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Learning Outcomes Assessment in Physical Sciences for the Moroccan Baccalaureate: An Approach Based on TIMSS Framework

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Abstract
The assessment of learning outcomes is an essential dimension of the educational process. It makes it possible to measure the degree of acquisition and development of learners' knowledge and skills, while supporting pedagogical practices in favor of quality teaching. In a context marked by the need to meet international standards, it becomes crucial to design tests that are both reliable and valid.
This article falls within this perspective by proposing a documentary study based on the analysis of the reference frameworks that govern the assessment practices of students' learning outcomes in physical sciences in Morocco. The adopted methodology relies on a critical analysis of the framework regulating the national unified baccalaureate exam in physical sciences (Experimental Sciences Division – French option), within a logic of certification assessment. It emphasizes the construction of a tool for analyzing baccalaureate exams in order to examine to what extent they comply with the prescriptions of the national reference framework, while drawing inspiration from the engineering of international surveys such as TIMSS.
The results reveal a divergence between the distribution of cognitive domains defined by the Moroccan reference framework, that of TIMSS, and the practices of inspectors responsible for test design. This comparative analysis shows an inconsistency that could explain the observed gap between students' performances in international standardized tests and their results in national exams.
Keywords: *Assessment – Learning Outcomes – Quality – Reference Framework – Baccalaureate – TIMSS.*

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I. INTRODUCTION

Quality education is an essential pillar of the school system for all pupils and students. This is why countries, including Morocco, are called upon to focus their efforts not only on the generalization of schooling but, above all, on the improvement of real learning outcomes and the results achieved.

The education system and human capital are two inseparable dimensions. Numerous studies highlight the importance of education as a determining factor in sustainable economic growth (Lucas, 1988; Nelson & Phelps, 1966). Indeed, when speaking of the school system, one inevitably refers to "human capital," which constitutes a fundamental lever for the socio-economic development of a country.

In Morocco, at the end of each educational cycle (primary, lower secondary, and upper secondary), certification assessments are organized in the form of regional or national exams. Each assessment test is built on the basis of a reference framework of learning outcomes, which precisely defines the targeted competencies, disciplinary content, and cognitive domains to be assessed. This reference framework ensures a balanced representativeness of content and objectives, generally presented in the form of a specification table.

The verification of the validity and reliability of the baccalaureate exams can be assimilated, in metrological terms, to a "calibration" operation. It consists of ensuring that the measuring instrument—in this case, the assessment tests—actually measures what it is supposed to measure and provides precise, consistent, and representative results of learners' achievements.

The second year of the baccalaureate constitutes a key stage: it represents a decisive transition between upper secondary education and university. The results obtained in this exam directly influence learners' academic future and career choices, conditioning access to certain competitive programs in higher education.

Hence, a central question arises: to what extent are the evaluation tests developed for the baccalaureate valid and reliable? Answering this question is essential to ensure that the results faithfully reflect the actual level of learners' acquisition and to guarantee a smoother transition between secondary and higher education.

This study focuses specifically on the baccalaureate program in physical sciences, Experimental Sciences Division – French option, in order to analyze the coherence between the national reference framework and international standards, particularly those of TIMSS.

II. THEORETICAL FRAMEWORK AND PROBLEM STATEMENT

1. Learning Outcomes

Over the past decades, the concept of learning outcomes has progressively established itself as a central pillar in international educational reforms. Unlike traditional approaches centered on teaching content, this perspective emphasizes what the learner is actually able to know, understand, and mobilize at the end of a learning process (Biggs & Tang, 2011).

Learning outcomes are thus defined as clear and observable statements that describe the knowledge, skills, and attitudes that a student must develop at the end of training. They translate pedagogical objectives into measurable results, ensuring better transparency and greater comparability of student performance at both national and international levels (CEDEFOP, 2017).

This approach represents a break from the pedagogy of simple transmission, since it aims to align teaching, learning, and assessment within a coherent framework (Anderson, 2002). The teacher is no longer just a transmitter of knowledge, but becomes a facilitator who designs learning situations allowing the student to demonstrate their achievements.

