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ORIGINAL RESEARCH

The Impact of Bilingual vs English-Only Instruction on the Performance of Undergraduate Saudi Medical Science Students

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Introduction: Using English as the medium of instruction in science courses may hinder comprehension for students who lack sufficient English language proficiency. This challenge is particularly relevant in non-English speaking countries, where students may struggle to follow complex scientific content delivered exclusively in English.

Methods: This study was conducted at King Saud bin Abdulaziz University for Health Sciences, where the majority of students are native Arabic speakers. To assess the impact of language on knowledge acquisition, two groups of first-year students enrolled in various health and medical science majors were compared. The test group attended a biology lecture delivered bilingually (Arabic and English), while the control group received the same lecture in English only. A pre- and post-test design was used to evaluate knowledge acquisition during the lecture session.

Results: Both groups showed improvement in post-test scores; however, the test group demonstrated a statistically significant higher gain compared to the control group. Furthermore, 86% of students in the test group reported that the bilingual approach reduced distractions, and 98% reported improved understanding. In contrast, only 32% of the English-only group reported reduced distractions, and 56% felt it improved their understanding.

Discussion: The findings suggest that bilingual instruction enhances comprehension and reduces cognitive load for students with limited English proficiency. This highlights the importance of adapting the medium of instruction to student language competencies in science education, especially for non-native English speakers, who lack sufficient English language skills.

Keywords: bilingual science teaching, medium of instruction, teaching science using foreign language

Introduction

Over the past few decades, Saudi universities have increasingly adopted English Medium Instruction (EMI) policies.[1–3] While Arabic has long been used in Saudi schools,[4] these higher education EMI policies reflect the global emphasis on English as a second language (L2) as a gateway to progress in higher education. By implementing such policies, most universities in Saudi Arabia have designed English language programs delivered mostly in a first, preparatory year. The goal of these programs aims at equipping university students with the language skills deemed necessary for their subsequent academic studies. However, this focus on the English language might likely pose several challenges for students that include linguistic, cultural, administrative, and institutional challenges.[5] Applying an EMI policy to science courses, for example, might risk students' participation in classroom discussions, comprehension of scientific concepts, and performance on English-only exams and other methods of assessment. This heavy reliance on English raises many questions with regard to the effectiveness of EMI and whether the use of the first Language (L1) along with English (L2) might yield better learning outcomes for students.

Considering the growing emphasis on English as a medium of instruction in Saudi universities, the current study aims at exploring whether the use of a bilingual method (Arabic and English) compared to using only English might deliver

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better achievement results in a biology course introduced to first year Saudi university students. By adding to the scarce, yet growing body of literature that focus on the implementation of bilingual approaches to scientific teaching, the study is also set to offer insights into the effectiveness of bilingual teaching in science. Although it is very important to understand current teaching practices in Saudi higher education, it is as much essential to explore the effectiveness of any other methods that could eventually inform current higher education language policies. Moreover, as Saudi universities continue to prioritize English-medium instruction,[6] it is necessary to understand the neglected roles of students' first languages, and how that could help in ensuring wider and equitable access to science education.

While numerous research studies have already explored language teaching in Saudi Arabia by focusing on issues of English as a second language (ESL) or English as a foreign language (EFL), only few studies have addressed language choices in classrooms and bilingual approaches to scientific teaching. Furthermore, many of these studies have addressed the use of English from a language policy perspective but lacked a practical foundation for analysis. Even when it comes to curriculum design and innovation, research is yet to explore whether EMI goals can be met and assessed.[7] Thus, this study could offer a practical understanding of the importance of the medium of instruction used in college-level science courses in Saudi Arabia. Central to this study is the importance of examining how language choice and medium of instruction could benefit or hinder students' learning experiences and achievement during their first year at college, which could in turn have an impact on their later academic performance.[8]

Literature Review

The use of students' native language in traditional lectures has been associated with various advantages. For example, using the first language in group discussions has been found to have a positive impact on students reading comprehension of English texts.[9] It was also reported that the use of the Arabic language in Saudi Arabia would likely enhance the teaching and learning of science.[10] Another study in the Saudi context emphasized how students' use of Arabic in addition to English facilitated the comprehension of different types of texts.[11] However, the sole use of EMI has not been investigated thoroughly in order to assess whether it would be beneficial for students' learning.[4] With such limited research on EMI in relation to other mediums of instruction, it is still unclear whether EMI might (or might not) improve students' language skills. An evaluation of such mediums is essential in ESL/EFL classrooms as it could also provide teachers with a wider variety of supporting learning materials such as videos, online learning options, and exam practices.

In ESL/EFL contexts, utilizing pre-existing knowledge in the first language could likely facilitate second or foreign language learning. This is referred to as language transfer[12] through which learners could make use of their fully developed first language (L1) to help them while learning another language, such as English. It is noteworthy to mention that being fully developed in L1 normally entails prior, long, and extensive exposure to language. In the case of adult language learners, the utilization of the first language might be a helpful tool in their journey of learning a second language. This was evident in prior research on second language learners, which reported learners' tendency to use lower-level linguistic processing while reading compared to L1 readers who used higher-order processes.[13,14] Likewise,[15] found that learners' L1 skills such as vocabulary and grammar could have a significant impact on L2 English reading comprehension. They also noted that L1 language skills can be transferable to L2 even if the two languages do not originate from the same language family. These findings support much earlier work on Linguistic Interdependence,[16] which suggested that proficiency in L1 could positively transfer to L2, especially in relation to cognitive and academic skills.

