STEM INTEGRATION IN MOROCCAN SECONDARY SCHOOLS: TEACHERS' PERSPECTIVES ON BARRIERS AND ENABLERS

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Abstract

This paper outlines the main aspects of a project focusing on STEM (Science, Technology, Engineering, and Mathematics) education in Moroccan schools. Although STEM subjects are now part of the national curriculum, little is known about how STEM teaching is actually implemented in this context, particularly regarding the factors that facilitate or hinder its integration. To explore how teachers incorporate STEM-based teaching in Moroccan schools (as self-reported), we surveyed science and technology teachers working in middle and high schools across the country. A convenience sample of 51 teachers was formed, and in the spring of 2022, participants completed an online questionnaire on STEM teaching. Using NVivo software, we conducted an interpretive qualitative analysis of the collected data.

While the majority of respondents reported integrating STEM into their teaching, the findings reveal significant structural and pedagogical challenges, including limited access to resources, large class sizes, and disciplinary fragmentation. At the same time, they highlight key enabling factors, such as improved working conditions, stronger interdisciplinary coordination, and expanded professional development opportunities. These results underscore the need for systemic support to facilitate the effective integration of STEM education within the Moroccan context.

Keywords:
STEM education – Morocco – Teacher perceptions – Self-reported practices – Barriers – Enabling factors – Interdisciplinary teaching – Educational integration – Working conditions – Professional development

Résumé

Cet article présente les principaux aspects d'un projet portant sur l'enseignement des STEM (Sciences, Technologie, Ingénierie et Mathématiques) dans les écoles marocaines. Bien que les disciplines STEM fassent désormais partie du curriculum national, on sait encore peu de choses sur la manière dont cet enseignement est réellement mis en œuvre dans ce contexte, notamment en ce qui concerne les facteurs qui facilitent ou entravent son intégration. Afin d'explorer la manière dont les

enseignants intègrent l'enseignement fondé sur les STEM dans les écoles marocaines (selon leurs déclarations), nous avons mené une enquête auprès d'enseignants de sciences et de technologie exerçant dans des collèges et lycées à travers le pays. Un échantillon de convenance de 51 enseignants a été constitué et, au printemps 2022, les participants ont été invités à répondre à un questionnaire en ligne portant sur l'enseignement des STEM. À l'aide du logiciel NVivo, nous avons réalisé une analyse qualitative interprétative des données recueillies.

Bien que la majorité des répondants aient déclaré intégrer les STEM dans leur enseignement, les résultats révèlent des défis structurels et pédagogiques importants, notamment l'accès limité aux ressources, les classes surchargées et le cloisonnement disciplinaire. Parallèlement, ils mettent en évidence des leviers essentiels, tels que l'amélioration des conditions de travail, le renforcement de la coordination interdisciplinaire et le développement d'opportunités de formation continue. Ces résultats soulignent la nécessité d'un soutien systémique afin de favoriser une intégration efficace de l'enseignement des STEM dans le contexte marocain.

Mots-clés :
Éducation STEM – Maroc – Perceptions des enseignants – Pratiques auto-déclarées – Obstacles – Facteurs facilitants – Enseignement interdisciplinaire – Intégration pédagogique – Conditions de travail – Développement professionnel

I. INTRODUCTION

STEM education (Science, Technology, Engineering, and Mathematics) has been receiving increasing attention from the international research community. In their systematic review of publications on the topic from 2011 to 2020, Irwanto et al. (2022) noted that "[…] the number of publications related to STEM education appears to have grown rapidly over the past decade, despite uneven contributions from countries around the world" (Irwanto et al., 2022, p. 29). These authors ranked the top 15 countries with the most publications on the subject and observed that no African country appeared on the list. While Morocco is no exception in this regard, a number of recent publications have emerged on STEM education in the country (e.g., Britel & Cherkaoui, 2021; Lechhab et al., 2023; Margoum et al., 2023; Benrherbal & Rioux, 2024). Despite this emerging body of work—and although STEM subjects are now part of the national curriculum in Moroccan schools—there remains little knowledge about how STEM education is being implemented in the Moroccan context. Are Moroccan teachers integrating STEM into their teaching? How do they conceptualize STEM education? What conditions, according to them, facilitate or hinder the implementation of STEM in Morocco? These were the initial questions that guided our inquiry.

While STEM is gaining traction globally, African countries—Morocco included—remain underrepresented in implementation studies. Our research addresses this critical gap by focusing on teachers' first-hand accounts.