Moreover, learning outcomes serve as a pedagogical and institutional management tool. They are used not only to define curricula but also to design fairer and more rigorous evaluation systems. In this sense, international initiatives such as TIMSS and PISA are based on standardized learning outcomes in order to compare the performance of educational systems worldwide.

In short, the learning outcomes approach paves the way for a renewed vision of teaching–learning, centered on the development of complex skills, reasoning capacity, and the adaptability of learners in a constantly changing world.

2. Bloom's Taxonomy and Cognitive Domains

The reflection on learning outcomes cannot be separated from the question of the cognitive levels they mobilize. Since the pioneering work of Bloom et al. (1956), the classification of educational objectives has made it possible to organize teaching and assessment by distinguishing different hierarchical levels of cognitive complexity. The original Bloom's taxonomy identifies six levels, ranging from simple memorization of knowledge to critical evaluation and creation.

These works have profoundly influenced educational systems worldwide. Numerous adaptations and revisions have been proposed, notably that of Anderson and Krathwohl (2001), which reformulates the categories in terms of observable and measurable cognitive processes, and that of Biggs & Tang (2011), which stresses the pedagogical alignment between objectives, teaching, and assessment. In addition, researchers such as Gras (2002) have developed taxonomies specific to mathematics, highlighting stages of understanding, analysis, and creativity.

In the Moroccan context, Ministerial Note No. 15-118 (2015), concerning the French-option baccalaureate, adopts a model inspired by these works by classifying learning outcomes into three skill levels:

- **Knowing**: use of basic resources (symbols, laws, definitions, models, formulas), description and explanation of phenomena;
- **Applying:** implementation of experimental procedures, analysis and exploitation of data, interpretation of results;
- **Reasoning:** mobilization of resources to solve problems, construction of logical reasoning, and formulation of critical opinions.

This distribution reflects a willingness to integrate the cognitive dimension into certification assessment. However, as shown in our analyses, the weights attributed to each level (50% for "knowing," 15% for "applying," and 35% for "reasoning") are not explicitly justified by a clear methodology.

Finally, the TIMSS Advanced survey (IEA, 2015) also applies a three-part structure (knowing, applying, reasoning), confirming the international influence of this approach.

3. National and International Assessments: PNEA, TIMSS, PISA

Morocco has several large-scale assessment systems aimed at measuring students' learning outcomes and evaluating the quality of the education system.
At the national level, the National Program for the Evaluation of Learning Outcomes (PNEA), conducted by the National Evaluation Authority (INE) under the CSEFRS, provides regular diagnostics of school performance. The PNEA surveys have highlighted structural difficulties: overall weakness of learning outcomes, significant heterogeneity depending on regions and social environments, and a marked deficit in scientific subjects. These findings confirm that the assessment system does not always faithfully reflect students' actual levels, as pointed out in thematic reports of the CSEFRS.
At the international level, Morocco has participated since 1999 in TIMSS (Trends in International Mathematics and Science Study), which measures student performance in mathematics and science based on two dimensions: content and cognitive (knowing, applying, reasoning). The results of successive cycles have regularly placed Moroccan students among the lowest rankings, reflecting a significant gap between the national curriculum and international standards. Morocco also takes part in PIRLS (reading) and PISA (cross-disciplinary skills in sciences, reading, and mathematics), which confirm this trend of performance below the international average.

