

An Acoustic-Phonetic Analysis of Duration, Fundamental Frequency, and Intensity in Arabic Greetings Produced by Young Learners of Arabic

Analisis Fonetik Akustik terhadap Durasi, Frekuensi Fundamental, dan Intensitas Pengucapan Ungkapan Salam Bahasa Arab oleh Pembelajar Muda Bahasa Arab

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ABSTRAK

Abstrak

Penelitian ini mengkaji karakteristik akustik ungkapan salam bahasa Arab yang diproduksi oleh dua pembelajar muda bahasa Arab sebagai bahasa asing dengan berfokus pada durasi, frekuensi fundamental (F0), dan intensitas. Penelitian ini bertujuan mendeskripsikan pola akustik serta mengidentifikasi persamaan dan perbedaan produksi ujaran partisipan melalui desain deskriptif kuantitatif dan pendekatan fonetik akustik. Data diperoleh dari rekaman percakapan dua pembelajar di *Educourse* (usia 14 dan 9 tahun) dan dianalisis menggunakan Praat. Hasil penelitian menunjukkan adanya variasi pada ketiga parameter akustik; pembelajar yang lebih muda cenderung menampilkan nilai F0 yang lebih tinggi, sementara pola durasi dan intensitas bervariasi di setiap ungkapan salam. Meskipun bersifat deskriptif karena keterbatasan partisipan, temuan ini menggambarkan realisasi akustik ujaran pembelajar sekaligus menunjukkan manfaat analisis akustik dalam mendeskripsikan produksi ujaran bahasa Arab secara empiris.

Abstract

This study examines the acoustic characteristics of Arabic greetings produced by two young learners of Arabic as a foreign language, focusing on duration, fundamental frequency (F0), and intensity. It aims to describe acoustic patterns and identify similarities and differences using a descriptive quantitative design and an acoustic-phonetic approach. Data were obtained from recordings of two learners at Educourse (aged 14 and 9) and analyzed using Praat. The findings revealed that variations across the three acoustic parameters; the younger learner generally exhibited higher F0 values, whereas duration and intensity patterns varied across expressions. Although descriptive due to the limited number of participants, these findings illustrate the acoustic realization of learners' speech and highlight the value of acoustic analysis in describing foreign-language speech production.

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1. Introduction

Speech production can be examined through acoustic measurements that provide information about the physical characteristics of spoken utterances. Acoustic phonetics investigates speech sounds as measurable physical phenomena, allowing researchers to describe differences in how speakers produce and realize speech (Ramadhani et al., 2024). Among the parameters commonly examined are duration, fundamental frequency (F0), and intensity. Duration refers to the temporal length of a speech segment or utterance (Kurnia et al., 2024), F0 is closely associated with the perception of pitch, and intensity represents the amplitude-related level of the acoustic signal (Boersma & Heuven, 2001). These parameters provide complementary information about speech production and can be used to describe variation across speakers and utterances. However, their interpretation requires attention to the linguistic material being analyzed and the context in which the speech is produced.

Previous studies have successfully applied acoustic measurements to various speech data, such as Mandarin single-vowel productions (Thamrin et al., 2023) and Indonesian prohibitive utterances (Aditiawan et al., 2025). These investigations illustrate how acoustic analysis quantitatively describes speech production rather than relying exclusively on auditory impressions. Regarding suprasegmental features, research has examined intonation patterns in German declarative sentences (Anggraini & Ridwan, 2024) and Arabic structures, including Egyptian interrogatives (Harahap et al., 2025). While these studies highlight the importance of prosody in connected speech, communicative functions and structures vary across different linguistic expressions.

Further acoustic research on Arabic speech encompasses children's voice parameters (Nugraha et al., 2024) and consonant-length contrasts in infant-directed speech (Al-gamdi, 2026), alongside investigations into how prosodic features influence perceived accentedness and intelligibility (Winters et al., 2013). Together, these works emphasize examining acoustic parameters in relation to specific speech materials rather than generalizing across contexts.

Taken together, these studies establish a useful basis for acoustic investigations of speech production. However, they address different research objects, including isolated vowels, prohibitive utterances, German declarative sentences, Egyptian Arabic interrogatives, and segmental pronunciation errors among foreign-language learners (Falsinah & Azhari, 2024). The present study focuses specifically on Arabic greeting expressions produced by two young learners of Arabic as a foreign language in an Indonesian learning context. It examines duration, fundamental frequency (F0), and intensity within the same set of greeting expressions. This focus provides a descriptive account of three acoustic parameters in a communicative context that differs from the speech materials examined in the studies discussed above. The study does not assume that age or length of learning experience causes particular acoustic patterns; rather, it compares the patterns observed in the available recordings of the two learners.

Accordingly, this study addresses three research questions: (1) How is duration realized in the Arabic greeting expressions produced by the two young learners? (2) What fundamental-frequency patterns are observed in their productions? (3) How does intensity vary across the greeting expressions produced by the two learners? By addressing these questions, the study aims to describe similarities and differences in the acoustic realization of Arabic greetings. Its contribution is a small-scale, descriptive examination of learner speech using acoustic measurements, providing an empirical account that may inform further research on Arabic pronunciation and speech production in foreign-language learning contexts.

