC)	32%

4.2. Data collection tool

The questionnaire, developed and distributed to 100 students, consists of eight items with a total of nine semi-open questions.

Table 8. Description of the student questionnaire (Developed by the authors)

Items	Attribut	Number of questions
1	Self-assessment of students' math skills	1
2	Difficulties in learning mathematics	1
3	Teaching practices related to mathematics education from the students' perspective	5
4	Student opinions on the use of ICT in education	1
5	Proposal to improve mathematics teaching	1

4.3. Results

According to respondents' answers to the first question, 42% would rate their level as fair to poor, 34% as fairly good, 18% as good, and 6% as excellent:

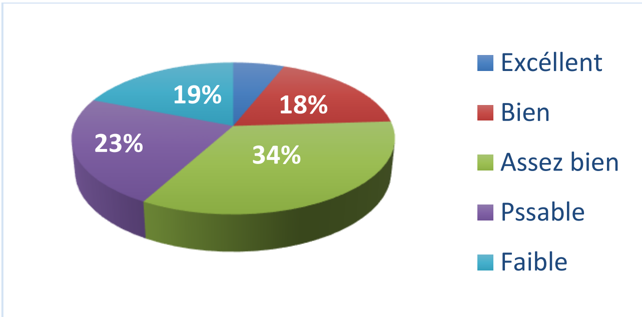

Figure 8. Distribution of students by level (Developed by the authors)

Regarding the difficulties encountered by students in mathematics, which we present in the figure below, 42% reported gaps in their prerequisite knowledge, 19% mentioned the issue of the language of instruction, 14% cited difficulties related to the application of knowledge and rules, and 11% reported difficulties in adapting to the methods used in higher education.

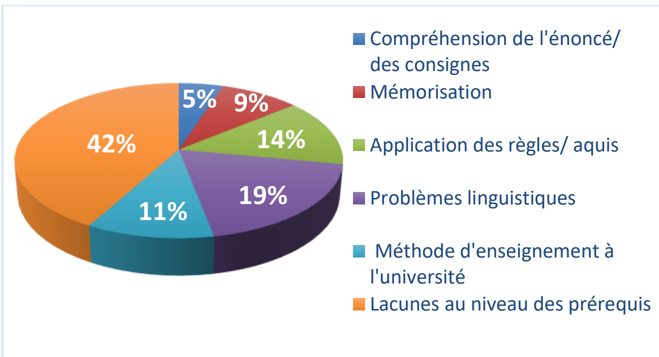

Figure 9. Difficulties encountered by students (Developed by the authors)

Teachers also raised the issue of the prerequisites necessary for learning development and the construction of new mathematical concepts, as well as the application of knowledge.

The results of the two questionnaires, one for teachers and one for students, validate the theory of a disconnect between high school and university.

This disconnect is also evident in the macro-didactic variables described by Bloch (2005) (Bloch. I, Ghedansi, I, 2005).

How does the secondary school curriculum prepare students for university studies?

We cite a few examples in the table below:

Table 9. Macro-didactic variables for measuring the discontinuity between high school and university (Developed by the authors).

Didactic variable	Secondary education	Early university
Degree of formalization	Low	High
Degree of generalization	Non	High
Introduction of new knowledge	Significant (but without specific theoretical validation tools)	Significant (with specific theoretical validation tools)
Degree of autonomy required (or sought)	Routines at technical levels and at most mobilizable	Little routine at more accessible levels
Mode of intervention of the concept	Process	Object
Status of exercise statements	Application, instantiation	Theorem, corollary, general statement

Regarding teaching practices, 84% of students report that mathematics teaching is based primarily on lectures and tutorials, 11% cite the use of digital resources, software, or applications, but only 5% mentioned the adoption of online support or platforms.

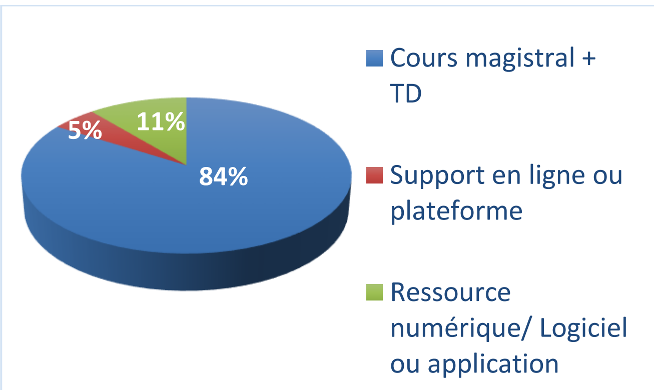

Figure 10. Teaching methods for the modules concerned, according to students (Developed by the authors).

