



Exploring the Usage of Language of Instruction for Teaching Science Subjects in Moroccan High Schools

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Abstract

Teaching in general and teaching of science in particular necessitates the choice of a language of instruction to reach effective learning outcomes. This study argues that the implementation and identification of language of instruction strategies can enhance the acquisition of scientific knowledge, skills and outcomes in Moroccan high schools and ultimately achieve the pre-set educational goals. This study aims to explore and identify the preferred language of instruction to teach science subjects in high schools and the reasons behind this preference, and to know how the language of instruction impacts students' learning outcomes in science subjects. To meet the objectives, the qualitative approach was used, relying on open-ended questions conducted with high school science teachers, as well as classroom observations in Moroccan high schools. The thematic analysis is applied to discuss the research questions. The results provide science educational policy and practice regarding effective teaching of science subjects through preferred language of instruction in Moroccan high schools.

1. Introduction

The use of language is as important as the text of the book during teaching in the classroom. One cannot deliver the concepts without using any means of communication such as language. The selection of appropriate language for the instruction is among the ingredients of a good lesson plan. According to Abdelhamid et al., (2023), empirical research shows that Moroccan teachers have varying perceptions regarding the use of French in STEM classes. Morocco knows the significance of equipping its students with the necessary skills of scientific knowledge for meeting the requirements of the global economy. The educational stakeholders including educators, policymakers, and administrators deliberate on the use of either French, Arabic or English as a medium of instruction. Here, teachers' perspectives become more important because of their direct involvement in the instructional process. Moreover, as they are also the crucial observers of the classroom, they can explain the implications of using a language to understand the effectiveness of their teaching and intended outcomes. But the fact that French has decreased in comparison to English as a universal language cannot be denied.

Globally speaking, the emphasis has been laid on English medium instruction (EMI) in countries where English is the secondary language. According to Bullock (2014), the higher their social class, the more likely respondents are to hold favourable attitudes towards French and the increasing use of English and move away from the local codes of Moroccan Arabic, Standard Arabic, and Berber. EMI is being practised across the globe especially in the post-colonial countries. Over the past 20 years, the application of EMI policies in education has rapidly increased. The reason behind using EMI as an instructional strategy is due to the

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diversity in cultures, political ideologies, ethnicity background, economic values, and educational implications. In Morocco, high schools have been using foreign languages e.g. French or English in some schools since 2014 as a result of Moroccan kingdom implementation of a new policy.

Sybil Bullock (2014) has quoted Fatima Sadiqi's (2003) argument that Morocco is a Berber, Arab, Muslim, Mediterranean and African country. Morocco's cultural landscape may be described as a rich context made of components of history, with each element signifying a unique culture that has left its mark on the area. According to the same source, Morocco's location allows it to receive and absorb ideas and customs from all over the world, including Europe, the Middle East, and Africa, which forms the basis of Moroccan culture. Colonial France also left an everlasting mark, with a multilingual approach that adds another degree of language complication. Morocco is a multilingual country with minority-dominant languages. Sybil Bullock (2014) has quoted Louis-Jean Calvet's (1998) assertion that Morocco is a multilingual country with minority-dominant languages, meaning that the numerically dominating languages are actually the less powerful ones in terms of politics and culture. Morocco is more than just a location on a map; it is a cultural crossroads and a worldwide gathering place for people.

The objective of this study is to investigate and determine the preferred language of instruction for the teaching of science subjects in high schools; in addition to examining the underlying reasons behind such preference. The study also seeks to understand the influence of the language of instruction on student learning achievement in science courses. Thus, to meet the objective mentioned earlier, three research questions are formulated as follows:

1. What is the preferred language of instruction for teaching science subjects in Moroccan high schools and what are the reasons behind this preference?
2. What effects does the language of instruction have on Moroccan high school students' understanding and interest in science subjects?
3. How do Moroccan high school instructors feel about the way that language of instruction helps learners acquire science concepts?