2. Research Method

This study employed a descriptive quantitative design with an acoustic-phonetic approach to examine the production of Arabic greeting expressions by two young learners (Delfariyadi et al., 2022). The descriptive quantitative design was used to describe and compare the acoustic measurements obtained from the recorded utterances. The acoustic-phonetic approach focused on three parameters: duration, fundamental frequency (F0), and intensity. The use of these parameters is consistent with previous acoustic studies that have employed Praat to investigate measurable characteristics of speech, including duration, frequency, and intensity. Research on Egyptian Arabic has also applied acoustic analysis to examine these parameters in spoken utterances (Harahap et al., 2025). Building on these studies, the present research examined the acoustic characteristics of Arabic greetings produced in a regular language-learning context. The analysis was descriptive and did not aim to establish causal relationships or test statistically significant differences between the participants.

The study was conducted at *Educourse*, where two Arabic learners aged 14 and nine participated. They had studied Arabic for four and two years, respectively, and represented the entire eligible population at the research site. Thus, the findings describe these participants' acoustic characteristics rather than generalize to all young Arabic learners. Data of this study were drawn from recordings of previously conducted online classes and routinely used for independent learning. Three greeting expressions were analyzed: *ṣabāḥ an-nūr*, *saʿīdah mubārakah*, and *masāʾ an-nūr*. The number of occurrences depended on their availability in the recordings. Praat was used to analyze acoustic parameters, including duration, fundamental frequency, and intensity, following its application in previous acoustic research (Dini, 2021).

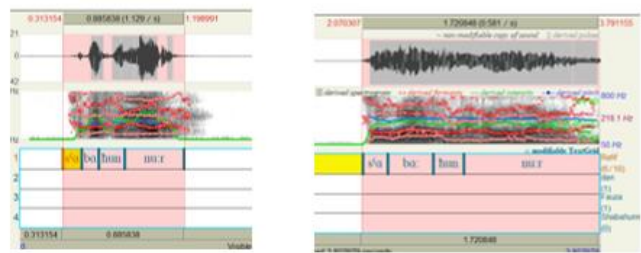
The selected utterances were analyzed using three acoustic parameters: duration, fundamental frequency (F0), and intensity. Before the measurements were obtained, the boundaries of the utterances and their constituent syllables were manually marked in Praat (Batubara & Rajagukguk, 2025). Duration was measured at two levels: the overall duration of each greeting expression and the duration of each individual syllable. These measurements were used to describe the temporal characteristics of the expressions and compare duration patterns across syllables and between the two participants. Fundamental frequency was examined through its minimum and maximum values and its pitch contour. The minimum and maximum values were used to describe the observed F0 range, while the pitch contour was examined to characterize changes in F0 throughout each utterance. Intensity was analyzed through its minimum and maximum values to describe the observed intensity range of each expression. The measurements were organized according to greeting expression and participant to facilitate descriptive comparison. This procedure follows

the general practice of using Praat to examine acoustic properties of recorded speech, as demonstrated in previous studies (Aditiawan et al., 2025). Given the limited number of participants, the interpretation was restricted to the acoustic patterns observed in the recordings and did not attribute the differences directly to age or length of Arabic-learning experience.

3. Finding and Discussion
3.1 Duration Analysis

The duration analysis of “ṣabāḥ an-nūr” revealed clear temporal differences between Student 1 (14 years old) and Student 2 (9 years old). Student 1 produces the utterance with a shorter overall duration of approximately 0.89 seconds, reflecting more mature articulatory control and temporal coordination. In contrast, Student 2 exhibits a noticeably longer duration of approximately 1.72 seconds, characterized by a slower speech tempo and prolonged vowel holding (particularly in *ba:* and **nu:*r*) due to developmental factors in speech planning and execution.

Figure 1
Duration analysis of the utterance ṣa-bā-ḥun-nūr produced by Student 1 and Student 2 in Praat.



At the syllabic level, both students segment the word into four syllables (*sa – ba – hun – nur*), but the temporal distribution differs significantly. Student 1 demonstrates more compressed syllable durations, whereas Student 2 shows consistent lengthening across all syllables. This supports the assumption that age and educational level influence speech timing, with older students producing more concise and temporally efficient utterances.

Table 1
Duration Comparison Between Student 1 and Student 2

Syllable	Student 1 (14 y/o)	Student 2 (9 y/o)	Difference	Notes
sha	0.144 s	0.182 s	+0.04	Slower syllable onset in younger speaker
ba	0.134 s	0.355 s	+0.22	Longer vowel sustains in child speech
hun	0.182 s	0.218 s	+0.36	Nasal articulation requires more time
nur	0.430 s	0.965 s	+0.53	Final-syllable lengthening more prominent

TOTAL	0.89 s	1.72 s	+1.15 s	Student 2 has 40% slower articulation rate
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Overall, the Praat-based duration analysis confirms that Student 1 exhibits shorter segmental and total durations than Student 2. These findings align with phonetic and developmental studies indicating that increasing age is associated with faster articulation rate and more stable temporal control in speech production.

