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ANALYSIS OF THE IMPACT OF USING VOICE CONNECTING BOX ON CHILDREN'S CONCENTRATION AND FOCUS IN LEARNING THE TRUTHS OF SOUND LANGUAGE IN AL-QURAN EDUCATION

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Abstract

This study examined the effectiveness of Voice Connecting Box (VCBox), an audio management technology, in enhancing concentration and pronunciation accuracy during Quranic learning among elementary school children. Using a mixed-methods approach with a randomized controlled design, 60 students (ages 7-12) were divided into experimental (n=30) and control (n=30) groups, with the experimental group using VCBox during 12 weeks of Quranic learning sessions. Data were collected through Hijaiyah Pronunciation Accuracy Tests (HPAT), systematic classroom observations, questionnaires on learning environment perceptions, and qualitative interviews. Results demonstrated that the experimental group showed significantly greater improvement in pronunciation accuracy scores (16.74 points vs. 5.66 points, $p<0.001$) and focus duration (from 12.3 to 21.8 minutes vs. 12.5 to 15.1 minutes for control group). Strong correlations were identified between sound detail awareness and pronunciation accuracy ($r=0.82$), and between focus duration and learning outcomes ($r=0.78$). Qualitative analysis revealed four dominant themes: enhanced auditory awareness, reduced cognitive load, personalized learning experience, and implementation challenges. These findings indicate that controlling auditory input through VCBox significantly improves children's concentration and pronunciation accuracy in Quranic learning by optimizing the auditory environment and reducing cognitive load. This research contributes to the integration of cognitive neuroscience principles into Islamic education practices and supports technology-enhanced approaches for improving Quranic learning outcomes.

Keywords: Voice Connecting Box (VCBox), Quranic learning, pronunciation accuracy, cognitive load, auditory processing.

INTRODUCTION

Learning the Quran for children requires a high level of concentration and auditory sensitivity. The ability to listen, distinguish, and pronounce the sounds of the hijaiyah letters correctly is an important foundation in reading the Quran (Arshad et al., 2020). In the context of Islamic religious education, the accuracy of pronunciation (makhraj) and the application of correct tajwid rules are crucial aspects that determine the quality of a person's reading of the Quran.(Mohamed et al., 2024). However, in the digital age full of auditory distractions, children face great challenges in maintaining focus and concentration during the learning process.

Recent neuroscience research suggests that children are more susceptible to auditory distractions than adults. According to Klatte et al. (2013), "Background noise, such as overlapping conversations or classroom noise, significantly reduces children's ability to process auditory information by up to 40%, compared to only an 11% reduction in adults."(Klatte et al., 2013, p. 326). This situation certainly has a negative impact on children's ability to absorb fine details in language learning and pronunciation, including in the context of learning the Qur'an.

Several previous studies have explored the relationship between acoustic environment and learning. Bidelman (2025) found that the quality of auditory input had a direct correlation with the accuracy of phoneme production in children aged 5-9 years.(Bidelman et al., 2025). Meanwhile, Kim (2022) highlighted the importance of minimizing external sound disturbances to improve children's cognitive performance in tasks that require high concentration.(Kim et al., 2022). However, there is still a gap in the literature regarding specific technological interventions that can improve children's ability to process fine auditory details, particularly in the context of Quran learning.

Voice Connecting Box (VCBox) is an innovative solution designed to provide greater control over the auditory environment. This device allows personalized volume settings for each ear, isolates unwanted sounds, and improves auditory focus.(Anne, 2025). Although similar technologies have been applied in the context of music and foreign language learning, their application in Quran learning has not been widely explored.

The phenomenon of auditory disorders in children is increasingly worrying. Children's ability to filter out irrelevant sounds develops gradually during childhood, with full maturation only being achieved in late adolescence. This puts children in the language learning phase in a very vulnerable position to external disturbances.(Cherry, 1981; Rohr et al, 2018). This condition is further exacerbated by increasing exposure to gadgets and digital media which creates an unhealthy "auditory diet" for children's cognitive development.(Vedechkina & Borgonovi, 2021).