There is a lack of research that examines the efficacy of language of instruction strategies designed for the Moroccan high school system, despite the large amount of literature on such strategies in other educational contexts, particularly science education. While there have been studies on language barriers and instructional approaches in Moroccan education, there is a significant lack of research on how to use language to teach science in this context. Instructing or teaching requires a full understanding of pedagogical and linguistic problems encountered by Moroccan high school students and teachers in science classes. Consequently, studies examining the effectiveness of language of teaching strategies aimed at improving scientific education results in Moroccan high schools are urgently needed in order to inform educational policy makers and practitioners and help enhance the quality and equality of scientific education in Morocco. So, it is urgent and fundamental to fill this research gap.

2. Literature Review

2.1. Historical Background of Instructional Language in Moroccan High Schools

A combination of colonial influence and internal educational changes have an impact on the development of language teaching in Moroccan high schools (Aguilar and Rodríguez, 2011). Morocco has been subject to the impact of many colonial powers, such as the French and Spanish ones, throughout its history, resulting in significant changes in its educational system. The French Protectorate period (1912–1956), during which French was required as the primary language of instruction, had a significant impact on the language policies in Moroccan schools (Başıbek, Dilek, & Kara, 2014). The lasting impact of colonialism on language policies persisted in Morocco even after gaining independence, since the French maintained a powerful

status in the educational system. In addition, following educational changes like the Arabization strategy implemented in the 1980s that aimed to advance Arabic as the first language of instruction and enhance national identity (Belhiah and Abdelatif, 2016). Nevertheless, the implementation of Arabization encountered obstacles as a result of the deeply rooted status of French within the educational structure and the perceived prestige linked to that language. Consequently, a bilingual methodology emerged, wherein Arabic was employed in primary education while French was utilised in secondary and tertiary education (Wilkinson, 2012).

A variety of historical occurrences, such as political changes and socioeconomic shifts, have influenced the choice of a language of instruction in Moroccan high schools. The task of updating the educational system and bringing it in line with international standards has triggered debates on language rules and their consequences on the quality and fairness of education (Hammou, 2021a). Nowadays, the linguistic policy in Morocco, especially in education, fluctuates between policymakers' decisions such as ministers of education who have been managing the educational sector.

2.2. The Impact of French Language Policies on the Educational System in Morocco

The implementation of French as the medium of instruction has had a significant influence on the educational system in Morocco (Werther, et al., 2014). The adoption of French language policies has led to unequal educational outcomes, as the availability of French-language education has frequently been restricted to urban regions and prestigious educational institutions. This linguistic divide has contributed to the continuation of social disparities, as students coming from underprivileged homes have obstacles in reaching academic achievement as a result of language competency challenges (Hammou, 2021b). Moreover, the prevalence of the French language in the field of education has further solidified a disparity between the curriculum and the linguistic and cultural backgrounds of students (Hammou, 2022). The lack of connection has hindered the efficacy of instruction and acquisition since students may have difficulties understanding complex scientific concepts transmitted in a non-native language (Uehara and Kojima, 2021). The French language policy has significant societal aftermaths, particularly in terms of worsening injustice in educational access and prospects for socio-economic progress (Borg, 2016). Individuals who possess a high level of proficiency in the French language are afforded enhanced possibilities for pursuing higher education and ensuring employment in industries that demand proficiency in French, hence intensifying social inequality.

2.3. Current Medium of Instruction in Science Education in Moroccan High Schools

The major language of instruction in science education in Moroccan high schools is French, which can be attributed to the enduring influence of colonial language regulations (Bradford, et al., 2022). In certain basic and lower secondary science classes, Arabic is employed, although French assumes a more prominent role in higher levels of education, specifically within scientific fields (Tong, et al., 2020). This implementation of French as language of instruction to teach science subjects goes back to 2014-2015 when it was optional for students in high school to choose what scientific stream to follow: the General Scientific Stream where science subjects are taught using Arabic, or International French Scientific Stream where those subjects are taught using French as a medium of instruction. However, this option quickly disappeared to be generalised in August 2019 with the coming of the Framework law that allows for technical subjects to be taught in foreign languages (Benabou, 2019). The national policy on languages remains random and ambiguous — clearly and mainly the new framework aims at reinforcing French as the language of instruction in Moroccan schools, leading to what has been termed the "Frenchification of Moroccan education" (Ben Haman, 2021). On the contrary,

advocates of adopting English in the Moroccan education have not been satisfied when the Higher Council of Education linked the choice of French to these reasons: (1) The scarcity of English instructors; (2) the existence of good historical and cultural ties with France as a strong ally of Morocco; and (3) the difficulty of switching the country from Francophone system to an Anglo-Saxon one.