Figure 2
Duration analysis of the utterance *sa-i-dah-mu-ba-ro-kah* produced by Student 1 and Student 2 in Praat

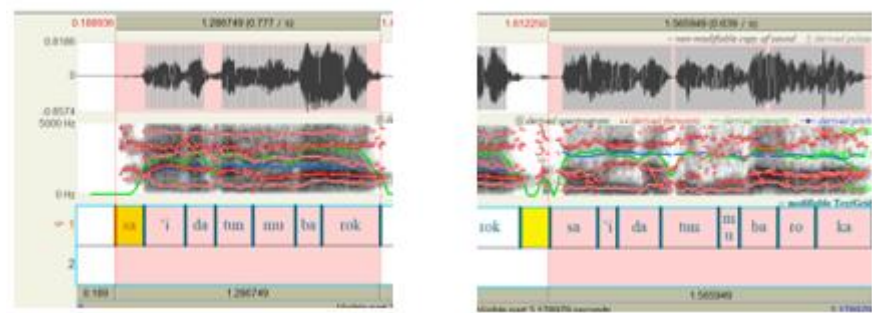


Table 2
Duration Comparison Between Student 1 and Student 2

Syllable	Student 1 (14y/o)	Student 2 (9y/o)	Difference	Notes
sa	0.15 s	0.19 s	+0.04	Younger child initiates more slowly
'i	0.21 s	0.15 s	-0.06	Longer vowel sustains
da	0.17 s	0.21 s	+0.04	Slower consonant–vowel transition
tun	0.18 s	0.22 s	+0.04	More time needed for nasal articulation
mu	0.19 s	0.15 s	-0.04	Vowel lengthening strategy
ba	0.155 s	0.19 s	+0.035	Younger speaker extends vowel duration
rok	0.24 s	0.30 s	+0.06	Largest difference, prosodic rise
ka	0.00 s	0.15 s	+0.15	Final-syllable lengthening more pronounced
TOTAL	1.295 s	1.565 s	+0.27 s	Student 2 has 40% slower articulation rate

The duration analysis of *sa'idah mubarakah* revealed differences in temporal organization between the two speakers. Student 1 (14 years old) produced the utterance in 1.295 seconds, while Student 2 (9 years old) required 1.565 seconds. Student 2 generally produced longer syllable durations, particularly in sa, da, tun, ba,

and rok, whereas Student 1 produced longer durations in 'i and mu. These variations indicated differences in speech timing between the speakers.

The most notable difference occurred in the final syllable ka showing a duration of 0.15 seconds for Student 2 and 0.00 seconds for Student 1. This value should be verified in Praat. Although Student 2's longer total duration suggests a slower production, the differences cannot be attributed solely to age or articulatory development, given that the analysis involves only two speakers.

Figure 3
Duration analysis of the utterance *ma-sā-un-nūr* produced by Student 1 and Student 2 in Praat.

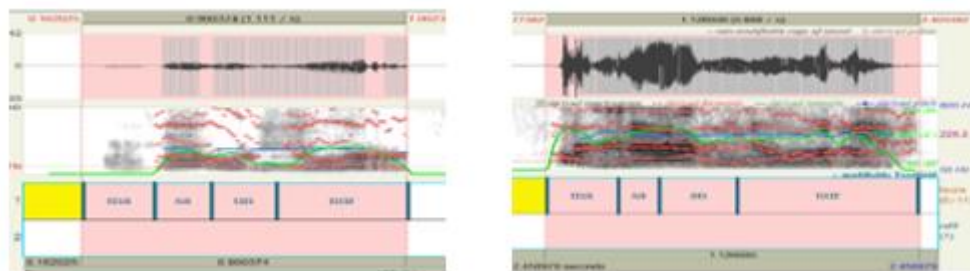


Table 3
Duration Comparison Between Student 1 and Student 2

Syllable	Student 1 (14 y/o)	Student 2 (9 y/o)	Difference	Notes
ma	0.208 s	0.330 s	+0.122 s	Younger child initiates utterance more slowly
sa	0.200 s	0.260 s	+0.060 s	Overall slower tempo in younger speaker
un/an	0.170 s	0.220 s	+0.050 s	Younger child tends to lengthen vowels
nur	0.322 s	0.310 s	-0.012 s	Final segment duration is relatively similar
Total	0.900 s	1.126 s	+0.226 s	Student 2 is about 25% slower overall

The acoustic analysis of *ma-sā-an-nūr* revealed temporal differences between the two speakers. Student 1 (14 years old) produced the utterance in 0.900 seconds, whereas Student 2 (9 years old) required 1.126 seconds. At the syllable level, Student 2 generally exhibited longer durations in the initial syllables, particularly *ma*, *sa*, and *un/an*, while the final syllable *nūr* showed relatively similar durations between the speakers. These findings indicate differences in the temporal organization of the utterance, particularly at its onset.