In addition, the importance of input might play a pivotal role in relation to reading comprehension for foreign language learners. For example,[17] reported that students' reference to and use of their knowledge in L1 reading and writing added support to their L2 integrated writing. Additionally, learners whose first language exhibits notable similarities and shared cognates with the English language are believed to have an additional advantage while learning English vocabulary.[18] Knowledge of such cognates and similarities between L1 and L2 was reported as a predictor of L2 reading comprehension and vocabulary acquisition.[19–21] Despite this, others suggested that even with languages that differ in their orthographic systems, reading achievement in L1 and L2 might be linked through language transfer, suggesting that improving learners' L1 could lead to better L2 development.[22]

Even with very young children, cross-linguistic transfer was found notable, emphasizing L1 as a strong predictor of later development in L2 for both monolingual and bilingual children.[23] Similarly, learners' ability in L1 was perceived as a predictor of their L2 ability in reading and writing.[24] This could also raise cross-linguistic awareness in multilingual settings, which in turn could also facilitate communication.[25] Furthermore, it is notable that learners' higher cognition in L1 could possibly lead to second language development.[26] As a result, instead of totally neglecting L1 in the L2 classroom, transfer strategies could be considered and used creatively in the classroom.[27] Students' first language could, for example, motivate students especially in productive language skills.[28]

Current trends in the teaching and learning of English are rooted in notions revolving around languaging,[29] which refers to "the process of making meaning and shaping knowledge and experience through language". Recent research emphasized how translanguaging[30] could be adopted to support bilingual students' engagement in "multiple discursive practices" in addition to utilizing their linguistic resources to make meaning.[31] However, further investigation is still required to assess whether these practices, which include bilingual teaching of science concepts might positively enhance students' educational experiences especially for Arabic, non-native English college students. Although students in many countries often enroll in English courses before studying science, the question remains: do students acquire the sufficient English skills and competencies that allow them to comprehend challenging science concepts?

As many Saudi universities introduce English language courses in their first year, students might find it a challenging experience to align their grade point average (GPA) with their academic expectations. With English adding more pressure on students, it is therefore critical for educators and curricula experts to provide supportive learning experiences during students' first year in college. Specifically, first semester's GPA in college was considered as a determinant for students' cumulative GPA and success.[32] With the absence of studies investigating the relationship between first semester GPA and graduation in many universities,[33] it is similarly crucial to understand the mediating effect of foreign language on students' first semester GPAs. In addition, in countries where science courses are taught in a language that is different from the students' native language, the medium of instruction (the language) could be an important factor that might interfere with students' comprehension of science concepts.[34] In this research study, we hypothesized that using bilingual teaching in traditional lectures may enhance students' comprehension and achievement in a science course. Therefore, this research paper aims at assessing whether using bilingual teaching (Arabic and English) compared to English-only as the medium of instruction might improve knowledge acquisition in a biology course for first year students at a Saudi college.

Theoretical Background

For the purpose of this study, it is important to present a brief history behind the theories that addressed the influences of L1 on L2 along with the theoretical framework that guides the direction of the study. Early attempts to investigate the relationship between L1 and L2 was made by Lado[12] in his Contrastive Analysis Hypothesis (CAH). He emphasized that errors in L2 could be avoided and even predicted by looking at what L1 and L2 share and how they differ. It posited that the differences between two languages, one being the first of the speaker and the other being the second, could lead to negative transfer to the second one. However, whenever similarities were found, the opposite could take place, allowing for positive transfer of forms and structures. Hence, to avoid such negative transfer or interference from L1, teachers usually looked at the differences and similarities between L1 and L2.[35] This theory paved the way for later major works in relation to the influences of L1 on L2. Moreover, a similar view with regard to the complex interplay between L1 and L2 was presented by Selinker[36] who proposed that learners could develop a system of knowledge while learning language. This system is to be considered as different from both the native (first) or target (second) language. Although such a system might involve parts of both languages, it is considered as natural and independent. Thus, on the way to learning a new language, a new system of knowledge is being structured by the learner. Similar to the Contrastive Analysis Hypothesis, language transfer could play a pivotal role during this transition, allowing for (or possibly hindering) learning.

Following earlier works on the relationship between L1 and L2, Cummins[37] provided another novel view through his Common Underlying Proficiency Hypothesis (CUP). He proposed that proficiency in L1 could lead to successful learning of L2. Transferrable skills such as problem-solving and critical thinking could be transferred to L2 given that learners are

already proficient in their L1. Central to his work are two levels of English proficiency:[16] Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP). While, the former is required for the daily social conversations, the latter is essential for academic use in areas such as critical reading of textbooks and research articles, scientific writing of reports and exams, discussing concepts, and asking question. This aligns with the assumption that students who study science courses without acquiring the necessary CALP skills might be negatively impacted with regard to their comprehension of new knowledge. In line with this argument, it has been shown that students with low CALP could be at a disadvantage while studying academic subjects and science concepts.[38,39] Along with this notion, it was also reported that using only English in teaching academic courses for students who do not speak it as their first language might negatively affect their level of understanding of scientific knowledge.[34,40] More recent evaluation of the common underlying proficiency hypothesis confirmed positive cross-linguistic transfer between L1 and L2.[41,42]