In this article, we begin by outlining the problem we address: a lack of understanding regarding the perceived barriers and supports to integrating STEM in Moroccan schools, as reported by teachers themselves. We then present the conceptual

framework grounding our approach, including our definition of an "integrated approach to STEM teaching." Next, we state our research objectives and provide methodological details, including information on sample composition, data collection, and analysis. We then present and discuss the findings related to our third objective. While the majority of respondents reported incorporating STEM into their teaching, our results highlight the importance of improving working conditions for teachers (available resources and class sizes), fostering interdisciplinary coordination, and providing professional development opportunities. We conclude by discussing the implications and limitations of our findings.

II. PROBLEM STATEMENT

Britel and Cherkaoui (2021) recently questioned whether the Moroccan education system is ready to integrate STEM and, to explore this question, conducted a focus group composed of school principals, administrators, STEM teachers, parents, and actors involved in children's STEM activity centers. Overall, the ten experts consulted believed that Morocco was indeed ready and made the following recommendations:

- The engagement of all stakeholders in effective communication and a collaborative approach.
- The development of a relevant curriculum based on best practices in integrated STEM and aligned with labor market needs.
- Providing STEM teachers with adequate support, professional development, training, and resources.
- Establishing partnerships and securing industry support to create better learning opportunities for students (adapted from Britel & Cherkaoui, 2021, p. 6061).

While these recommendations appear relevant, they provide limited insight into how integrated STEM teaching is perceived by Moroccan teachers themselves. What obstacles do they face? What factors support the integration of STEM? Are Moroccan teachers encountering the same challenges as their peers in other countries?

Margot and Kettler (2019) conducted a systematic review of studies addressing teachers' perceptions of STEM integration. They examined 29 peer-reviewed articles published between 2000 and 2017. Their findings highlighted both barriers and challenges to STEM integration, as well as supporting factors. Table 1 provides a summary.

Barriers and Challenges to Integration	**Supports for Integration**
Pedagogical challenges	Collaboration
Curricular challenges	Curriculum
Structural challenges	Administrator support
Student-related considerations	Teachers prior experiences
Time constraints, assessment tools, and subject knowledge	Professional development opportunities

Table 1 – Barriers, challenges, and supports for STEM integration identified by Margot and Kettler (2019)

While Margot and Kettler (2019) offer valuable insights into teachers' perceptions of STEM integration globally, we currently lack information on whether Moroccan teachers share these views. In our opinion, it is essential to directly engage with teachers to better understand how STEM education is being implemented in Moroccan schools and to identify ways to support their practice.

III. CONCEPTUAL FRAMEWORK

Although STEM refers to a group of disciplines, simply teaching one of these subjects—such as mathematics—does not suffice to qualify as an integrated STEM approach. As noted by Martín-Páez and collaborators (2019), defining this teaching approach is no easy task. In their literature review, the authors identified inconsistencies in how integrated STEM is conceptualized. Nevertheless, in most studies reviewed, integrated STEM teaching referred to:

- a learning experience that incorporates all four STEM disciplines (Science, Technology, Engineering, and Mathematics).
- in which engineering plays a central role.
- and that typically involves the use of real-world technological contexts (adapted from Martín-Páez et al., 2019, p. 815).

For the purpose of our study, we adopted the definition proposed by Kelley and Knowles (2016), who describe integrated STEM as "[…] an approach to teaching STEM content through two or more STEM domains, connected by STEM practices in an authentic context, with the goal of linking these subjects to improve student learning" (adapted from Kelley & Knowles, 2016, p. 3). Thus, when we refer to "STEM-based teaching," we mean an interdisciplinary teaching approach that integrates content from at least two STEM subjects.

IV. OBJECTIVES

To gain a deeper understanding of how STEM-based teaching is integrated in Moroccan schools, we formulated three research objectives:

1. To explore how teachers in Moroccan schools conceptualize STEM-based teaching.
2. To identify, from the teachers' perspective, the resources required to implement STEM-based teaching in Moroccan schools.
3. To examine how teachers integrate STEM-based teaching in Moroccan schools (self-reported practices).

In this paper, we report on the findings related to the third objective.

V. METHODOLOGY

This section presents key elements related to the methodology used to construct our sample, collect data, and carry out the analysis.

1. Sample

Since our aim was to better understand the integration of STEM-based teaching in Moroccan schools—and specifically to gather teachers' perspectives—we formed a convenience sample composed of 51 science or technology teachers working in middle or high schools in various regions of Morocco. These teachers voluntarily agreed to respond to an online questionnaire on STEM teaching in the spring of 2022.