Several factors influence the choice of French as a primary language to teach science courses, including the perceived prestige linked to the language, the need to adhere to international scientific standards, and the availability of educational materials in the French language (Chen and Peng, 2019). Furthermore, the implementation of a bilingual approach in Moroccan educational institutions seeks to achieve a harmonious equilibrium between the promotion of Arabic as the language of national identity and the cultivation of students' competitiveness within a globalised context (Thanda, et al., 2020). Nevertheless, there is ongoing disagreement regarding the efficacy of the existing instructional medium in facilitating science education. The French language has the potential to improve access to scientific publications and simplify communication within international academic communities (Simbolon, 2016). However, it can also provide challenges for students, especially those who have low competence in the French language. A discrepancy between the linguistic proficiency of students and the medium of instruction can hinder their understanding and involvement with scientific concepts which finally result in impacting educational achievements (Coleman, 2006).

2.4. Current Language Policies and Practices for Instruction in Teaching Science Subjects

The language policies and instructional strategies currently implemented in Moroccan high schools for teaching science courses are influenced by a multifaceted interaction of linguistic, educational, and socio-political elements (Costa et al., 2012). The use of a bilingual strategy, wherein Arabic and French are used interchangeably based on the educational level and the subject matter, is supported by state policies (Nieto Moreno de Diezmas & Fernández Barrera, 2021). However, the actual implementation of this method indicates variation among schools and areas. Practically, French continues to be the prevailing language in teaching science, leaving learners with few chances to interact with scientific material in Arabic (Doiz, Lasagabaster, & Sierra, 2013). The contrast between the words used in policies and the actual conditions in classrooms highlights the difficulties of balancing linguistic variety with educational goals (Farrell, 2020).

The teaching and study of science in Moroccan high schools are influenced by language policy in several manners (Fonseca, Corbett, & Costa, 2020). The use of French as the predominant language of instruction has the potential to marginalise students who have little proficiency in French, eventually retarding their academic performance and maintaining existing disparities (Galloway, Kriukow, & Numajiri, 2017). Furthermore, the difference between the linguistic background of students and the language used for instruction can impede their ability to successfully and scientifically interact and restrict the development of critical thinking skills. Significant progress has been made in language policy related to science education, such as initiatives to increase the use of Arabic in scientific disciplines and encourage the inclusion of indigenous knowledge systems in the curriculum (Gröblinger, 2017). However, given the ongoing difficulties with language competency, teacher preparation, and resource availability, the efficacy of such initiatives is still far from being determined.

2.5. Science Education Learning Environment and Intended Outcomes in Moroccan High Schools

The science education learning environment in Moroccan high schools is characterised by a number of complex interactions of socio-cultural, linguistic, and pedagogical factors (Haines,

2014). Classroom arrangements vary significantly depending on criteria such as educational facilities, teacher proficiency, and students' characteristics (Helm, 2019). While certain schools may possess adequately equipped laboratories and highly skilled educators, others may be deficient in crucial resources and confront challenges related to oversized classes.