A different, yet revolutionary work that theorized language learning was Universal Grammar (UG).[43] UG suggests that all human beings are typically born with an innate linguistic capacity that helps them with language acquisition. Such capacity, many argue, involves a set of universal principles and parameters found in the different languages. Applying this theory to L2 learning, it is believed that L1 could act as a filter to learners' principles and parameters. Therefore, L1 is considered as the starting point where transfer of such principles and parameters to L2 could be possible. By providing adequate L2 input as learners adjust their principles and parameters, better acquisition of L2 might occur over time.

Another theory that could be examined in relation to the influences of L1 on L2 is the Sociocultural Theory by Lev Vygotsky.[44] This theory emphasizes that in order for language acquisition to take place, peers' social interaction within a given culture should be enhanced. Applying this into learning a second or foreign language, L1 could act as a mediating tool to support the comprehension of complex language structures. Vygotsky also presented the notion of the Zone of Proximal Development (ZPD), which originally examined the difference between the children's "actual developmental level as determined by independent problem solving" and their "potential development as determined through problem solving under adult guidance or in collaboration with more capable peers". By targeting the learners' ZPD through social interaction, learners could acquire language skills as they engage in more advanced cognitive activities. In doing so, the sociocultural theory stresses on language acquisition as dynamic and based on social interaction rather than simply a cognitive task.

From the aspect of the Cognitive Load Theory (CLT),[45] a learner's working memory is typically constrained in the sense that only a limited amount of information could be retained and processed at any given time. It suggests that instruction should avoid overloading the memory in order to capitalize on the learning experience. Applying this theory to science, teaching scientific concepts in students' native language might reduce the cognitive burden associated with language processing. This reduction allows the working memory to allocate more resources to understanding and retaining the taught material, thereby enhancing comprehension. This was confirmed in listening tasks in which the use of L1 compared to L2 was reported to have beneficial impact on language learning.[46] In addition, Bian et al[47] have recently investigated the application of CLT in reading academic articles by medical students. They found that by balancing cognitive load, students were able to improve their learning efficiency.

The relationship between L1 and L2 is indeed a complex one, and the development of theories in the field has enhanced researchers' views and directions. Regardless of their differences, the above-mentioned theories emphasized that language transfer could take place whether positively or negatively. In academic settings and with adult language learners in scientific classes, it is very important to study such phenomena to understand possible ways for improving learning experiences. In this study, we situate language learning in a socially constructed and culturally sensitive environment.[44] We also considered language transfer as a meditating tool that could help students in their acquisition of advanced scientific and abstract ideas. Furthermore, we utilized the Cognitive Load Theory in relation to monolingual and bilingual teaching. By using a bilingual method in teaching as opposed to only English, the load on working memory might likely be reduced, leading students to learn more efficiently and perform better in exams.

Method

The study was conducted at the College of Sciences of Health Professions, King Saud bin Abdulaziz University for Health Science, Riyadh, Saudi Arabia. The college aim is to provide a pre-professional phase for all freshmen students admitted to the University prior to their admission to health professional college such as college of medicine. The program consists of two years (four semesters), which is designed to enhance students' English language skills and necessary knowledge of basic sciences. During their first semester, students are mostly enrolled in English courses in addition to two humanities courses taught in Arabic language. The following three semesters involve science and health science courses with little focus on English.

Participants

Ethical approval was obtained from the Institutional Review Board (IRB) at King Abdullah International Medical Research Center (KAIMRC) (approval number SP18/500/R). All participants provided their informed consent to participate in this study.

The participants were the male students who were registered in the Biology 101 course, which was taught, in the second semester of the first year. Freshmen students in their second semester were selected because, according to the university curriculum, science courses begin in the second semester. These students had recently transitioned from Arabic-medium high school education to an English-medium university environment. This made them an ideal group for examining the impact of instructional language on science learning. Biology was selected for this study because, compared to Chemistry and Physics, it relies more on conceptual understanding, descriptive content, and subject-specific terminology rather than mathematical analysis. These features make it more sensitive to the language of instruction and therefore more appropriate for evaluating the effect of bilingual versus English-only teaching. All participants were native Arabic speakers who completed their secondary education in Arabic. English proficiency was assessed through a standardized English placement test (EPT) administered upon university entry. In addition, all students in the university were enrolled in more than 14 credit hours of English courses during their first semester, including academic English, communication skills, and writing, which aimed to prepare them for English-medium instruction in subsequent semesters.

The reason only male students were included is that the university has separate campuses for male and female students, which is aligned with local cultural and educational norms, and the researchers are instructors at the male campus. It is important to note that these students were enrolled in this biology course for the first time. Students who were retaking the course were thus excluded. In this course, 243 freshmen students were enrolled.