It is important to note that, as a convenience sample, the results may not be generalizable. Additionally, participants may have been more likely to engage with STEM, which could introduce a social desirability bias.

2. Data Collection

As mentioned above, during the spring of 2022, we invited the participants in our study to complete an online questionnaire focused on STEM teaching. The questionnaire included 12 questions, five of which were specifically designed to explore how teachers integrate STEM-based teaching in Moroccan schools (our third objective). These five questions were as follows :

- Do you integrate this type of teaching into your professional practice?
- How do you integrate STEM into your teaching?
- How frequently do you use this type of teaching?
- In your view, what hinders the integration of STEM-based teaching in your professional context?
- In your view, what would facilitate the implementation of STEM teaching in your professional context?

These questions allowed us to access both teachers' self-reported STEM teaching practices and their perceptions of the facilitators and barriers to STEM integration in their educational settings.

2. Data Analysis

We conducted an interpretive qualitative analysis of the data collected. The data analysis process began with the import of the raw responses into the qualitative analysis software NVivo. We then created a case for each respondent (a total of 51 cases). The responses were coded according to the corresponding question. We analyzed each question independently to identify emerging themes. When relevant, we also noted the frequency of each identified theme.

VI. RESULTS

This section presents the findings related to our third research objective: to explore how teachers integrate STEM-based teaching in Moroccan schools (self-reported practices).

First, analysis of responses to the initial question revealed that the majority of surveyed teachers (28 out of 51) reported integrating STEM into their teaching.

Second, analysis of responses to the question *"How do you integrate STEM into your teaching?"* highlighted the goals, contexts, and strategies used by teachers in this

integration. In descending order of frequency, respondents indicated that the goal of STEM integration was to study or design a technical system (10 mentions), often within the framework of projects (6 mentions), and frequently using robotics as a teaching tool (5 mentions).

Third, it should be noted that the analysis of responses to the third question did not allow us to determine how frequently teachers integrate STEM into their practice. The wording of the question may have contributed to this limitation and would benefit from revision in future studies.

Fourth, analysis of the responses to the fourth question enabled us to identify the obstacles perceived by teachers regarding the integration of STEM-based teaching in their respective contexts. Figure 1 provides an overview of the reported barriers.

Based on the teachers' responses, four main categories of barriers to the integration of STEM-based teaching in Moroccan schools were identified:

• **Barriers Related to Working Conditions:** Teachers reported a lack of instructional resources, overcrowded classrooms, inadequate infrastructure, and limited access to technological tools, which constrain the effective implementation of STEM activities.
• **Barriers Related to STEM Disciplines:** The disciplinary structure of the curriculum remains rigid, with little room for interdisciplinary collaboration. Inconsistencies between subject-specific curricula, lack of joint planning, and overloaded content make integration difficult.
• **Barriers Related to Students:** Several respondents mentioned students' academic level, lack of interest in STEM subjects, unequal access to foundational knowledge, and the persistence of gender or social stereotypes as challenges to overcome.
• **Barriers Related to Teachers:** Teachers expressed a need for professional development focused on integrated STEM approaches. Many noted limited experience with interdisciplinary methods and some resistance to changing traditional teaching practices.

Figure 1 – Obstacles identified by respondents.

As shown in Figure 1, the most frequently cited barrier was the lack of resources (13 mentions), followed by students' academic level (12), large class sizes (10), and disciplinary silos (9).

The most frequently cited obstacles included lack of resources (13 mentions), followed closely by students' academic level (12), large class sizes (10), and disciplinary silos (9).

Furthermore, the analysis of responses to the fifth question shed light on the key factors that teachers believe would support the integration of STEM-based teaching in their educational environments. Figure 2 provides an overview of the enabling factors most mentioned by teachers.

Teachers identified several essential levers that could help facilitate the adoption of STEM approaches in Moroccan schools. These enables are organized into four main categories:

• **Enablers Related to Working Conditions:** Teachers emphasized the need for adequate resources and infrastructure, as well as smaller class sizes, to create an environment more conducive to STEM-based pedagogical approaches.
• **Enablers Related to STEM Disciplines:** Respondents pointed to the importance of fostering coordination and collaboration across disciplines to support interdisciplinary teaching and overcome subject silos.
• **Enablers Related to Students:** While less frequently mentioned, some teachers noted that raising student awareness and interest in STEM fields could improve engagement and participation in integrated learning activities.
• **Enablers Related to Teachers:** The availability of training opportunities and professional development focused on STEM practices was considered essential. Teachers also highlighted the importance of peer collaboration and shared planning time to support effective implementation.