Scientific education aims to achieve desired goals in both cognitive and socio-emotional dimensions (Macaro, et al., 2019). Furthermore, students are anticipated to cultivate critical thinking skills, problem-solving capabilities, and a profound respect for scientific research in addition to acquiring understanding of scientific concepts and procedures (Macaro and Dearden, 2018). Moreover, the ultimate goal of science education is to foster curiosity, ingenuity, and a conscientious attitude towards the natural world and community. However, attaining these objectives depends on the resolution of some significant obstacles within the Moroccan educational system (Macaro, et al., 2019). Limited resources, inadequate teacher preparation, and linguistic barriers are just a few of the fundamental challenges that prevent the delivery of effective science education (Molino, 2017). Teacher-student interactions, curriculum design, instructional materials, and extracurricular activities are among the key factors that influence the quality of the science education learning environment (Morell, 2020). Promoting a comprehensive educational climate that matches the diverse needs and experiences of students is very vital for implanting enthusiasm and skill in the subject of science (Helm, 2019).

2.6.Challenges Encountered by Science Educators in Moroccan High Schools

Science teachers in Morocco's secondary schools encounter numerous difficulties that affect both their effectiveness as teachers and the educational experiences of their students (Alhassan, 2021). The lack of resources presents a remarkable obstacle for scientific instructors, as numerous educational institutions face a scarcity of essential laboratory equipment, textbooks, and instructional materials (O'Dowd, 2018). Science instructors have significant challenges due to linguistic limitations, especially in schools where French is the main language used for teaching (OECD, 2009). Teachers must skilfully handle the complexities of instructing scientific topics in a non-native language while dealing with learners with varied linguistic origins and levels of ability (Coleman, 2006). Science education outcomes are influenced by socio-economic inequalities, since students from poor families may encounter additional obstacles to reaching academic achievement (Richards, 2010). Students' motivation, engagement, and performance in science disciplines can be influenced by factors such as access to educational resources, parental participation, and socio-cultural expectations. Therefore, a comprehensive strategy is required to face these difficulties: policy changes, programmes for professional growth, and efforts to involve the community. Ensuring that Moroccan high school teachers of science disciplines receive sufficient training, support, and resources is essential for strengthening teaching effectiveness and improving students' results (Rose, et al., 2020). Furthermore, the use of inclusive and culturally sensitive educational approaches can help to create a learning environment that is fair and equitable for all students.

3. Methodology

This study adopted a qualitative research approach to gather comprehensive insights into the effectiveness of language of instruction in science education inside Moroccan high schools. This approach incorporated two data collection techniques, interviews with open ended questions in Arabic and French to get in-depth and rich data, also to help participants express their thoughts freely; in addition to classroom observation that was conducted using a predetermined checklist in particular classrooms. The participants of this study included thirty teachers of science subjects (21 were males and 9 were females) from Moroccan high schools with specific characteristics: currently teaching science subjects, teaching science both in Arabic and/or in French, teaching different levels in high school and having important years' experience. A purposive sampling technique was employed to gain in-depth insights to meet the criteria relevant to the research objectives. Hence, the participants were selected from the

delegation of Fez city in Morocco, particularly the district of the old Medina that includes five high schools. Additionally, to meet the objectives, classroom observations were conducted inside six classrooms and were documented using structured observation protocols to record key behaviours and interactions. Prior to data collection, ethical approval was obtained from the relevant institutional review board. Descriptive and thematic analysis were conducted on interview transcripts and qualitative data from classroom observation to identify recurring themes, patterns, and insights related to effective language of instruction strategies in science education. All participants were provided with informed consent forms explaining the purpose of the study, their rights, and the confidentiality of their responses. The research methodology outlined above aims to explore and analyse the effectiveness of language of instruction strategies in science education in Moroccan high schools, providing valuable insights for educational policymakers, curriculum developers, and practitioners.

4. Findings

An extensive summary of the research findings about the use of instructional language in scientific teaching operation at the high school level in Morocco is provided in this section. This study's main goal was to look into the approaches, problems, and possible solutions around the use of language in scientific topic instruction. The primary themes found throughout the data analysis are used to categorise the findings.