Procedures

The study design was a quasi-experimental matching-only design where the subjects were divided into test group and control group. Both groups received a test prior to the intervention (pre-test) and after the intervention (post-test), both testes were in English. The reason for this design was that the researchers were not able to randomly assign individual students to the test and control groups. The practice at the college is that students are pre-assigned to different classes by the college, prior to the start of the academic semester. However, all classes are matched in terms of the students' performance on the college's English Placement Test (EPT). The advantage of this process is that all classes have equivalent numbers of students who scored high, medium, and low results in the EPT. In addition, control for pre-existing differences in the academic performance using a pre-test confirmed that all groups were at the same level.

Both the test and control groups were presented to the same lecture in the biology course using the same power point slides, which are written in English and delivered by the same instructor. The instructor holds a PhD in Molecular Biology from a US institution and a master's degree in medical education. Both degrees were completed in English. The instructor is a native Arabic speaker with demonstrated fluency in both English and Arabic, ensuring accurate and effective delivery of course content in both languages. The only difference between the test and the control groups was the language of teaching during the lecture. In the test group, the instructor used both the Arabic and English languages, while in the control group, he only used English. In the test group, each concept was first explained in English, followed by a second explanation where English and Arabic were used interchangeably. During this explanation, the scientific

terms were retained in English, while the meaning and elaboration were provided in Arabic. In the control group, each concept was explained twice, with both explanations delivered entirely in English. This ensured that both groups received the same level of reinforcement and instructional time, differing only in the language approach used for the second explanation. Students received the same pre- and post-test before and after the lecture to assess the amount of gained knowledge. The pre-test and the post-test consisted of 5 science questions related to the topic of the lecture. Grading the tests was based on a 0 or 1 score where 1 was given for correct answers and 0 was for wrong answers. In addition, two extra questions were added in the post-test. Students were also asked to provide their responses about their understanding of the lecture based on the language of instruction. (bilingual – test group, English-only – control group). Responses were categorized into "Yes" and "No" for each group, indicating whether the students felt the respective language approach improved their understanding. In addition, we asked students to provide their feedback on the frequency of distractions during the lecture to assess any notable differences when English-only or both Arabic and English (bilingual) was used in the lecture.

Sample Size and Sampling Technique

The suggested sample size using Piface software was 99 for control and 99 for the treatment using the following conditions (Significance level = 0.05, the power of the test = 80%, Mean difference = 0.5, Standard deviation = 1.25 point (max. point is 5 and min. point is 0). However, the total number of accessible subjects who met the inclusion criteria were 164 in the test group and 159 in the control group.

The sample was collected using a non-probability consecutive approach where all the subjects who were accessible to the researcher were used. The total number of the subjects who met the inclusion criteria was 323 divided into two test groups and two control groups by the college.

Data Analysis

Frequencies and percentages were used to describe categorical variables (eg, number of students who correctly answered the questions). For inferential statistics, as the data was not normally distributed, nonparametric analysis was used. The Mann–Whitney *U*-test was used to compare the pre-test and the post-test between the control and the test groups. P value <0.05 was considered significant.

Results

In order to assess the impact of delivering a science lecture using bilingual method (Arabic and English) vs Unilingual (English) on students understanding of the subject and their overall experience and perceptions, a total of 323 students were divided into a test group, of 164 students, and a control group, of 159 students. Both groups received a pre-test and post-test and a survey at the end of the lecture (Figure 1). The number of students who agreed to participate was 123 out of 164 (75%) for the test group and 120 out 159 (75%) for the control group.

To ensure no prior knowledge in the tested subject and both groups have equivalent academic performance, we conducted a pre-test for both groups, consisted of five questions related to the lecture. The results showed a comparable performance in the two groups, with no statistically significant difference (Figure 2). This conforms no prior knowledge of the tested material between the two groups.

In order to assess the intervention, we performed a post-test given to both test and control groups immediately at the end of the lecture. In doing so, we observed an improved performance in the test and control groups. Specifically, the number of students who scored 0 and 1 in the pre-test dropped significantly as compared to the post-test. Also, there was a slight decrease in the number of students who scored 2 in the post-test compared to the pre-test. Most notably, there was an improvement in the number of students who scored 4 and 5 out of 5 in the post-test compared to their original scores in the pre-test. Overall, students' performance in the post-test improved considerably in both group (Figure 3a). Although the control group showed improvement in the post test scores, the test groups showed better improvement, as more students scored 4 out of 5 and 5 out of 5 compared to the control group. The observed difference between the two groups was statistically significant indicating that giving the lecture in Arabic and English improved students acquisition of knowledge during the lecture (Figure 3b). In addition, to further assess the enhancement of students' understanding due

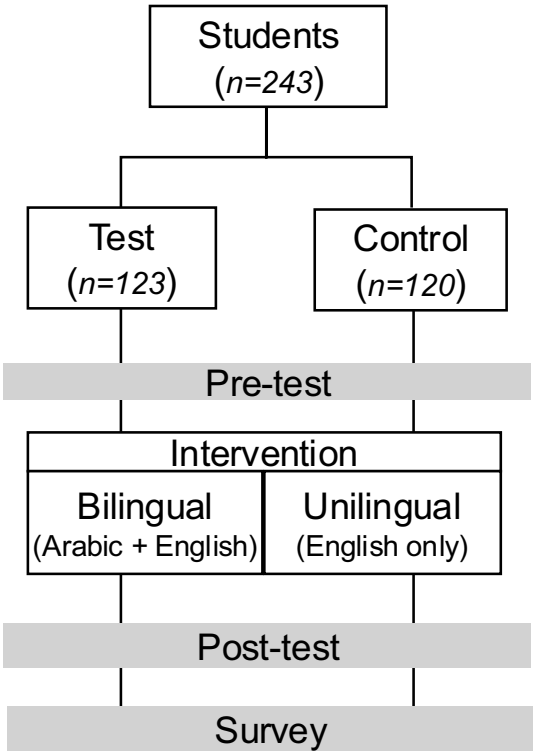

Figure 1 Summary of the study design.