The low rate of ICT use is confirmed by teachers. As illustrated in the following figure, written exams are mainly used as a means of assessing learning.

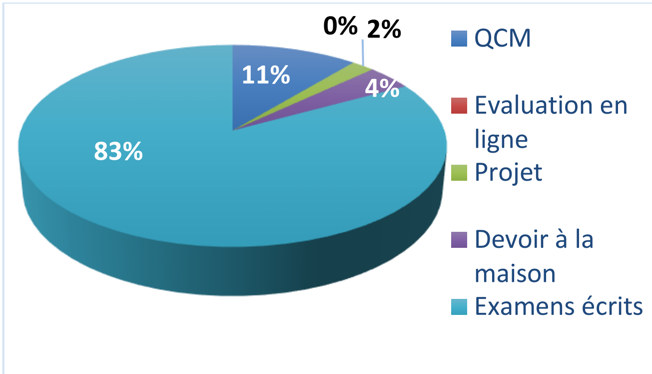

Figure 11. Students' assessment of the modules concerned (Developed by the authors).

In response to the item on the integration of ICT in education, the majority of students stated that teachers do not use ICT in mathematics teaching.

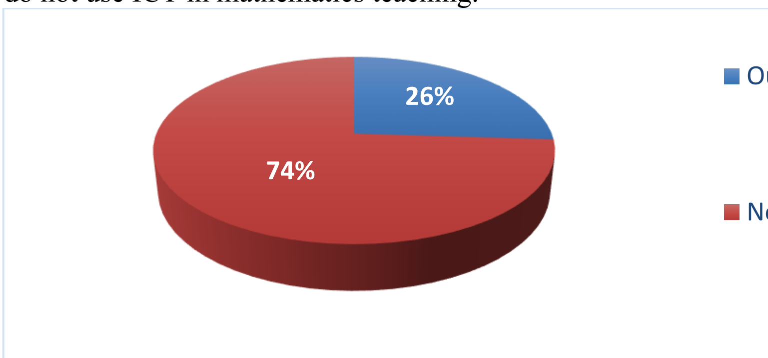

Figure 12. Use of ICT by teachers according to participating students

Those who do so mainly use Microsoft PowerPoint and certain dynamic geometry and spreadsheet software programs.

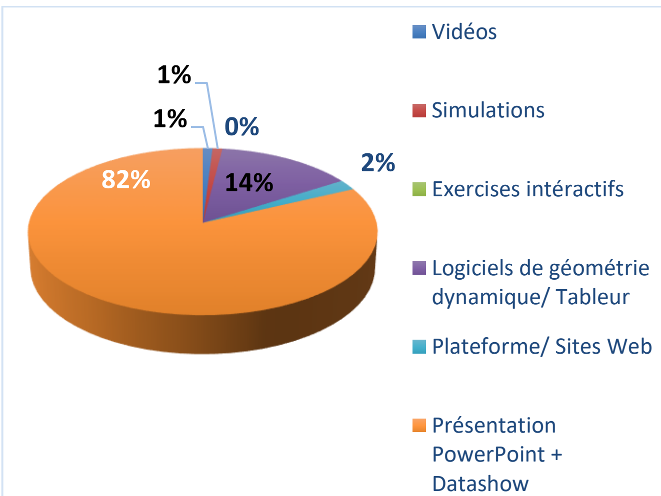

Figure 13. Types of ICT used by teachers according to participating students (Developed by the authors)

These statements are consistent with those of teachers, although the latter are aware of the benefits of integrating ICT in improving mathematics teaching. Moreover, 92% of students are convinced of the role that ICT can play in overcoming the obstacles encountered.

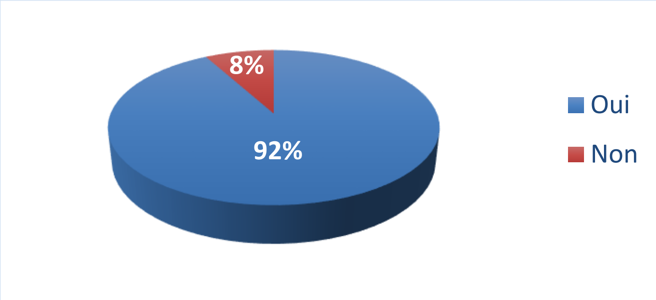

Figure 14. Opinions of participating students on the usefulness of ICT in education (Developed by the authors)

To overcome the difficulties of teaching and learning mathematics, respondents suggested strengthening prerequisites (51%), while 13% believed that teaching methods at university needed to be reviewed.