In the context of learning the Qur'an, the accuracy of the sound of the language becomes very crucial. Al-Faruqi (1989) emphasized that "Every phonology in the Qur'an has intrinsic and exoteric values that affect the meaning and beauty of the holy book."(Faruqi & Faruqi, 1989, p. 42). Therefore, the ability to hear clearly and reproduce these sounds accurately becomes the main goal in Quranic education, especially at the beginner level.

Based on the identified gaps, this study aims to analyze the impact of using Voice Connecting Box (VCBox) on children's concentration and focus in learning the Quran, especially in terms of the accuracy of language sounds. Specifically, this study intends to: 1) Measure the difference in children's concentration levels when learning the Quran with and without VCBox, 2) Evaluate the accuracy of pronunciation of the makhraj of hijaiyah letters before and after using VCBox, 3) Analyze the relationship between auditory environmental control and the ability to maintain focus on learning the Quran, 4) Identify factors that influence the effectiveness of VCBox in the context of learning the Quran

The results of this study are expected to provide significant contributions to the development of more effective Al-Quran learning methods, as well as enrich the literature on the use of technology in Islamic education. In a broader context, this study also has the potential to provide solutions to the challenges of auditory disorders in the learning process, which are increasingly relevant in today's digital era.

METHOD

This study uses a mixed-method approach with a quasi-experimental design to analyze the impact of using Voice Connecting Box (VCBox) on children's concentration and focus in learning the Quran. This approach was chosen because it is able to combine the strength of quantitative data to measure measurable changes with in-depth insights from qualitative data, thus providing a comprehensive understanding of the phenomenon being studied. A quasi-experimental design with a pretest-posttest control group design was implemented to compare the experimental group using VCBox with the control group following conventional learning, allowing researchers to measure the effects of the intervention more accurately.

The research population was students who were studying the Al-Quran at an Islamic educational institution inin Jakarta and Bekasi. The research sample consisted of 60 children aged 7-12 years who were studying the Quran at SDI (Islamic Elementary School). The sampling technique used was purposive sampling with stratification based on age and level of ability to read the Quran. Inclusion criteria included students who had known the hijaiyah letters, did not have significant hearing impairments, and obtained parental consent to participate in the study. The sample was then randomly divided into two groups: 30 students in the experimental group using VCBox and 30 students in the control group learning with conventional methods.

The research instrument was designed comprehensively to measure various aspects relevant to the research objectives. For quantitative measurements, the researcher used: (1) the Hijaiyah Pronunciation Accuracy Test (TKPH) developed together with experts in the science of tajwid to assess the accuracy of makhraj and tajwid; (2) the Behavioral Observation of Students in Schools (BOSS) which was modified to measure the duration of focus and the frequency of unfocused behavior; (3) the Learning Environment Perception Questionnaire (KPLB) to measure students' perceptions of their learning experiences; and (4) the Al-Quran Learning Concentration Scale (SKPAQ) which measures students' subjective concentration levels. For qualitative data collection, the researcher used semi-structured interview guidelines, classroom observation protocols, and focus group discussion guides that had been validated by experts in Al-Quran education and educational psychology.

The data collection procedure was carried out in three main stages. The first stage was baseline measurement for both groups, including the TKPH pretest, initial observation using BOSS, and filling in the KPLB by students. The second stage was the

implementation of the intervention for 12 weeks, where the experimental group learned the Quran using VCBox with volume personalization and sound isolation features, while the control group followed conventional learning. During the intervention period, classroom observations were conducted periodically (weeks 2, 6, and 10) to record changes in focus behavior. The third stage was the final measurement which included the TKPH posttest, final observation using BOSS, filling in the KPLB and SKPAQ, and conducting in-depth interviews with 10 students and 5 teachers selected purposively, followed by 4 focus group discussion sessions.

Data analysis techniques integrated quantitative and qualitative approaches. For quantitative data, analysis of covariance (ANCOVA) was used to compare posttest results between experimental and control groups by considering pretest scores as covariates. Paired t-test was applied to analyze within-group changes from pretest to posttest. Pearson correlation analysis was used to explore the relationships between research variables. For qualitative data, thematic analysis with an inductive-deductive approach was used to identify, analyze, and report patterns (themes) in interview and observation data. The analysis process included familiarization with the data, initial coding, theme search, theme review, defining and naming themes, and compiling a report. The integration of quantitative and qualitative data was carried out through the triangulation method to strengthen the validity of the findings.