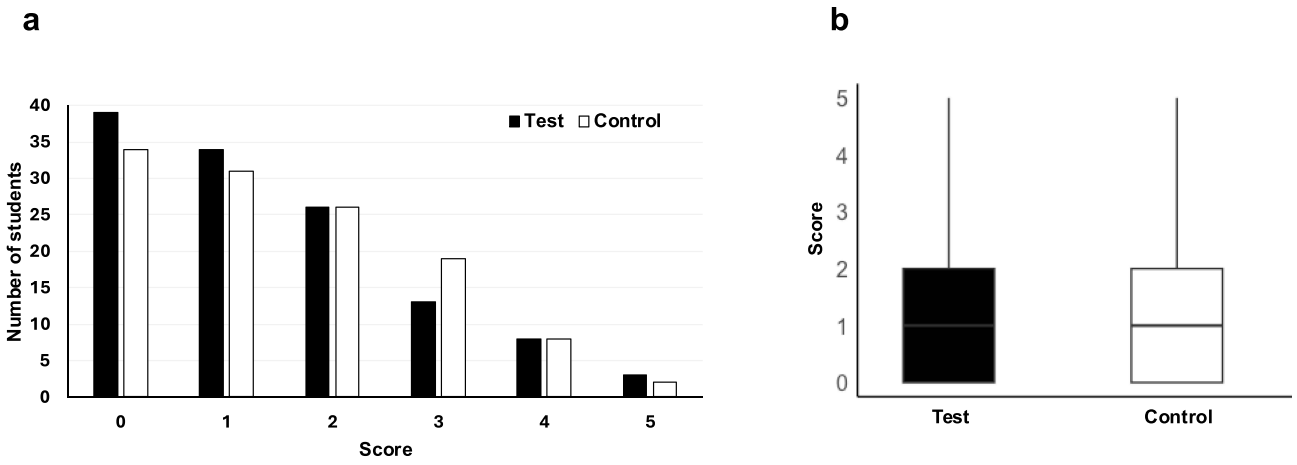

Figure 2 Performance of the Control and Test Groups in the Pre-test. (**a**) Frequency of the students' performance in the Pre-test (before intervention); (**b**) A boxplot represents the distribution of pre-test scores (before intervention) for the Test and Control groups. Boxes represent the interquartile range (IQR). The horizontal line within each box shows the median score. Whiskers extend to the smallest and largest values within 1.5 times the IQR. No statistically significant difference between the test and control group (Wilcoxon rank sum test p-value = 0.42).

to the intervention, we also included two new questions in the post-test that the students had not seen in the pre-test. The test group significantly outperformed the control group on these new questions, highlighting the effectiveness of the bilingual instructional approach (Figure 3c).

Next, we looked at the level of score improvement for each student from the pre-test to post-test scores. The level of score improvement was calculated by subtracting the score of the post-test from the score of the pre-test for each student in both groups. In the post-test, more students in the control group (37 students) showed no improvement compared to the