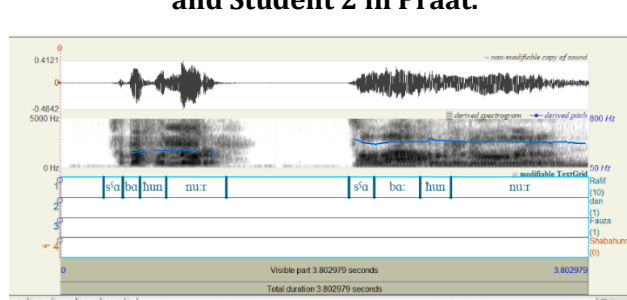
Student 1 demonstrated a more compact overall production, whereas Student 2 exhibited greater duration in the initial portion of the phrase. The comparable duration

of *nūr* suggests that temporal variation was not consistent across all syllables. Although these differences may reflect variations in articulatory timing, the limited number of participants does not support attributing them solely to age or developmental maturity. Further investigation involving more speakers and repeated recordings is needed to establish broader patterns in the temporal production of Arabic greetings.

The acoustic analysis also examined suprasegmental differences between the two speakers, focusing on pitch contour, pitch range, and prosodic patterns. Praat-generated waveforms, spectrograms, and pitch tracks were analyzed for the utterances *ša-bā-ḥun-nūr*, *sa-‘ī-dah-mu-bā-ra-kah*, and *ma-sā-an-nūr*.

3.2 Pitch Contour Analysis

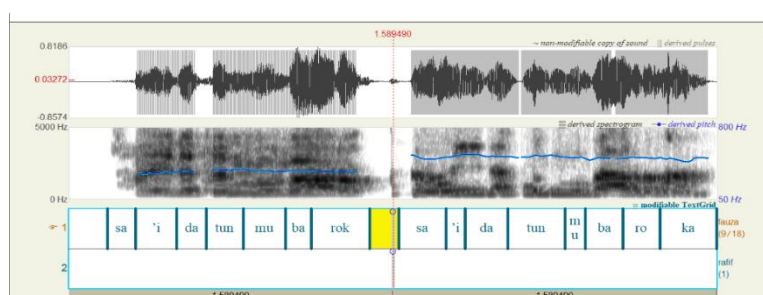
Figure 4
Pitch contour analysis of the utterance *ša-bā-ḥun-nūr* produced by Student 1 and Student 2 in Praat.



The pitch contour analysis of *šabāḥ an-nūr* revealed differences in fundamental frequency (F0) between the two participants. As shown in Figure 4, both productions displayed changes in pitch across the utterance. However, the extent of these changes differed between the speakers. Student 1, aged 14, had an F0 range of 112.68–138.45 Hz, whereas Student 2, aged 9, had an F0 range of 192.07–268.00 Hz. These measurements indicate that Student 2 produced the utterance with higher minimum and maximum F0 values than Student 1.

The difference between the minimum and maximum F0 values was 25.77 Hz for Student 1 and 75.93 Hz for Student 2. Thus, Student 2 exhibited a wider F0 range in this utterance. This difference describes the extent of the measured pitch range, but it does not by itself establish that one participant had better control of pitch or produced a more appropriate intonation pattern. The contour should therefore be interpreted in conjunction with the numerical measurements rather than treated as direct evidence of prosodic proficiency.

Figure 5
Pitch contour analysis of the utterance *sa-‘ī-dah-mu-ba-ro-kah* produced by Student 1 and Student 2 in Praat.



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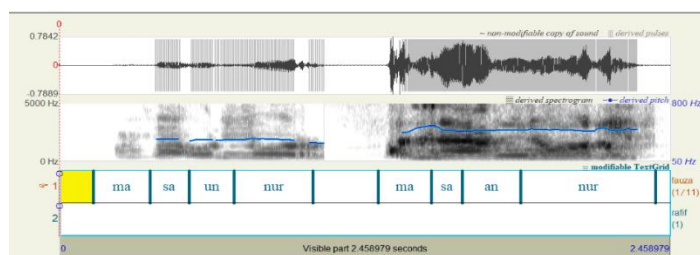
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Figure 5 presents the F0 contours of *sa'īdah mubārakah* produced by the two participants. The numerical measurements show that Student 1 had a minimum F0 of 132.60 Hz and a maximum of 161.03 Hz. In comparison, Student 2 had a minimum F0 of 210.40 Hz and a maximum of 282.05 Hz. As in the first expression, both the minimum and maximum values were higher for Student 2.

The calculated F0 range was 28.43 Hz for Student 1 and 71.65 Hz for Student 2. These values indicate that the measured pitch range of Student 2 was wider than that of Student 1 in this expression. Nevertheless, the results should be interpreted as a descriptive difference between the two recorded productions. The measurements do not establish whether the difference resulted from age, individual voice characteristics, language-learning experience, or other factors that were not examined in this study.

The comparison also demonstrates the importance of distinguishing pitch height from pitch variation. Student 2's higher F0 values indicate a higher measured pitch level, while the wider F0 range indicates a greater difference between the minimum and maximum values. Neither measurement alone is sufficient to determine the overall quality or appropriateness of the speaker's intonation.