To ensure the validity and reliability of the research results, several steps were strictly implemented. The validity of the quantitative instrument was guaranteed through content validation by a panel of experts consisting of experts in the science of tajwid, educational psychologists, and research methodology experts. The reliability test of the instrument was carried out using the test-retest method and Cronbach's alpha calculation (minimum 0.80 for all instruments). For qualitative data, credibility was guaranteed through triangulation of data sources (students, teachers, researcher observations) and triangulation of methods (interviews, observations, FGDs). Member checking was carried out by confirming the researcher's interpretation with some participants. Dependability was guaranteed through an audit trail that documented all methodological decisions. In addition, the researcher used negative case analysis to identify cases that did not fit the emerging pattern, thereby enriching the interpretation of the data. Reflexive journaling was applied to control researcher bias during the research process. The research protocol has also been approved by the research ethics committee at the relevant institution, with special attention to ethical considerations when conducting research with children.

This methodological approach is well suited to achieving the research objectives because it is able to provide measurable measurements of the impact of VCBox on concentration and pronunciation accuracy, while exploring the subjective experiences of participants and learning dynamics that cannot be captured by quantitative data alone. The quasi-experimental design allows researchers to isolate the effects of the intervention by minimizing the influence of external variables, while the qualitative

component helps explain the mechanisms underlying the observed changes and identify contextual factors that influence the effectiveness of VCBox in Quran learning.

RESULTS

1. VCBox Description: Technology to Support Al-Quran Learning

Voice Connecting Box (VCBox) is an innovative audio management device specifically designed to optimize the auditory learning environment (Figure 1). The device is developed based on cognitive neuroscience principles with a focus on auditory processing and cognitive load management.

As seen in Figure 2, the VCBox is a compact cube measuring 15×15×15 cm with a sturdy construction and intuitive interface. It is equipped with eight control knobs that allow for precise audio adjustment: Volume A (L/R), Volume B (L/R), Microphone Volume, and Master Volume. This design allows for independent audio input and output settings for teachers (Input A) and students (Input B), creating a fully customizable learning environment.

The VCBox audio connection system enables high-quality sound transmission (24-bit/48kHz) with low latency (<5ms), ensuring the crucial timing in pronunciation learning. Through integrated microphone and headphone ports, the VCBox isolates the voices of teachers and students from environmental distractions, while allowing for smooth interaction between the two.

As a key component of the intervention in this study, the VCBox was designed to address common challenges in conventional Quran learning, where auditory impairments and limitations in phonetic discrimination often act as barriers. The device creates a "personal auditory space" without the need for expensive soundproof rooms, making it an affordable solution with an investment of around IDR 7,500,000 per unit that can be used interchangeably by multiple students.

Figure 1. VCBox

VCBox's ability to isolate and enhance the clarity of auditory input is critical in learning the hijaiyah alphabet, which requires high-level phonetic discrimination. In traditional classroom settings, students often have difficulty distinguishing the sound characteristics of similar letters such asﺚ(tsa) andس(sin), orح(ha) andه(ha). VCBox addresses this problem by creating an optimal audio environment, allowing students to hear subtle details in pronunciation that might be missed under conventional learning conditions.

Initial observations during the pilot phase showed that students using VCBox demonstrated significant improvements in sustained attention and active engagement during learning sessions. Teachers also reported ease in providing more precise corrective feedback, as communication between teacher and student was not disrupted by ambient noise.

2. Demographic Characteristics of Participants

This study involved 60 students consisting of 32 males (53.3%) and 28 females (46.7%) with an age range of 7-12 years (M = 9.4, SD = 1.6). Table 1 displays the distribution of demographic characteristics and initial Quran reading ability levels of participants in both groups.