4.1 Findings of Interview

4.1.1 Language Practices

The results of this study revealed a complex landscape of language practices inside Moroccan secondary schools in relation to the teaching of science disciplines like Mathematics. Although French is used as a secondary language, particularly in the domains of science and technology, Arabic is the main language used for education. However, there is significant disparity in the usage of each language among various schools and localities. In urban locations and elite institutions, French is commonly preferred as the main language of instruction for science courses. The tendency to be inclined towards this phenomenon is often associated with historical ties to the French education system and the expected advantages in terms of worldwide chances and prospects for higher education. On the other hand, in rural and economically challenged areas, where English and French are not widely spoken, Arabic continues to be the primary language of teaching or at least to balance it with the use of French as a respect to the government legislative laws.

Excerpt 1:

"The use of French "I mean the Frenchification of science subjects" is used only on the government's papers but reality inside our classes is something different. When I start explaining in French, students keep gazing at me. Once I switch to Arabic or Moroccan Arabic everybody raises his hand and wants to participate". (Hassan teacher of science of life and earth)

"The practical side of this issue is a thorny one: how can a teacher who has been teaching Mathematics for 26 years in Arabic suddenly switch to French without any consent, training or even a preparation. the same thing is applied to students". (Omar, teacher of Mathematics)

"Implementing the Frenchification policy equals two difficulties: simplifying the scientific concepts and facilitating linguistic deficiency. That is why we resort to Arabic or Moroccan Arabic to facilitate the task". (Abdeslam, teacher of ICT)

4.1.2 Perceived Challenges and Benefits

The participants recognized a variety of perceived advantages and difficulties related to teaching science courses in many languages. The benefits of learning French, according to proponents, include giving students access to rich scientific information and tools, improving their competitiveness in international contexts, and giving them the tools they need to pursue higher education nationally or internationally. Furthermore, becoming fluent in French is

frequently linked to social standing, intellectual achievement and job opportunities. On the other hand, Arabic supporters stressed the language's significance for maintaining cultural heritage, encouraging diversity, and guaranteeing equal access to education. They argued that using Arabic promotes improved comprehension and engagement among students, particularly those from disadvantaged backgrounds. Additionally, some participants expressed concerns about the quality of teaching and learning when using languages other than Arabic, emphasising issues related to teacher proficiency, curriculum alignment, and student comprehension.

Excerpt 2:

"I can't deny that teaching science subjects using French in Moroccan middle and high schools will bridge the linguistic gap between high school and tertiary education, However, the pattern of implementing this policy which is challenging due to the fact that though French is the first foreign language in Morocco, students' level is still low in this language". (Majid, Physics teacher)

"Like it or hate it, the Frenchification of science in Morocco is a deeply persisting French colonialism that we will never get rid of until we value our culture and identity". (Abdulkader, Technology teacher)

4.1.3 Pedagogical Approaches and Adaptations

Participants suggested several pedagogical strategies and adjustments to address the challenges associated with language usage in science courses. Bilingual instruction entails incorporating Arabic and either English or French into science classes, with the aim of backing up different linguistic backgrounds and enhancing the learners' comprehension. The use of language aid programmes is an appropriate approach for enhancing students' English or French language skills, particularly at the level of technical vocabulary and academic writing. Professional development has provided educators with opportunities for training and skill enhancement to improve their language proficiency and pedagogical aptitude in multilingual settings.

Excerpt 3:

"There is a lot to do to address the problem of language in science teaching but policymakers do not move. Let's take, for example, the 'Translation subject', in which students were taught translation of scientific vocabulary and items from French into Arabic and vice versa, that was deleted from the educational program in high school could have served at this level to face the problem of suddenly Frenchifying the teaching of science subjects". (Hussein, Science teacher)

"I think before dictating a certain strategy, the government should study its future challenges and prepare some planning to confront them. The in-service training which can serve as a remedy to some troubles in the field is completely ignored by the ministry of education". (Naima, Mathematics teacher)

4.1.4 Student Perspectives

As far as students are concerned, they have varying perspectives on the language employed in science classes, influenced by their linguistic backgrounds, academic goals, and personal experiences. Some students choose to learn scientific subjects in French since it is seen as more prestigious and practical; while, others emphasise the need of receiving issues in their native language for better understanding and long-term memory. Additionally, students from multilingual backgrounds frequently expressed favour for a flexible and comprehensive approach that supports different language preferences and learning techniques.