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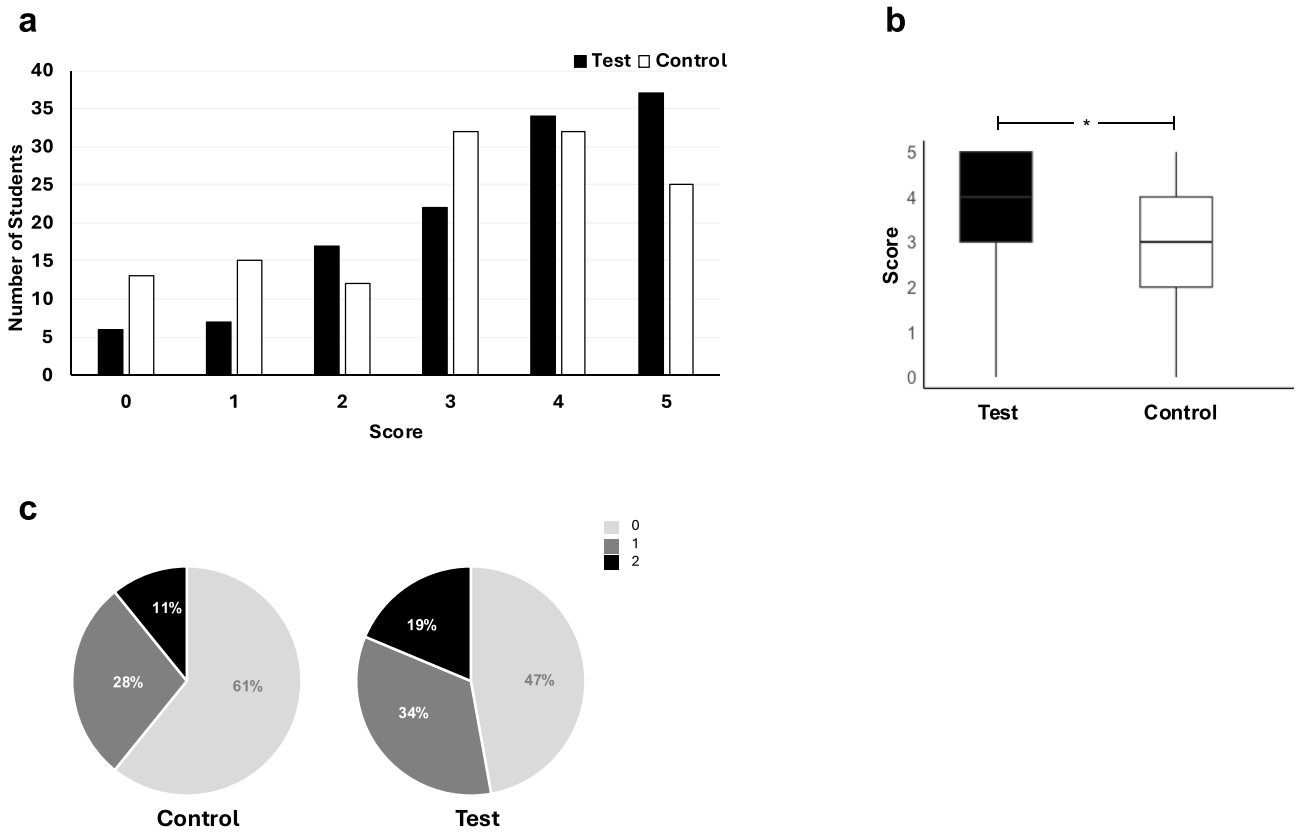

Figure 3 Performance of the Control and Test Groups in the Post-test. (**a**) Frequency of the students' performance in the Pre-test (before intervention); (**b**) The boxplot represents the distribution of post-test scores (after intervention) for the Test and Control groups. Boxes represent the interquartile range (IQR). The horizontal line within each box shows the median score. Whiskers extend to the smallest and largest values within 1.5 times the IQR. There a statistically significant difference between the test and control group (Wilcoxon rank sum test *p-value = 0.0077); (**c**) The pie chart shows the percentage of students who answered correctly both new questions correctly, only one question correctly, or none of the questions correctly.

test group (15 students). Conversely, a greater number of students in the test group (48 students) achieved an improvement of more than 2 points compared to the control group (32 students) (Figure 4a). Overall, the analysis demonstrated that students in the test group experienced significantly greater performance gains after the lecture compared to those in the control group. (Figures 4b).

Lastly, we wanted to assess the students experience and perceptions following the intervention. To this end, we investigated the effect of a bilingual versus English-only instructional approach on the frequency of student distractions during the lecture. Students in the control group (English-only) reported more distractions during the lecture compared to the test group (bilingual) (Figure 5a). To assess whether the language of instruction might contribute to students' distraction during the lecture, we asked the test group, "Do you think using English and Arabic during the lecture reduces your distraction?" and the control group, "Do you think using English only during the lecture reduces your distraction?" In the test group, 98 (86%) students answered YES, while 16 (14%) answered NO. Conversely, in the control group, 37 (32%) students answered YES, while 78 (68%) answered NO (Figure 5b). Next, we asked students to provide their feedback on their understanding of the subject matter using of either English of both English and Arabic in the lecture. In the test groups, 98% agreed that using Arabic and English helped them understand the lecture, while only 56% of the students in the control group agreed that using English only helped them to understand the lecture (Figure 5c).

Discussion

Because scientific discourse can pose many challenges for students,[48] educators need to consider language as a facilitator while teaching science courses. One of the factors that might affect students' achievements in science courses is the medium of instruction.[34,49] In this work, we attempted to assess the students' acquisition of knowledge in biology