Figure 6
Pitch contour analysis of the utterance *ma-sā-un-nūr* produced by Student 1 and Student 2 in Praat.



The pitch contours of *masā' an-nūr* also showed differences between the two participants. As reported in Table 4, Student 1 produced F0 values ranging from 119.73 to 147.74 Hz, whereas Student 2 produced values ranging from 197.19 to 278.82 Hz. The minimum and maximum F0 values were therefore higher for Student 2, consistent with the pattern observed in the other two expressions.

The F0 range for Student 1 was 28.01 Hz, compared with 81.63 Hz for Student 2. Among the three expressions, *masā' an-nūr* showed the largest difference between the participants' calculated F0 ranges. This finding suggests that the extent of pitch variation differed between their productions of this expression. However, the result should not be interpreted as evidence that the younger participant necessarily had less stable phonation, because stability cannot be established solely from the difference between minimum and maximum F0 values.

Taken together, the three expressions showed a consistent descriptive pattern: Student 2 had higher minimum and maximum F0 values and a wider calculated F0 range than Student 1. Although the magnitude of the difference varied across expressions, the pattern was observed in all three. The findings provide a basis for describing differences in pitch realization between these two young learners, but they do not establish a general developmental pattern among young learners of Arabic.

Table 4
Pitch Contour ranges (minimum and maximum values) for the utterances produced by Student 1 and Student 2.

Comparison	Minimum Pitch	Maximum Pitch
Student 1 (<i>sa-ba-hun-nur</i>)	112.68 Hz	138.45 Hz
Student 2 (<i>sa-ba-hun-nur</i>)	192.07 Hz	268.00 Hz
Student 1 (<i>sa-'i-da-tun-mu-ba-ro-k</i>)	132.60 Hz	161.03 Hz
Student 2 (<i>sa-'i-da-tun-mu-ba-ro-ka</i>)	210.40 Hz	282.05 Hz
Student 1 (<i>ma-sa-un-nur</i>)	119.73 Hz	147.74 Hz
Student 2 (<i>ma-sa-un-nur</i>)	197.19 Hz	278.82 Hz

Note. F0 range is calculated by subtracting the minimum F0 from the maximum F0. The minimum and maximum values are retained from the original manuscript.

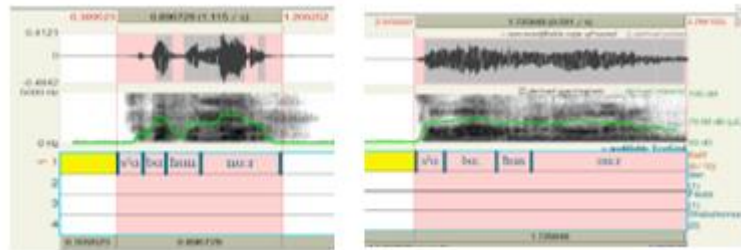
The measurements in Table 4 confirm that Student 2 had higher minimum and maximum F0 values across all three expressions. Student 2 also showed a wider F0 range in each expression. The difference in F0 range was 50.16 Hz for *ṣabāḥ an-nūr*, 43.22 Hz for *sa'īdah mubārakah*, and 53.62 Hz for *masā' an-nūr*. These comparisons summarize the numerical differences between the two participants without assuming that age alone accounts for the observed patterns.

Overall, the results demonstrate that the two participants differed in both pitch height and the extent of their measured F0 ranges. These findings provide a descriptive account of F0 variation in the selected Arabic greetings. Since the study involved only two participants, the results should be understood as characteristics of the recorded productions rather than evidence of a general relationship between age and prosodic development.

3.3 Voice Intensity Analysis

The pitch characteristics of the two students reveal notable developmental contrasts in the production of the greeting expression *ṣa-bā-ḥun-nūr*. Student 1 (Grade 8) demonstrates a low and relatively stable pitch contour, with a minimum of 112.68 Hz and a maximum of 138.45 Hz, corresponding to a narrow pitch span of 25.77 Hz. This compact range suggests that Student 1 has reached a level of phonatory maturity in which the vocal folds vibrate with greater regularity and tension control. The contour remains largely steady across the four syllables, with only moderate rises during /ṣa/ and /bā/, followed by a stabilizing trend during /ḥun/ and /nūr/. Such a pattern is indicative of a developing but more adult-like intonation system, where prosodic movements are purposeful and distributed evenly across the utterance. The stability of the pitch also suggests consistent subglottal pressure and coordinated laryngeal control features often emerging in early adolescence when the voice is transitioning toward adult resonance characteristics.

Figure 7
Voice intensity analysis of the utterance *ṣa-bā-ḥun-nūr* produced by Student 1 and Student 2 in Praat.



The intensity analysis of *ṣabāḥ an-nūr* revealed differences in the minimum and maximum intensity values between the two participants. As presented in Table 5, Student 1, aged 14, produced intensity values ranging from 34.08 to 78.90 dB, whereas Student 2, aged 9, showed values ranging from 28.44 to 75.48 dB. Student 1 therefore had higher minimum and maximum intensity values than Student 2 for this expression.