4. Research Context

The Moroccan education system organizes certification assessments at the end of each cycle, particularly the national unified baccalaureate exam, which constitutes a crucial stage in the academic journey of students. Beyond its certification value, the baccalaureate conditions access to higher education and guides the professional trajectories of graduates.
To ensure transparency and coherence in test development, the Ministry of National Education relies on reference frameworks designed and distributed by the National Center for Evaluation, Exams and Orientation (CNEEO). Ministerial Note No. 15-118 of November 4, 2015, governing the French-option baccalaureate, plays a decisive role since it specifies the learning objectives, defines the domains and subdomains of the subjects (physics and chemistry), and assigns percentages to content and cognitive levels ("knowing," "applying," "reasoning").
However, the distribution established by this framework does not provide any explanation regarding the methodology used to determine these percentages. In this sense, our work seeks to reconstruct this logic by drawing inspiration from the methodological engineering of TIMSS Advanced, in order to analyze the extent to which national exams actually comply with the reference framework.
Moreover, the combination of results from PNEA and international surveys such as TIMSS and PISA reveals a persistent inconsistency: although the scientific streams of the baccalaureate have recorded a success rate of around 70% for more than 15 years (statistics from the Ministry of National Education), the results of Moroccan students in TIMSS and PNEA remain well below the international average.

III. PROBLEM STATEMENT

For more than two decades, international (TIMSS, PISA, PIRLS) and national (PNEA) assessments have revealed the persistent weakness of Moroccan students' achievements, particularly in scientific subjects, with results significantly below the international average. Yet, at the national level, success rates in the scientific baccalaureate remain high, around 70% for over fifteen years.
This contradiction raises questions about the validity and reliability of the evaluation systems used: how can it be explained that students succeed massively in national certification exams while achieving very poor results in standardized international surveys?
This contradiction also raises a central question: do these two types of evaluation (national exams and standardized surveys) really measure the same learning outcomes? To what extent do national exams, particularly the physical sciences baccalaureate, comply with official reference frameworks and align with international recommendations? Do national baccalaureate exams in physical sciences really measure the same learning outcomes as those targeted by standardized evaluations such as TIMSS Advanced?
To address this issue, our study relies on a critical analysis of the reference framework for Moroccan national exams, compared with the "TIMSS Advanced 2015 Physics Framework."

Research Questions

- Do the baccalaureate exams in physical sciences comply with the recommendations of the national reference framework and TIMSS Advanced?

- What discrepancies exist between the learning outcomes assessed by the baccalaureate and those measured by standardized national and international evaluations?
- To what extent do teachers' and inspectors' practices and experiences influence the design of exam papers?

IV. METHODOLOGY

1. General Approach

The methodology adopted in this work is based on the engineering of international surveys, particularly TIMSS Advanced, in order to analyze the compliance of Moroccan baccalaureate exams in physical sciences with the national reference framework. The objective is to construct an analytical tool that makes it possible to identify to what extent these exams respect the standards set by the Ministry and to understand the discrepancies observed with international benchmarks.

2. Sources and Reference Frameworks Used

Our study relied mainly on:

- **Ministerial Note No. 15-118 (2015)**, which defines the reference framework of the baccalaureate exams (French option), specifying the domains and subdomains of physics-chemistry as well as their respective weightings;
- **The specification table** attached to this reference framework, indicating the percentages assigned to each cognitive skill level ("knowing," "applying," "reasoning") with explanations of their components:

Table 1: The specification table

Skill Level	Components	Weight
Use of resources (knowledge and know-how)	▪ Know and use: symbols - conventions - units - order of magnitude - definitions - laws - principles - models - formulas - relationships... ▪ Describe and explain a phenomenon. ▪ Predict the evolution of a physical phenomenon or a chemical system.	**50%**
Application of an experimental solution	▪ Propose an experimental protocol. ▪ Draw a diagram of an experimental set-up. ▪ Distinguish between the different parts of an experimental set-up and determine the function of each part. ▪ Use experimental data, analyze them and draw conclusions. ▪ Anticipate possible hazards in experimental situations and use appropriate safety precautions.	**15%**
Problem solving	▪ Mobilize the necessary resources. ▪ Organize solution steps. ▪ Use mathematical tools, curves and tables. ▪ Construct or prove a logical deduction. ▪ Describe and analyze scientific data or results; present practical conclusions. ▪ Give an opinion or express a critical view.	**35%**

The TIMSS Advanced 2015 framework, which served as a comparative reference to adapt and reconstruct the weighting of subdomains, focusing exclusively on "physics." This framework structures learning outcomes according to two dimensions:

- Content dimension (disciplinary domains and subdomains)
- Cognitive dimension (skill levels: knowing, applying, reasoning).