Excerpt 4:

"The majority of my students wonder why the government obliged them to study subjects they were accustomed to studying in Arabic and Moroccan Arabic using French? One of my active students once said: 'did we even like French or understand it in the French session to understand it in Mathematics?'" (Abdeljabbar, teacher of Mathematics)

"In the annual meeting with students, I ask the two streams, the French stream and the general stream, the same question which is why they chose to learn science in French or in Arabic. Those who study in French usually reply that they studied in private schools using French, or because French is a must in higher education so there is a need to master it now before confronting more challenges at the university level." (Zakaria, Physics teacher)

The findings emphasise the complex relationship between language use and scientific instruction in Moroccan secondary schools, highlighting the need for comprehensive strategies that consider linguistic diversity, educational equity, and academic rigour. Policymakers, educators, and other relevant parties must collaborate to promote inclusive and effective scientific education for all learners in order to properly handle the challenges and maximise the future potential of multilingualism.

4.2 Findings of Observational Checklist

4.2.1 Respect for Official Language Policy

Most of the classrooms that were observed followed the Moroccan high schools' official language policy, with teachers mostly utilising the language that was assigned for instruction, showing a struggle to respect the ministry note inside their classrooms.

4.2.2 Language Switching

During instruction, teachers have occasionally moved from using the official language to another language. There are several reasons for this change, such as the belief that students need to understand concepts more clearly, the fact that the other language is one's native tongue, or the fact that teaching resources are only offered in that language.

4.2.3 Use of Other Language for Clarification

While clarifying particular science topics or basic concepts, teachers frequently turn to another language, usually Arabic or Moroccan Arabic, which suggests a possible preference for these languages' apparent grammatical clarity or quick explanation.

4.2.4 Use of Audio-Visual Aids

A considerable percentage of teachers use audio-visual aids (especially in Science of Earth and life and Physics) to support the language of teaching in the classroom with the goal of improving understanding and facilitating the achievement of learning outcomes.

4.2.5 Enhanced Participation and Engagement

When multiple languages are used, mainly the mother tongue, in the teaching process, there is typically an increase in student participation and engagement and readiness to learn. This phenomenon may be explained by the fact that learners are accustomed to speaking various languages or by the inclusive learning environment that multilingual education promotes.

4.2.6 Language Preferences and Learning Impact

Students tend to communicate with their teachers in the language in which they feel most at ease, but this might differ from one person to another. This choice may have an impact on how well they learn; some students may perform better when using their preferred language in terms of understanding and engagement.

4.2.7 Difficulties in Teaching Science Courses

Educators face challenges when teaching science courses in languages other than the official one. Language impediments, a lack of relevant educational resources, or a low proficiency in the target language are a few examples of these difficulties.

4.2.8 The Effect of Linguistic Ability on Comprehension

Students' understanding of basic scientific concepts is greatly influenced by their language competency. Stronger language proficiency tends to help understand important concepts more quickly, whereas language-related obstacles may make it difficult for others.

4.2.9 Linguistic and Cultural Influences

The language that science teachers use can have an impact on students' perceptions and comprehensions of the material since it can represent linguistic or cultural influences. This interaction emphasises how crucial it is to take linguistic and cultural aspects into account in educational settings.

4.2.10 Differentiated Teaching Approaches

When teaching science, teachers use a number of techniques, tailoring their strategies to language ability, classroom dynamics, and learning objectives. These variations demonstrate the diversity and adaptability that instructional methods have in various language circumstances.