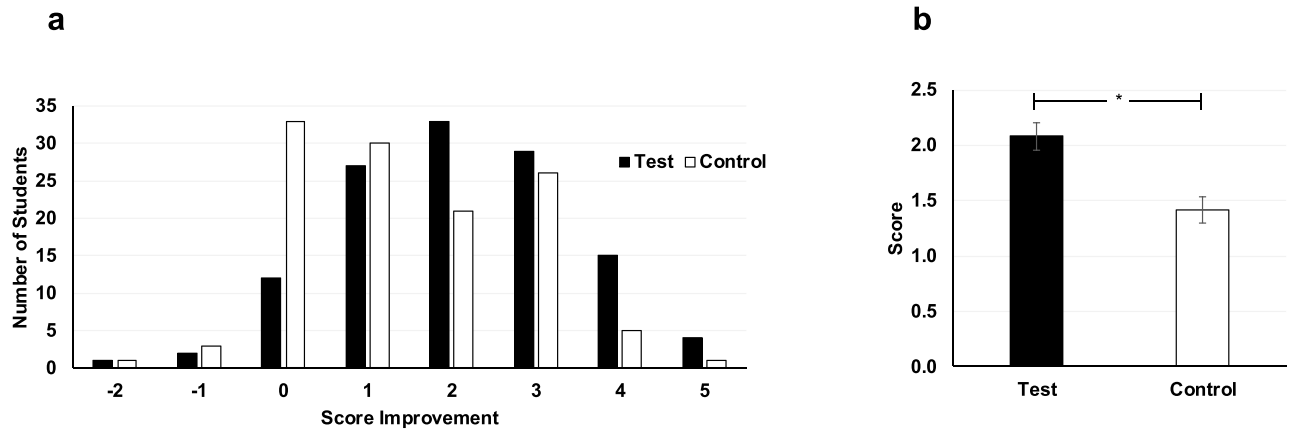

Figure 4 Improvement Scores Following Bilingual and Unilingual Instruction. (**a**) Frequency of the students' improvement scores following the intervention; (**b**) Average improvement scores following the intervention per group (There is a statistically significant difference in the improvement scores between the Test and Control groups. Wilcoxon rank sum test *p-value = 0.0002. Error bar represents standard error.

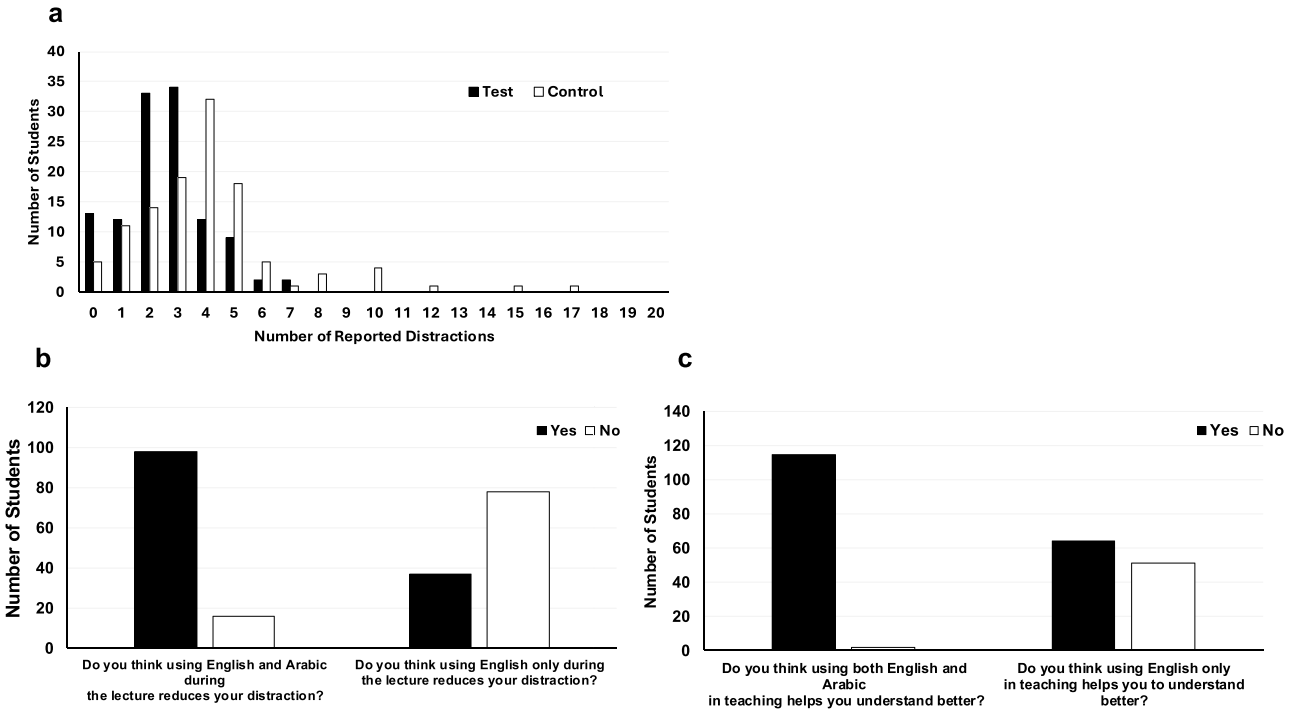

Figure 5 Student Experience and Perceptions During the Lecture. (**a**) Frequency of Student Distractions During the Lecture. The bar chart shows the frequency of students over the number of times they reported getting distracted during the lecture; (**b**) Student Responses to Language Use and Distraction Reduction. The bar chart shows student responses regarding whether the language of instruction. (bilingual – test group, Unilingual – control group) reduced their distraction. The test group was asked, "Do you think using English and Arabic during the lecture reduces your distraction?" The control group was asked, "Do you think using English only during the lecture reduces your distraction?" Responses are categorized as "Yes" or "No" for each group; (**c**) The bar chart shows the responses of students about their understanding of the lecture based on the language of instruction. (bilingual – test group, Unilingual – control group). Responses were categorized into "Yes" and "No" for each group, indicating whether the students felt the respective language approach improved their understanding.

lectures that were conducted in either a bilingual (Arabic and English) format or an English-only medium of instruction. Using a pre-test and post-test approach, our analysis showed that using both Arabic and English significantly improved the students' acquisition of knowledge after the lecture compared to English-only. This finding is less likely to be related to cognitive differences between the two groups, as the pre-test results were equivalent and showed no significant differences. In addition, English language skills were comparable, as all students were distributed into groups based on similar English Placement Test (EPT) scores. These results are in line with previous research conducted in Saudi Arabia,