The difference between the maximum and minimum intensity values was 44.82 dB for Student 1 and 47.04 dB for Student 2. These values indicate that Student 2 had a slightly wider measured intensity range, although Student 1 reached a higher maximum intensity. The findings illustrate that the minimum and maximum values do not necessarily follow the same pattern across participants. However, the intensity range alone cannot establish which participant produced a more consistent or more appropriate utterance. The measurements describe the recorded intensity values and should be interpreted within the context of the available data.

Figure 8
Voice intensity analysis of the utterance *sa-ʿi-dah-mu-ba-ro-kah* produced by Student 1 and Student 2 in Praat.

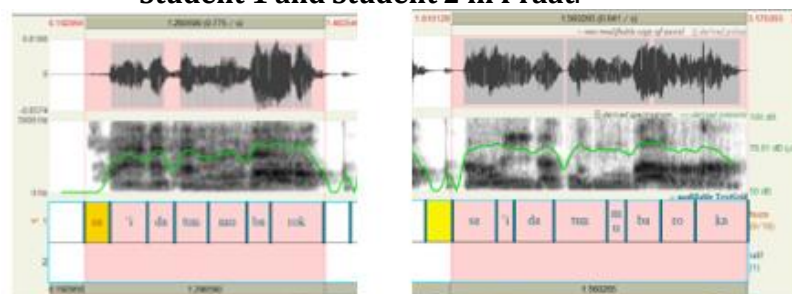
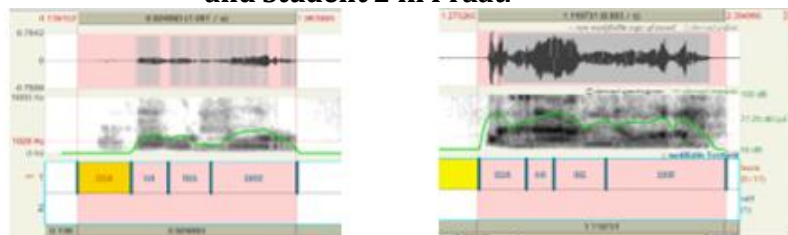


Figure 8 presents the intensity measurements for *saʿīdah mubārakah*. Student 1 had a minimum intensity of 41.79 dB and a maximum intensity of 84.19 dB. Student 2, in comparison, had a minimum intensity of 49.30 dB and a maximum intensity of 83.11 dB. In this expression, Student 2's minimum intensity was higher, whereas Student 1's maximum intensity was slightly higher.

The calculated intensity range was 42.40 dB for Student 1 and 33.81 dB for Student 2. Thus, the difference between the minimum and maximum intensity values was wider for Student 1 in this expression. This pattern differs from the results for *ṣabāḥ an-nūr*, in which Student 2 had the wider range. The contrast suggests that the relationship between the two participants' intensity measurements varied according to the expression produced.

These findings should be interpreted as descriptive observations of the recorded utterances. Minimum and maximum intensity values showed the extent of the measured intensity range but do not, on their own, explain the factors underlying the differences. The findings therefore do not establish whether the observed patterns were associated with age, individual speaking habits, learning experience, or recording conditions.

Figure 9
Voice intensity analysis of the utterance *ma-sā-un-nūr* produced by Student 1 and Student 2 in Praat.



The intensity analysis of *masā' an-nūr* showed another pattern of variation between the participants. Student 1 produced intensity values ranging from 41.02 to 71.34 dB, while Student 2 produced values ranging from 42.35 to 83.26 dB. The minimum intensity values were relatively close, with a difference of 1.33 dB. However, Student 2's maximum intensity was 11.92 dB higher than that of Student 1.

The calculated intensity range was 30.32 dB for Student 1 and 40.91 dB for Student 2. Unlike the results for *sa'īdah mubārakah*, the intensity range was wider for Student 2 in this expression. This finding further demonstrates that the differences between the participants were not uniform across all three greetings.

The measurements indicate that Student 2 reached a higher maximum intensity in *masā' an-nūr*, whereas the minimum intensity values were similar. Nevertheless, a higher maximum intensity should not automatically be interpreted as greater vocal strength or better pronunciation. Intensity measurements from recorded speech may reflect several factors, and the present analysis does not isolate their individual contributions.

Intensity Comparison

Table 5
Intensity range (minimum and maximum values) for the utterances produced by Student 1 and Student 2.