5. Discussion

5.1 Discussion of Interview Results

5.1. Interpretation of Findings in the Context of Existing Literature

The findings of this study shed light on the complex relationship between the language used for instructions and the acquisition of scientific knowledge in high schools in Morocco. Previous research has highlighted the importance of language skills in attaining academic mastery, especially in subjects like physics that need complex vocabulary and abstract concepts. Our research proves this assertion, suggesting that students who possess a higher level of proficiency in the language used for giving instructions tend to attain high outcomes in science. A significant hindrance in teaching science courses is the existence of a language barrier, particularly for students whose native language differs from the language used for instruction. This is consistent with research that highlights how language obstacles negatively impact understanding, engagement, and performance in general. The literature has emphasised the need for language assistance aids in science education. The strategies encompassed in this approach consist of bilingual education, exercises aimed at enhancing vocabulary, and scaffolding techniques. They are seen as effective in tackling the obstacles presented by linguistic difficulties. The findings of this research underscore the importance of integrating these strategies to enhance students' understanding and engagement in science educational contexts. Cultural and sociolinguistic factors play a significant role in shaping students' attitudes about the language of instruction and their perceived level of competency in science courses. Gaining a comprehensive understanding of these qualities is essential to effectively addressing the different language origins of students.

5.2. Implications for Science Education, Policy and Practice of the Language of Instruction

Our findings, especially with regard to instructional language, have broad implications for science education, policy, and practice. Our study highlights the importance of implementing curriculum and pedagogical changes that prioritise linguistic support in science education. This strategy's components involve incorporating language development activities, providing multilingual materials, and training educators on effective language teaching methods. Educators play an important role in promoting language-rich science education. As a result, it is critical to allocate resources to programmes that focus on teacher training and professional development, particularly in language pedagogy. Teachers will be able to help language learners succeed in scientific classrooms by acquiring the necessary information and abilities. Legislators should consider enacting rules that promote bilingualism and multilingualism in the classroom, particularly in regions such as Morocco where language diversity is common.

This could include analysing and changing language policies, backing programmes to help language learners, and encouraging collaboration among individuals involved in language and scientific education. It is critical to identify and address linguistic barriers. To promote fair and equal access to outstanding science education and academic performance, authorities and educators must address the needs of students with diverse language origins.

5.3. Strategies for Improving Language of Instruction in Teaching Science Education

Based on our research findings and the implications discussed above, we suggest the following recommendations for strengthening the linguistic elements of science education instruction in Moroccan secondary schools. The goal is to establish a science curriculum that allows for the integration of language development goals alongside science topic guidelines. Providing continuing professional development opportunities is an effective strategy for improving language teaching skills and enhancing cultural competency among educators. Additionally, providing necessary equipment and support programmes for language learners, such as peer tutoring, extracurricular language workshops, and bilingual dictionaries and textbooks. Another prospective remedy is to encourage collaboration between educational institutions and community organisations in order to utilise resources and specific skills to help language learners in science education. It is preferable to conduct further future research to determine the efficacy of certain language support methods and techniques in enhancing scientific learning outcomes for students having various linguistic backgrounds. By implementing such principles, Moroccan secondary schools can create inclusive and equitable educational learning settings, ensuring that every student, regardless of his linguistic heritage, has the opportunity to excel in science education.

It is worth mentioning that the results of the interview go hand in hand with what has been observed inside classroom. In other words, all participants deploy enormous efforts to implement the ministry note in their teaching but the difficulties they encounter oblige them to switch to students' preferred language, which is Arabic or Moroccan Arabic, to facilitate the comprehension of scientific concepts.

5.2 Discussion of Observational Checklist

The findings of the current study have shown an insightful vision on the complex dynamics underlying language use inside Moroccan secondary school classrooms, particularly when science is taught. The majority of classrooms adhere to the official language policy, demonstrating institutional norms. This commitment is likely to take place due to institutional expectations and regulatory requirements. This approach reflects respect for national linguistic policies as well as measures to maintain linguistic standards. Yet, switching from one language to another while teaching indicates the practical measures educators take to guarantee clear communication and facilitate comprehension. Although adhering to the official language is essential, a teacher's ability to adapt and respond to the changing needs of the classroom is proven by their willingness and readiness to switch languages in response to changing pedagogical requirements, resource availability, or student understanding. The propensity to use languages like Standard Arabic, Moroccan Arabic or even English to explain difficult ideas points to a teaching method meant to improve students' comprehension of scientific concepts. This approach recognizes the variety of languages spoken in the classroom and makes use of the languages that the students are familiar with to provide clear explanations that will ultimately improve their comprehension.