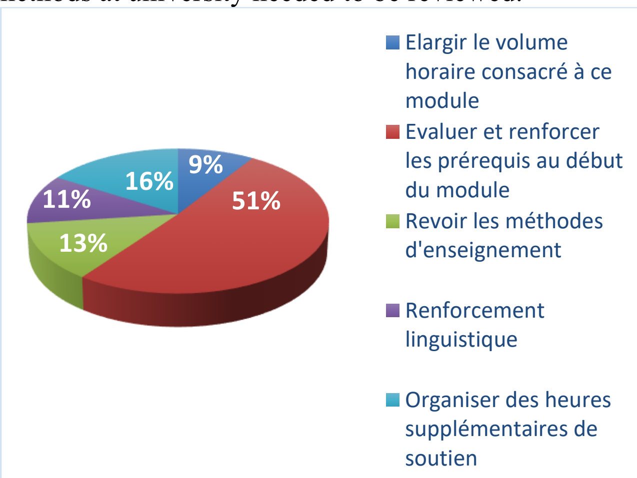

Figure 15. Solutions proposed by students (Developed by the authors)

These recommendations are particularly relevant in a context characterized by a lack of preparation among students for the transition from high school to university and for independence.

5. Assessment of student learning:

In order to assess first-year university students' learning of the concept of “equations” and related concepts, we developed a written test that we administered to the students who participated in the previous survey.

5.1. Target audience

The target participants are the students who responded to the previous questionnaire. The sample, therefore, includes 100 first-year university students from Ibn Tofail University in Kenitra.

5.2. Data collection tool

The test given to the student respondents is in the form of a multiple-choice questionnaire (MCQ) consisting of nine items with a total of nine questions, each with three to four choices (see Appendix 3). Each question aims to assess certain skills, and answering it requires several prerequisites, as shown in the table below:

Table 9. Excerpt from the test given to students responding from the SMIA and SPC programs (Developed by the authors)

Question	Capacity	Prerequisites
1	Solve a second-degree polynomial equation.	-Concept of roots. -The discriminant. -The relationship between roots.
2	Solve a third-degree polynomial equation.	-Concept of roots. -Euclidean division. -The discriminant. - The relationship between roots.
3	Solve a first-order differential equation.	-Concept of derivative. -Definition of the solution to an equation.
4	Solve an equation with an integer part.	-Concept of integer part. -Bounding.
5	Solve a second-order differential equation.	-Concept of derivative. -Definition of the solution to an equation. -Knowing how to solve a quadratic equation.
6	Solve an equation containing an exponential function.	-Algebraic properties of the exponential function. - Knowing how to solve a quadratic equation.
7	Solve an equation containing a logarithm.	- Algebraic properties of the ln function. - Knowing how to solve a quadratic equation.
8	Solve a linear system or a matrix equation.	- Methods for solving systems. - The concept of a matrix, determinant, and inverse of a matrix.
9	Solve a quadratic equation in C.	-Notion de racine. -Le discriminant. - La relation entre les racines.

5.3. Results:

The following graph shows the results of students in both programs:

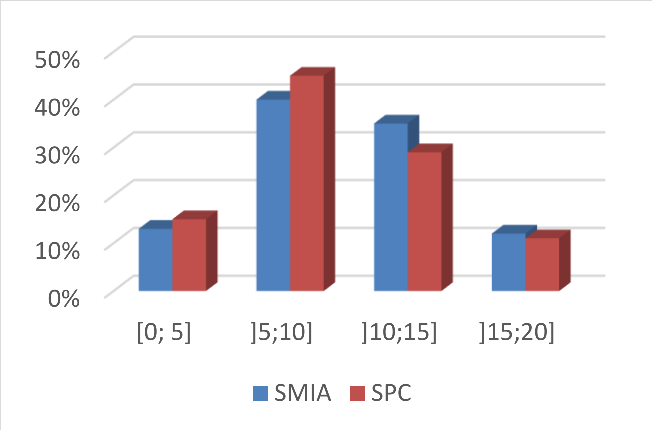

Figure 16. Results of students who responded to the test (Developed by the authors)

According to the test results, it appears that 53% of students in the SMIA program and 60% of students in the SPC program scored between 0 and 10.