Comparison	Minimum Intensity	Maximum Intensity
Student 1 (<i>sa-ba-hun-nur</i>)	34.08 dB	78.90 dB
Student 2 (<i>sa-ba-hun-nur</i>)	28.44 dB	75.48 dB
Student 1 (<i>sa-'i-da-tun-mu-ba-ro-k</i>)	41.79 dB	84.19 dB
Student 2 (<i>sa-'i-da-tun-mu-ba-ro-ka</i>)	49.30 dB	83.11 dB
Student 1 (<i>ma-sa-un-nur</i>)	41.02 dB	71.34 dB

Student 2 (<i>ma-sa-un-nur</i>)	42.35 dB	83.26 dB
<i>Note. Intensity range is calculated by subtracting the minimum intensity from the maximum intensity. The minimum and maximum values are retained from the original manuscript.</i>		

The measurements in Table 5 show that the relationship between the participants' intensity values differed across the three expressions. For *ṣabāḥ an-nūr*, Student 1 had a higher maximum intensity, while Student 2 had a wider intensity range. For *saʿīdah mubārakah*, Student 1 had a slightly higher maximum intensity and a wider range, whereas Student 2 had a higher minimum intensity. For *masāʾ an-nūr*, Student 2 had both a higher maximum intensity and a wider range.

Overall, the intensity results do not reveal a single consistent pattern in which one participant always produced higher intensity values or a wider intensity range. Instead, the measurements varied according to the greeting expression. These findings provide a descriptive account of intensity differences in the selected utterances produced by the two young learners. Given the limited number of participants and the use of recordings from regular online classes, the results should be interpreted as characteristics of the recorded productions rather than as evidence of a general relationship between age and voice intensity.

4. Discussion

Acoustic Characteristics of Arabic Greetings Produced by Young Learners

This study examined how two young learners of Arabic as a foreign language produced three Arabic greeting expressions: *ṣabāḥ an-nūr*, *saʿīdah mubārakah*, and *masāʾ an-nūr*. By analyzing duration, fundamental frequency (F0), and intensity, the study described the acoustic characteristics of these expressions in ordinary classroom interactions. The results revealed differences between the participants, although the patterns varied across expressions and acoustic parameters.

The findings indicate that the production of familiar greetings cannot be described solely in terms of pronunciation accuracy. Differences may also occur in utterance duration, pitch movement, and intensity. These parameters provide additional information about speech production, but they represent distinct aspects of speech and should not be treated as interchangeable measures of pronunciation ability.

Duration and the Temporal Organization of Speech

Duration was examined at two levels: the overall length of each expression and the duration of its individual syllables. These measurements provide complementary information because a shorter utterance may still contain prolonged syllables, while a longer utterance does not necessarily mean that every syllable was produced slowly.

The duration of the greetings should be interpreted in relation to their syllabic structures and constituent sounds. Arabic distinguishes short and long vowels, making vowel duration relevant to temporal organization. However, syllable duration cannot be attributed to vowel length alone without examining the relevant segments and their acoustic boundaries.

Speaking rate and utterance delivery may also contribute to the observed differences. The classroom context is equally important. Because the recordings came from regular online lessons rather than a controlled experiment, the measurements reflect naturally occurring productions under conditions that were not identical.

Consequently, the observed differences cannot confidently be attributed to a single factor.

Duration should therefore be understood as a description of temporal patterns rather than a direct measure of proficiency. A shorter utterance does not necessarily indicate greater accuracy or naturalness, just as a longer utterance does not automatically indicate difficulty. Further assessment would require attention to segmental accuracy, vowel length, syllable boundaries, and communicative context.

Fundamental Frequency and Pitch Realization

The F0 analysis revealed a consistent numerical difference across the three expressions: Student 2 had higher minimum and maximum F0 values and a wider F0 range than Student 1. These findings indicate that the younger participant's recorded productions had higher measured pitch levels and greater differences between minimum and maximum F0 values. Pitch height and pitch range represent different properties. A higher pitch does not necessarily imply a wider range, and a wider range does not automatically indicate inappropriate or uncontrolled intonation. While minimum and maximum values summarize the observed range, pitch contours show how F0 rises and falls throughout an utterance. Both forms of evidence are therefore important for interpreting pitch realization.

Although Student 2 demonstrated wider F0 ranges, this finding alone cannot establish less stable pitch control. Such an interpretation would require an appropriate reference pattern or comparison with a larger group of speakers. Similarly, the participants' age and learning experience differed simultaneously: Student 1 was 14 years old and had studied Arabic for four years, whereas Student 2 was nine years old and had studied Arabic for two years. The study cannot determine whether age, learning experience, individual voice characteristics, or other factors explain the observed differences.

Previous research provides a methodological context for these findings. Harahap et al. (2025), for example, examined suprasegmental features, including fundamental frequency and duration, in Arabic utterances using acoustic analysis. Similarly, Al-Gamdi (2026) demonstrated how acoustic dimensions such as F0 and intensity manifest differently across speaker demographics in Arabic speech. While their research illustrates the application of acoustic measurements to Arabic utterances, the present study focuses specifically on greeting expressions produced by foreign-language learners in classroom interactions. The different speech materials and research contexts mean that the findings should be treated as complementary rather than directly comparable.

Intensity and Differences Between Greeting Expressions

Unlike F0, intensity showed no consistent pattern across the three expressions. Student 1 had higher maximum intensity values for *ṣabāḥ an-nūr* and *saʿīdah mubārakah*, whereas Student 2 recorded a higher maximum value for *masāʾ an-nūr*. The direction of the differences therefore depended on the expression being produced.