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which showed that the use of the Arabic language led to students' better comprehension of knowledge.[11] One reason for such improvement compared to students who were introduced to English-only medium of instruction could be related to the Cognitive Academic Language Proficiency (CALP) skills needed to understand scientific material.[38,39] This, in turn, negatively affected students' understanding of the scientific concepts when only English was used as the medium of instruction. In lieu of using English alone, translanguaging could be utilized while teaching to reach better learning outcomes.[50]

Following the Cognitive Load Theory,[45] learners' use of their working memory should be maximized in order for them to comprehend and store information into their long-term memory. Students who were instructed solely in English might have found it challenging to retrieve information from their working memory due to the amount and nature of scientific information given in the lecture. This poses an additional challenge since they already lack the necessary CALP skills. This is also reflected by the number of distracters that students reported after the lecture. Therefore, the main goal for educators is to reduce the cognitive load on their students during teaching to enhance students' acquisition of knowledge in general and scientific learning materials specifically. Overloading the working memory during the teaching process might negatively impact students' comprehension of knowledge.[51,52] Based on this theory, teaching basic science courses solely in the English language for non-English speakers would likely increase the load on students' working memory, which they significantly need to memorize scientific vocabulary and process new scientific concepts. Alternatively, explaining science concepts using students' native language along with the English language might have less load on the working memory and better understanding of scientific concepts.

Using Arabic and English side by side might increase students' attention compared to using only one foreign language during science lectures. By incorporating Arabic into the teaching of science, students might feel more comfortable to ask questions and discuss scientific concepts. This would likely engage them more with teachers and content, backed by previous reports indicating teachers' favored use of Arabic as the medium of instruction while teaching.[10] In addition, students could refer to their first language as a linguistic resource that could help them understand various scientific concepts[53,54] leading them to higher levels of comprehension and engagement.[55] It is also noteworthy to mention that when L1 is concurrently used with L2, students' linguistic backgrounds should be carefully considered. Students' language skills such as vocabulary, reading, and grammar, which are already developed in their L1, could have a positive impact on their L2 comprehension and proved a valuable opportunity for them to enhance their language skills.[15,22] This could be the case of students in this study whose development in Arabic might have had a positive impact on their comprehension of cognitively demanding scientific content.

Conclusion

Data from this study concluded that using two languages (Arabic and English) for students whose native language is Arabic is likely to have a positive impact on enhancing students' acquisition of knowledge in a basic science lecture at a first-year, preparatory college program. In addition, despite the different attitudes of instructors towards the use of English as a medium of instruction, students' perceptions of the language of instruction should be taken into consideration by policy makers and scholars in future research. Notably, it is important to test the relationship between English proficiency and cumulative GPAs when graduating from university.[56,57]

Though teachers' attitudes towards the use of students' first language in classrooms might be conflicting, the results in this study go in line with previous research that indicated the beneficial use of two languages or more in science classrooms for different age groups such as in primary schools[53] and middle schools[58] given that lessons need to be prepared carefully according to students' needs. In addition, allowing students to practice their language as they learn science might provide them with the opportunity to improve in both English and science.[59] On the other hand, teachers' explicit and clear communication with regard to the language used in science may lead to students' better understanding and usage.[60]

Limitations in this study include the reliance on one lecture for collecting data for each group of students. Though it could be time consuming given the number of students participating, future research might look at students' progress in science over a longer period of time. Another limitation lies in restricting the study to a single course, which was biology. Biology was chosen because its emphasis on conceptual understanding and terminology—rather than mathematical

analysis—makes it more sensitive to the language of instruction and thus more suitable for evaluating the impact of bilingual versus English-only teaching. Nevertheless, other scientific areas need to be examined to see whether language plays pivotal roles in shaping students' comprehension of scientific concepts. For this study, freshmen in their second semester were selected because this is the point when basic science courses, such as Biology 101, are first introduced in the curriculum. As students are transitioning from Arabic-based high school education to English-medium university instruction, this stage provides a valuable opportunity to assess how language impacts their understanding of foundational scientific concepts. However, we acknowledge that the effect of language on learning could also be explored at higher levels in the curriculum. Other factors related to students' engagement and motivation need to be taken into consideration as well. Moreover, due to the mostly segregated system of education in Saudi universities, the only accessible participants in this study were male students. Future studies need to involve female students as well to validate the results of this study. Replication of the study in other contexts is also recommended in order to see if teaching in other languages would produce similar results.

For practical implications, teachers have to consider maximizing students' use of their first languages while teaching in a foreign language, especially in the science classroom. They also need to utilize students' already advanced higher-order linguistic processes in L1 to help advancing their L2. Likewise, policymakers need to consider the effectiveness of improving students' L1, and how that could potentially lead to better L2 learning experiences. Translanguaging, on the other hand, should be revisited especially in the Saudi context, which might pave the way for early intervention in schools.[61] Finally, as Hou et al[62] suggested, there is a need for more collaboration between STEM and bilingual education to explore the effectiveness of translanguaging in science teaching and learning.

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