5. Discussion

The results of the first questionnaire analysis validate those of studies conducted on the transition from secondary school to university, in particular, the problem related to the shortcomings of new high school graduates and teaching methods (ALAGUI and al, 2019). These findings apply not only to students enrolled in open-access institutions but also to ENSA. The field of study is not a determining factor either.

It should be noted that the integration of ICT could potentially contribute to improving the teaching of mathematics, such as dynamic geometry (Benkenza and al., Aydi and al.), and the use of a platform to overcome the constraints of mass teaching at the faculty.

In this context, analysis of the students' answers indicates that some encounter difficulties with concepts such as roots and polynomials, particularly when it comes to high-degree polynomials. In addition, understanding the fundamental theorem of algebra, which states that every non-constant polynomial has at least one complex root, also poses problems for most of the students tested.

Furthermore, it is noteworthy that many of them have difficulty solving equations involving the integer part and mastering the prerequisites associated with this concept.

The results also suggest that about half of the students in the sample have an insufficient understanding of the fundamental concepts necessary for solving equations. These concepts include arithmetic operations, number properties, and algebraic rules.

Regarding differential equations, some students seem to have difficulty fully grasping the concept of derivatives and their relationship to differential equations, as well as the general understanding of the concept of derivatives.

Finally, matrix systems and equations also posed difficulties, particularly regarding matrix manipulation. Students encountered obstacles when performing operations such as addition, subtraction, multiplication, and inversion of matrices, as well as when applying methods such as the Gauss method.

This shows that they are experiencing difficulties with this concept and its underlying notions and need solutions to overcome their difficulties.

6. Conclusion

The results of this study highlight persistent difficulties in teaching and learning mathematics, particularly during the transition to university and in solving equations. Data collected from teachers and students converge on the finding that these difficulties stem mainly from cumulative gaps in prerequisites and a heavy reliance on traditional transmissive methods. Although stakeholders recognize the potential of Information and Communication Technologies (ICT), their use remains superficial, limited mainly to presentation tools such as PowerPoint and video projectors. This gap between the recognized potential of digital teaching methods and their insufficient implementation highlights the need for systemic change.

By adopting a longitudinal curriculum analysis, this work makes an original contribution. Unlike studies that focus solely on gaps at the university level, our approach traces the conceptual evolution of fundamental concepts from primary school onwards, revealing discontinuities and insufficient reinforcement in national curricula. Cross-referenced testimonials from teachers and students confirm that weaknesses in prerequisites and a lack of pedagogical innovation are major obstacles to effective mathematics learning.

In order to address these challenges, it is recommended that educational authorities support the development of diagnostic and remedial modules focused on prerequisites, to be implemented from the outset of university mathematics programs. Institutions should invest in the continuous professional development of university teachers, going beyond simple ICT proficiency to train them in the use of interactive digital tools such as dynamic mathematics software or adaptive learning platforms, thereby promoting better conceptual understanding. It is also necessary to encourage a transition to hybrid learning environments, integrating the targeted use of technologies to visualize abstract concepts and provide formative feedback.

Future research should implement and evaluate the effectiveness of specific intervention strategies, such as gamified learning applications or flipped classroom models using dynamic mathematics software, in order to address identified gaps in prerequisites.

It would also be useful to examine the institutional and cultural barriers to more profound pedagogical change in the university context, to identify sustainable paths for innovation in mathematics education.

Declarations

Author Contributions

Conceptualization, Sounia. EL BAKKALI.; methodology, Sounia. EL BAKKALI. and Khadija. RAOUF.; software, Sounia. EL BAKKALI.; validation, Khadija. RAOUF, Mohammed BARKATOU; formal analysis, Sounia. EL BAKKALI.; investigation, Sounia. EL BAKKALI.; resources, Sounia. EL BAKKALI. and Youssef. KARIM.; data curation, Sounia. EL BAKKALI, writing—original draft preparation, Sounia. EL BAKKALI. writing—review and editing, Sounia. EL BAKKALI. and Khadija. RAOUF.; visualization, Youssef. KARIM.; supervision, Mohammed. BARKATOU; project administration, Khadija. RAOUF. and Mohammed. BARKATOU.;. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to [insert reason here].

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List of abbreviations and acronyms

Information and communications technology (ICT)
Faculty of Sciences in Kenitra (FSK)
National School of Applied Sciences at Ibn Tofail University in Kenitra (ENSA)
Physical and Chemical Sciences (SPC)
Mathematics and Computer Science/Applied Mathematics (SMIA)

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