3. Adaptation of the Reference Framework

The first step consisted of adjusting the weights and proportions of the subdomains in order to restrict the analysis to the physics domain only (since the national framework also includes chemistry). This made it possible to recalculate the percentages of each subdomain (waves, nuclear transformations, electricity, mechanics), taking into account the cognitive skill levels.

4. Assignment of Items to Cognitive Levels

Each program element was associated with “knowing,” “applying,” or “reasoning,” in accordance with the explanation of the components of each skill level as defined in the specification table.

5. Validation

To ensure the scientific rigor of the analysis, a workshop was organized at the National Center for Evaluation, Exams, and Orientation (CNEEO) with the participation of 16 physics-chemistry inspectors from different regional academies. The inspectors were invited to classify the items of the reference framework into the three proposed cognitive levels (“knowing,” “applying,” “reasoning”). This step aimed to obtain an expert consensus on the categorization of learning outcomes and to strengthen the credibility of the work of associating each item with the adopted cognitive levels.

6. Data Processing and Filtering

The inspectors’ responses were then subjected to a multi-step treatment procedure:

- **Elimination of duplicates**: certain responses were identical (inspectors 1 and 9; inspectors 8 and 12) and were considered as one.
- **Correction of inappropriate attributions**: incoherent or manifestly erroneous responses (especially regarding “knowing” items) were excluded.
- **Handling of ambiguous items**: for certain items where no consensus emerged, data were neutralized to avoid bias.
- **Global analysis**: collective treatment determined the number of inspectors who assigned each item to a specific cognitive level.

V. RESULTS

At the end of these steps, we compared:

- The weightings set by **TIMSS Advanced,**
- Those defined by **the Moroccan reference framework**,
- And those resulting from **the inspectors’ classifications.**

1. Adaptation of the Reference Framework Weightings

Adjusting the Moroccan reference framework to include only the physics subdomains made it possible to recalculate the respective weights. For example, mechanics now represents 40% of the total, followed by electricity (31%), waves (16.5%), and nuclear transformations (12%). These results show a strong weighting given to classical physics content, to the detriment of more recent areas such as nuclear physics.