Table 1.Demographic Characteristics and Initial Abilities of Participants

Characteristics	Experimental Group (n=30)	Control Group (n=30)	p-value
Gender			
- Man	16 (53.3%)	16 (53.3%)	0.795
- Woman	14 (46.7%)	14 (46.7%)	
Age (years)			
- 7-8	10 (33.3%)	9 (30.0%)	0.842
- 9-10	12 (40.0%)	13 (43.3%)	
- 11-12	8 (26.7%)	8 (26.7%)	
Initial Ability Level			
- Beginner	11 (36.7%)	12 (40.0%)	0.912
- Intermediate	14 (46.7%)	13 (43.3%)	
- Carry on	5 (16.7%)	5 (16.7%)	

Table 1 presents the demographic characteristics and initial ability levels of the study participants in detail. The gender distribution in both groups showed an identical composition, with each group consisting of 16 male students (53.3%) and 14 female students (46.7%). The p-value of 0.795 confirmed that there was no significant difference in gender distribution between the two groups.

The age distribution of participants was also relatively balanced, with most students in the 9-10 age group (40.0% in the experimental group and 43.3% in the control group). The 7-8 age group was the second largest proportion, followed by the 11-12 age group which had the same number in both groups (26.7% each). The statistical test produced a p-value of 0.842, indicating that there was no significant difference in age distribution between the experimental and control groups.

The initial Qur'an reading ability level was also grouped into three categories: beginner, intermediate, and advanced. In the experimental group, the majority of students were at the intermediate level (46.7%), followed by beginner (36.7%), and advanced (16.7%). A similar pattern was also seen in the control group with slight variations in beginner (40.0%) and intermediate (43.3%) levels, while advanced had an identical proportion (16.7%). The p-value of 0.912 indicated that there was no significant difference in the distribution of initial proficiency levels between the two groups.

This equality of demographic characteristics and baseline abilities is essential to minimize potential bias in the study, ensuring that any differences observed after the intervention can be attributed to the use of the VCBox, rather than differences in participants' baseline characteristics. The chi-square test results indicate that randomization has successfully created two groups that are comparable on all important parameters before the start of the intervention.

3. Focus Duration and Frequency of Unfocused Behavior

Observations using the modified Behavioral Observation of Students in Schools (BOSS) produced data on the duration of focus and frequency of unfocused behavior during a 30-minute Quran learning session, as presented in Figure 2.