Figure 2 – Enabling factors identified by respondents

In descending order of frequency, the main supports identified were availability of resources (12 mentions), limiting the number of students per group (7 mentions), teacher training (6 mentions), and coordination between disciplines (5 mentions).

VII. DISCUSSION

The barriers and enablers most frequently identified by respondents are consistent with those reported by Margot and Kettler (2019) in their systematic literature review. Moroccan teachers' perceptions of STEM integration do not appear to differ significantly from those of teachers in other national contexts. As expected, our findings reveal a clear alignment between the most frequently cited barriers and their corresponding enablers. For instance, lack of resources, large class sizes, and disciplinary silos were identified as major obstacles, while increasing resource availability, reducing class sizes, and strengthening interdisciplinary coordination were highlighted as key facilitating factors.

Beyond these general observations, the findings should be interpreted in light of the specific characteristics of the Moroccan educational context. The barriers identified

(particularly the lack of resources, large class sizes, and the rigidity of disciplinary structures) reflect systemic constraints that are well documented within the national education system. Overcrowded classrooms, especially in public schools, significantly limit the implementation of active and interdisciplinary pedagogical approaches such as STEM. In addition, unequal access to technological and material resources between urban and rural schools further exacerbates disparities in opportunities to implement STEM-based teaching.

Furthermore, the current curriculum organization, which remains strongly compartmentalized by discipline, constitutes a major obstacle to the interdisciplinary collaboration required by STEM approaches. This institutional structure, combined with a professional culture that is still largely centered on traditional subject-based teaching, may explain the difficulties reported by teachers in adopting integrated practices.

The strong demand for professional development also highlights a critical issue: many Moroccan teachers have had limited exposure during their initial training to interdisciplinary approaches or to the active pedagogies associated with STEM education. Consequently, beyond the availability of resources, pedagogical and institutional support appears to be a key lever for facilitating the effective adoption of STEM-based teaching.

Finally, some of the challenges related to students, such as disparities in academic level and limited interest in STEM subjects, may also be linked to broader socio-economic and cultural factors. This suggests that the integration of STEM education should not be addressed solely at the classroom level, but rather through a more comprehensive reflection on educational policies, student orientation, and the promotion of scientific fields within Moroccan society.

Moreover, when participants were asked how they integrate STEM into their teaching, they frequently referred to the study or design of technical systems, one of the core practices identified in Kelley and Knowles (2016) conceptual framework. It is also noteworthy that many teachers reported using real-world technological contexts, such as robotics, which aligns with key elements in the conceptualization of integrated STEM proposed by Martín-Páez et al. (2019). These findings suggest that, despite existing constraints, some teachers are already engaging with essential dimensions of STEM integration.

VIII. CONCLUSION

This paper presented the main findings of an exploratory research project focused on STEM (Science, Technology, Engineering, and Mathematics) education in Moroccan schools. While the study contributes to advancing knowledge on this topic, several limitations should be acknowledged. First, the relatively small sample size limits the generalizability of the results and raises questions regarding sample representativeness. Second, the reliance on self-reported data means that the practices described by teachers may differ from their actual classroom practices. As

such, potential discrepancies between reported perceptions and observable practices should be taken into account.

Despite these limitations, the study provides valuable insights into how STEM education is perceived and implemented by teachers in the Moroccan context. The findings highlight key structural and pedagogical challenges, including limited access to resources, large class sizes, and the persistence of disciplinary silos. At the same time, they point to important levers for action, such as improving working conditions, fostering interdisciplinary collaboration, and expanding access to professional development opportunities.

These results are consistent with previous work by Britel and Cherkaoui (2021), who emphasized the importance of a collaborative approach and the need to provide STEM teachers with adequate support, training, and resources. In the Moroccan context, however, our findings suggest that these conditions are not only supportive but essential, given the structural constraints identified in this study.

More broadly, this research contributes to a better understanding of STEM integration in an underrepresented context and underscores the need for systemic support to enable its effective implementation. It also suggests that efforts to promote STEM education should extend beyond the classroom and involve broader educational policies aimed at reducing inequalities, supporting teachers, and enhancing the attractiveness of scientific fields.

We hope that this study represents a first step toward the development of STEM training programs tailored to the specific needs and realities of the Moroccan education system.

Future research should consider expanding the sample and combining self-reported data with classroom observations in order to provide a more comprehensive and nuanced understanding of actual STEM integration practices.

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