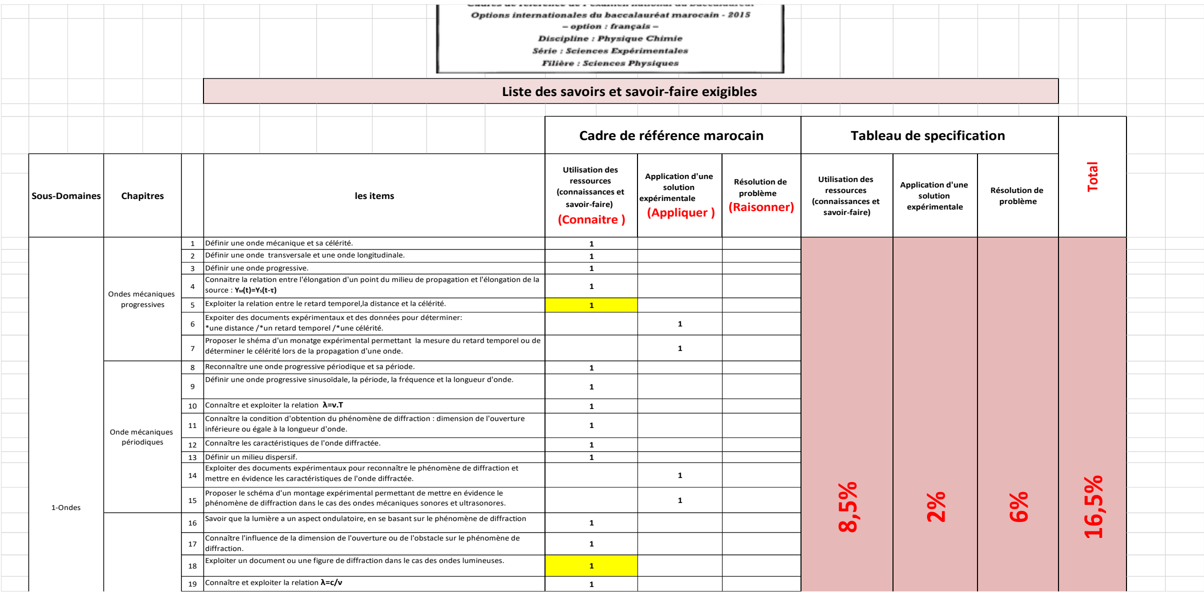
Table 2: Initial table

Domain	*Subdomain*	*Skill levels*			*Total*
		Know	Apply	Reason	
PHYSICS	Waves	5 ,5%	1.65%	3.85%	11%
	Nuclear transformation	4%	1.2%	2.80%	8%
	Electricity	10,5%	3.15%	7.35%	21%
	Mechanics	13,5%	4.05%	9.45%	27%
	Total	33,5%	10%	23.45%	67%

Tableau 3: Calculates the weight and percentage of the main area of physical matter:

Domain	***Subdomain***	***Skill levels***			***Total***
		Know	**Apply**	**Reason**	
PHYSICS	**Waves**	**8.5%**	**2%**	**6%**	**16.5%**
	Nuclear transformation	**6%**	**2%**	**4%**	**12%**
	Electricity	**15.5%**	**5%**	**11%**	**31%**
	Mechanics	**20%**	**6%**	**14%**	**40%**
	Total	**50%**	**15%**	**35%**	**100%**

2. Assignment of Items to Cognitive Levels



Cadres de référence de l'examen national du baccalauréat
Options internationales du baccalauréat marocain - 2015
– option : français –
Discipline : Physique Chimie
Série : Sciences Expérimentales
Filière : Sciences Physiques

Liste des savoirs et savoir-faire exigibles

Sous-Domaines	Chapitres		les items	Cadre de référence marocain: Utilisation des ressources (connaissances et savoir-faire) (Connaitre)	Application d'une solution expérimentale (Appliquer)	Résolution de problème (Raisonner)	Tableau de specification: Utilisation des ressources (connaissances et savoir-faire)	Application d'une solution expérimentale	Résolution de problème	Total
1-Ondes	Ondes mécaniques progressives	1	Définir une onde mécanique et sa célérité.	1			8,5%	2%	6%	16,5%
		2	Définir une onde transversale et une onde longitudinale.	1						
		3	Définir une onde progressive.	1						
		4	Connaitre la relation entre l'élongation d'un point du milieu de propagation et l'élongation de la source : $Y_M(t)=Y_S(t-\tau)$	1						
		5	Exploiter la relation entre le retard temporel,la distance et la célérité.	1						
		6	Expoiter des documents expérimentaux et des données pour déterminer: *une distance /*un retard temporel /*une célérité.		1					
		7	Proposer le shéma d'un monatge expérimental permettant la mesure du retard temporel ou de déterminer le célérité lors de la propagation d'une onde.		1					
	Onde mécaniques périodiques	8	Reconnaître une onde progressive périodique et sa période.	1						
		9	Définir une onde progressive sinusoïdale, la période, la fréquence et la longueur d'onde.	1						
		10	Connaître et exploiter la relation $\lambda=v.T$	1						
		11	Connaître la condition d'obtention du phénomène de diffraction : dimension de l'ouverture inférieure ou égale à la longueur d'onde.	1						
		12	Connaître les caractéristiques de l'onde diffractée.	1						
		13	Définir un milieu dispersif.	1						
		14	Exploiter des documents expérimentaux pour reconnaître le phénomène de diffraction et mettre en évidence les caractéristiques de l'onde diffractée.		1					
		15	Proposer le schéma d'un montage expérimental permettant de mettre en évidence le phénomène de diffraction dans le cas des ondes mécaniques sonores et ultrasonores.		1					
		16	Savoir que la lumière a un aspect ondulatoire, en se basant sur le phénomène de diffraction	1						
		17	Connaître l'influence de la dimension de l'ouverture ou de l'obstacle sur le phénomène de diffraction.	1						
		18	Exploiter un document ou une figure de diffraction dans le cas des ondes lumineuses.	1						
		19	Connaître et exploiter la relation $\lambda=c/v$	1						