Modern educational practices go hand in hand with the use of audio-visual aids in order to suit a wide range of learning styles. Despite a student's linguistic proficiency, visual aids can help make abstract concepts clearer and more comprehensible. The link between increased student engagement and bilingual instruction demonstrates how inclusive these pedagogical practices are. By recognising linguistic variety, teachers create an environment in which

students are motivated to act actively and contribute to a more enriching learning experience. The recognition of students' linguistic preferences highlights the importance of linguistic comfort in achieving academic success. It is possible to increase student involvement and comprehension by recognising and addressing their preferences, which will finally lead to a propitious learning environment. The problems that instructors have while teaching science in languages other than the official one underline the need for qualified assistance and resources. By eliminating language barriers and enhancing teachers' proficiency, these difficulties can be remedied, ensuring equal access to high-quality education.

The impact of students' linguistic proficiency on their comprehension emphasises the link between language and learning. Improved linguistic proficiency can accelerate brain processes and help students thoroughly understand complex scientific concepts. The recognition that linguistic and cultural factors influence students' viewpoints highlights the importance of culturally responsive teaching practices. Integrating many language and cultural perspectives into the curriculum may ensure a more inclusive and equitable educational experience. In brief, implementing diversified instruction demonstrates a teacher's grasp of students' diverse needs and learning preferences. Educators can maximise learning outcomes in a variety of language environments by designing personalised instructional strategies based on student proficiency, classroom dynamics, and learning goals.

6. Conclusion

This final chapter combines the main findings from our research into the use of instructional language to teach science topics in Moroccan high schools. The authors acknowledge the limitations revealed in this work and propose future avenues for research in this topic.

6.1. Summary of Key Findings

Our research into the implementation of instructional language in Moroccan secondary schools yielded substantial results. From an academic perspective, the relationship between Arabic and French languages in science instruction was and is still complex. French remained the dominant language in higher science classes, while Arabic was used mostly in lower educational levels. The presence of a dual language of instruction can be explained by a confluence of historical, cultural, and educational factors. Students and teachers have different opinions and preferences concerning the language used in science teaching. Several participants expressed a preference for French due to its perceived global practicality and technical accuracy, while others emphasised the importance of Arabic in terms of cultural preservation and ease of access. The study's findings revealed a number of challenges to using language for educational purposes, including linguistic barriers, restrictions in instructional approaches, and discrepancies in students' linguistic proficiency. Still, it recognised the potential for using several varieties of language to increase student engagement, analytical reasoning, and intercultural understanding. Our study's findings emphasise the importance of language policies that encourage diversity, justice, and high-quality education and are based on extensive data. When designing language programmes, it is critical to take into account students' linguistic rights, science education instructional requirements, and Morocco's larger social context.

6.2. Limitations of the Study

It is essential to highlight the different limits in our research, as well as the unique insights it provides on language patterns in Moroccan high schools. One potential limitation is the presence of sampling bias, which may result in an inadequate representation of Morocco's diversified high schools across various regions: the study was limited to one province in one city in Morocco. Future research ought to include other regions. Also, the data was collected from high school teachers, further research can benefit from the opinion of other stakeholders. While classroom observation and interviews can be useful, they may have difficulties in fully capturing complex aspects of language usage and its impact on science education; hence,

additional quantitative data collection instruments may be relied on to get statistical data and enlarge the scope of data analysis. Last but not least, the study's conclusions are limited to the Moroccan educational setting and may not be applicable to other situations with distinct sociolinguistic variables.

6.3. Suggestions for Further Research

Longitudinal studies are essential to determine the long-term effects of language training on students' scientific attitudes, language competence, and academic success. To what extent do teacher preparation programmes and professional development opportunities equip teachers with the language and pedagogical skills required to deliver high-quality bilingual scientific education? And to what extent is the language policy currently adopted will yield positive results throughout the academic itinerary of students? These are the essential questions that the coming future research should attempt to solve and to which the Moroccan government should find an answer.

7. References

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