These findings indicated that neither participant consistently exhibited a higher maximum intensity across all greetings. However, acoustic intensity should be distinguished from perceived loudness, which concerns how sound is heard. Higher maximum intensity does not, by itself, establish greater vocal effort, deliberate voice raising, or clearer pronunciation.

The recordings were obtained from routine online classes rather than a controlled recording environment. Consequently, the measured intensity may reflect both speech production and recording conditions. Similarly, a wider intensity range indicates a greater difference between minimum and maximum values but does not establish whether the changes were appropriate to the communicative context. Intensity is therefore most informative as part of the overall acoustic description rather than as a basis for ranking pronunciation ability. The results demonstrate differences between the recorded productions, but their direction and magnitude varied across the greetings.

Understanding Duration, F0, and Intensity Together

Considering the three parameters together provides a broader description of the participants' speech. Duration represents temporal organization, F0 describes pitch characteristics, and intensity reflects the strength of the recorded acoustic signal. The findings show that differences between the participants were not uniform across these dimensions. This distinction is important because pronunciation cannot be adequately characterized by a single overall measure. A difference in pitch does not necessarily correspond to a difference in intensity, while temporal differences cannot be inferred directly from either parameter. The study therefore demonstrates the value of examining multiple acoustic properties separately.

Nevertheless, these parameters do not provide a complete assessment of pronunciation. They do not directly establish intelligibility, intonational appropriateness, or segmental accuracy. Such questions would require additional evidence, including listener judgments, systematic consonant and vowel analysis, or comparisons with suitable reference speakers. Examining three expressions also helps distinguish recurring patterns from expression-specific differences. The consistent F0 differences contrast with the less uniform intensity results, illustrating that the participants' acoustic characteristics cannot be summarized by a single general claim about greater or lesser variation. The most defensible conclusion is that the two participants produced the selected greetings with different temporal and acoustic characteristics. The findings document these differences without establishing that either participant demonstrated superior overall prosodic control.

Furthermore, while the present study focuses exclusively on suprasegmental acoustic parameters (duration, F0, and intensity), foreign-language pronunciation is inherently multifaceted. Previous research on Arabic and Indonesian learner phonology has documented various segmental challenges, such as phonological errors in vowels and consonants (Rafkahanun, 2021) and context-sensitive substitutions in nasal consonants (Hasana & Subiyanto, 2025). Taken together, these findings suggest that a comprehensive evaluation of Arabic pronunciation proficiency requires examining both segmental accuracy and suprasegmental organization.

Limitations and Directions for Further Research

Several limitations should be considered when interpreting the findings. First, the study included only two participants, who constituted the entire eligible population of Arabic learners at *Educourse* during the research period. The results describe these particular learners and cannot represent the broader population of young Arabic learners. Second, the participants differed in both age and learning experience. Student 1 was older and had studied Arabic longer than Student 2, making it impossible to determine whether the observed acoustic differences were associated with age,

learning experience, individual voice characteristics, or a combination of factors. Future research could include learners of different ages with comparable learning experience or learners of similar ages with different lengths of Arabic study. Third, the recordings came from routine online classes rather than a controlled experiment with a predetermined number of repetitions. Although this approach captures speech from a natural learning context, the number of usable instances depended on the availability of each greeting, limiting comparisons under identical conditions.

Future studies could combine classroom recordings with systematic recording procedures in which participants produce each expression several times under comparable conditions. Larger participant groups and appropriate reference data from proficient Arabic speakers could also help distinguish individual patterns from broader tendencies. Finally, future research could extend the analysis to segmental realization and listener perceptions. Such additions should follow specific research questions: intelligibility studies require listener evidence, while investigations of vowel length require closer examination of the relevant segments. This approach would connect acoustic measurements more directly with the particular aspects of Arabic pronunciation under investigation.

5. Conclusion

This study examined the suprasegmental features of Arabic greetings produced by two child learners at different ages and stages of Arabic learning. The analysis focused on duration, fundamental frequency (F0), and intensity to describe how these acoustic features were realized in three expressions: *ṣabāḥ an-nūr*, *saʿīdah mubārakah*, and *masāʾ an-nūr*. The findings showed differences between the two learners across the three expressions, although the patterns varied depending on the acoustic parameter and the expression being produced. Student 2 generally exhibited higher minimum and maximum F0 values and a wider F0 range than Student 1, whereas the intensity measurements did not show a consistent pattern across all expressions. These findings revealed that the acoustic characteristics of the greetings cannot be adequately described through a single parameter alone.

The results provide a descriptive account of individual variation in the pronunciation of Arabic greetings. However, because the study involved only two learners and relied on recordings from regular online classes, the findings should not be generalized to Arabic child learners as a whole. Differences in age and duration of Arabic learning were present between the participants, but this study does not establish either factor as the cause of the observed acoustic patterns. Future research involving a larger number of learners, more controlled recording conditions, and a broader range of Arabic expressions could provide a more comprehensive understanding of acoustic variation in the pronunciation of Arabic by young foreign-language learners.

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