Figure 1: Assignment of Items to Cognitive Levels (Our Analysis based on CDR)

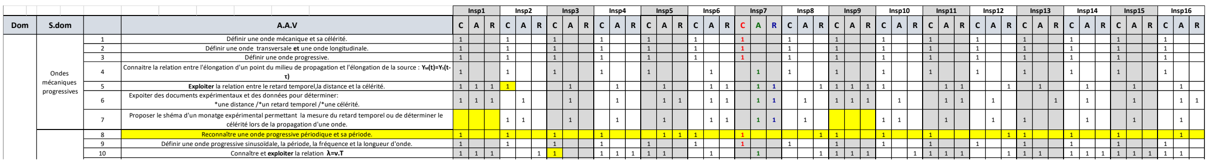


Figure 2: Assignment of Items to Cognitive Levels (Inspectors)

The classification of items, after filtering and elimination of anomalies, revealed important trends:

- An **overemphasis on the "knowing" level** (46% on average according to inspectors, 64% according to our own analysis),
- An **under-representation of the "applying" level** (between 16% and 36%),
- A **marginalization of reasoning** (only 18% to 20%).

3. International Comparison

Tableau 4 the differences between the distribution of cognitive domains

	TIMSS Adv	***The Moroccan reference framework "CDR"***	***INSPECTORS***	***Our Analysis (based on CDR)***
know	**30%**	**50%**	**46%**	**64%**
Apply	**40%**	**15%**	**36%**	**16%**

Reason	30%	35%	18%	20%

The graph below illustrates the major differences between the distribution of cognitive domains in TIMSS Advanced, the Moroccan reference framework, the practices reported by inspectors, and our calculations based on the Moroccan framework.

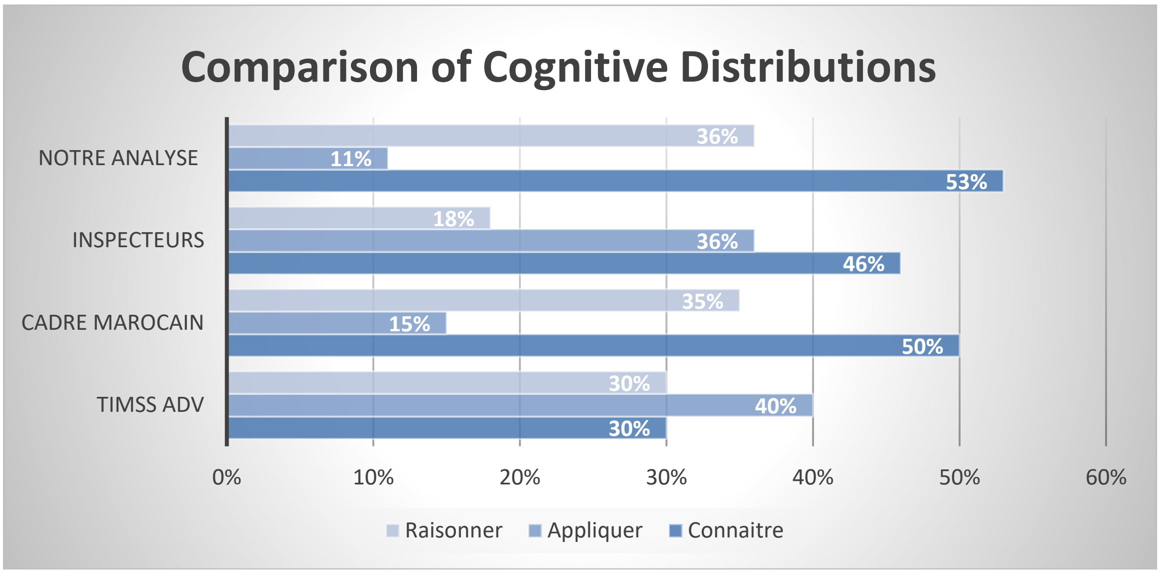


Figure 3: Comparison of Cognitive Distributions

It shows that:

- TIMSS proposes a **balanced distribution** (30% knowing, 40% applying, 30% reasoning),
- The Moroccan framework **heavily favors "knowing"** (50%),
- Inspectors confirm this trend (46%), while giving less space to reasoning,
- Our calculations even amplify this shift (64% knowing).

4. Initial Interpretation

These results suggest a structural incompatibility between international standards and national practices:

- Moroccan baccalaureate assessments emphasize **knowledge recall**,
- Whereas TIMSS emphasizes **application and reasoning**,
- This may partly explain the contradiction between the high pass rates in the baccalaureate and the weak performances in international assessments.

VI. DISCUSSION

The results obtained highlight a significant discrepancy between the national reference framework of the Moroccan baccalaureate, the actual practices of exam designers (inspectors), and international evaluation standards. This discrepancy calls for several interpretations.

1. The Predominance of "Knowing"

The analysis showed that the "knowing" level is overrepresented in the baccalaureate exams, reaching up to 64% of the items in our own calculations. This trend confirms an orientation of the tests toward the reproduction of knowledge, to the detriment of its mobilization and transfer. Yet, according to Bloom (1956) and later revisions, learning outcomes should not be limited to simple memorization but should also develop application and reasoning skills.

This predominance of "knowing" reflects a traditional vision of science education, centered on disciplinary content, whereas international surveys such as TIMSS prioritize the ability to solve problems and apply knowledge in new contexts.

2. The Role of Exam Designers

The gap between the official prescriptions (50% knowing, 15% applying, 35% reasoning) and the actual results indicates that exam designers, as former teachers, tend to project their own pedagogical practices into exam construction. This leads to two possible hypotheses:
exam designers may consider the reference framework as an indicative guideline rather than a binding norm, professional culture acquired through years of teaching exerts a stronger influence on their choices than official directives.
Thus, exam design in Morocco does not appear as a mere technical alignment with the prescribed framework but rather as a compromise between normative standards and professional habitus.

3. The Contradiction Between National Exams and International Evaluations

The contrast between high success rates in national exams (around 70% for more than 15 years) and weak performances in international surveys suggests that the two systems measure different types of competencies. This contradiction gives rise to several interpretations:

- national exams mainly validate conformity to the official curriculum, without ensuring students' ability to mobilize their knowledge in new situations,
- success in the baccalaureate does not necessarily reflect the development of higher-order competencies expected at the international level,
- this divergence creates a misleading image of the performance of the Moroccan education system, combining internal success with external failure.

VII. CONCLUSION

The objective of this research was to analyze the validity and reliability of Moroccan baccalaureate exams in physical sciences through the lens of learning outcomes. By drawing on both the national reference framework (Ministerial Note No. 15-118) and the methodological engineering of TIMSS Advanced, we were able to design an analytical tool that compares official prescriptions, the actual practices of exam designers, and international standards.

The results highlight three major findings:
1. The overrepresentation of the "knowing" level,
2. The influence of inspectors' professional practices,
3. The contradiction between high pass rates in the baccalaureate and poor performance in international surveys.

The main contribution of this work lies in exposing this inconsistency and proposing a methodological approach inspired by TIMSS to reconstruct a reference framework more closely aligned with international standards. This framework can serve as a steering tool for harmonization. Such harmonization should not be limited to a mere technical adjustment of percentages but should involve a comprehensive reflection on the purpose of evaluation, its role in student training, and its contribution to improving the quality of learning.

In short, while national exams remain indispensable for certifying learning outcomes, their alignment with international standards is an unavoidable condition for ensuring the credibility of the Moroccan education system and for improving the quality of scientific learning.

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