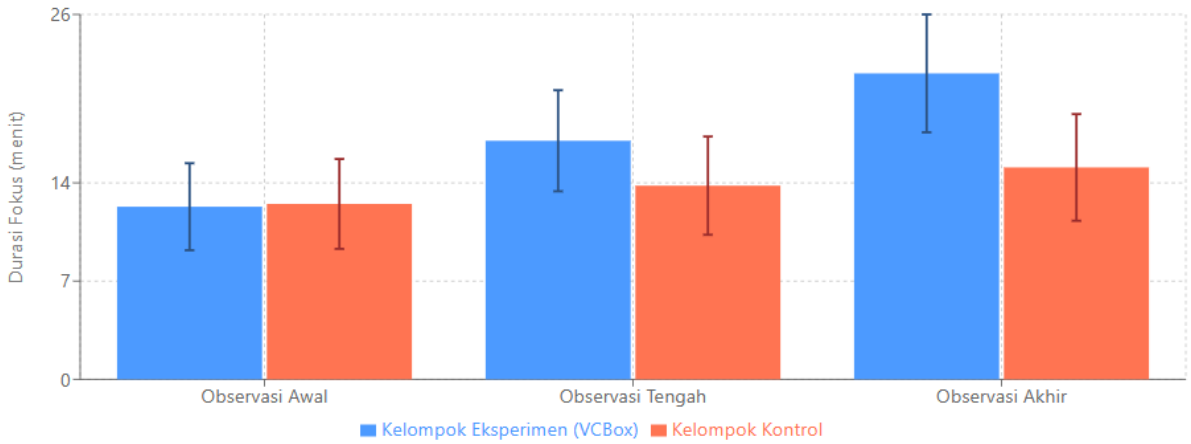

Figure 2. Comparison of Average Focus Duration (in minutes) During Observation

The experimental group showed a significant increase in focus duration from baseline (M = 12.3 min, SD = 3.1) to final observation (M = 21.8 min, SD = 4.2), while the control group showed a smaller increase from baseline (M = 12.5 min, SD = 3.2) to final observation (M = 15.1 min, SD = 3.8). A repeated-measures ANOVA showed a significant interaction between time and group ($F(2,116) = 28.73$, $p < 0.001$, $\eta^2 = 0.33$). The frequency of disengagement behavior also showed a consistent pattern, with the experimental group experiencing a greater decrease in disengagement behavior (from 18.5 ± 4.3 to 6.7 ± 2.8 events per session) than the control group (from 18.2 ± 4.5 to 13.9 ± 3.7 events per session).

4. Comparison of Hijaiyah Pronunciation Accuracy Scores

The results of the analysis of the differences in pretest and posttest scores of the Hijaiyah Pronunciation Accuracy Test (TKPH) between the experimental and control groups are presented in Table 2.

Table 2.Comparison of TKPH Scores Between Experimental and Control Groups

Group	Pretest	Posttest	Difference	t	p-value
Experiment	68.43 (SD = 7.21)	85.17 (SD = 6.34)	16.74 (SD = 4.92)	18.65	<0.001*
Control	67.87 (SD = 7.56)	73.53 (SD = 7.12)	5.66 (SD = 3.28)	9.45	<0.001*

*Significant at p<0.05

Table 2 displays a comprehensive comparison of the Hijaiyah Pronunciation Accuracy Test (TKPH) scores between the experimental and control groups, both before and after the intervention. The pretest scores showed relatively equal starting points between the two groups, with the experimental group having a mean score of 68.43 (SD = 7.21) and the control group having a mean score of 67.87 (SD = 7.56). This equivalence strengthens the internal validity of the study and confirms that both groups started from comparable levels of ability.

After the 12-week intervention period, posttest results showed improvements in both groups, but with substantial differences in magnitude. The experimental group achieved a mean score of 85.17 (SD = 6.34), indicating an increase of 16.74 points (SD = 4.92) from the pretest score. In contrast, the control group achieved a mean score of 73.53 (SD = 7.12), with a more moderate increase of 5.66 points (SD = 3.28).

Paired t-tests for each group confirmed that the improvement in scores in both groups was statistically significant, with $t = 18.65$ ($p < 0.001$) for the experimental group and $t = 9.45$ ($p < 0.001$) for the control group. However, the difference in score between the two groups (16.74 vs. 5.66) indicated that the use of VCBox resulted in almost three times the improvement compared to the conventional method.

To control for the influence of baseline scores on the final outcome, an analysis of covariance (ANCOVA) was conducted using pretest scores as a covariate. The results of this analysis confirmed a significant difference between the two groups ($F(1,57) = 82.36$, $p < 0.001$) with a large effect size ($\eta^2 = 0.59$). The eta square value of 0.59 indicates that 59% of the variation in posttest scores can be explained by the use of VCBox, after controlling for differences in pretest scores. Based on Cohen's convention, this effect size is considered large and indicates a substantial impact of the intervention given.

These data clearly illustrate the superiority of using VCBox in improving the accuracy of pronouncing the hijaiyah letters compared to conventional learning methods, with the magnitude of the difference being not only statistically significant but also practically meaningful.

5. Perception of Learning Environment and Subjective Concentration

Table 3 presents the results of the Learning Environment Perception Questionnaire (KPLB) and the Al-Quran Learning Concentration Scale (SKPAQ) after the intervention period in the form of mature scores (percentage of the maximum score).

Table 3.KPLB and SKPAQ Maturity Scores After Intervention (in%)

Variables	Experimental Group	Control Group	t	p-value
KPLB				
- Comfortable Learning Environment	87.40 (SD = 8.40)	65.00 (SD = 12.20)	8.36	<0.001*
- Ease of Hearing	90.40 (SD = 7.60)	63.60 (SD = 11.40)	10.84	<0.001*
- Minimize Disturbances	89.00 (SD = 8.80)	58.80 (SD = 13.60)	10.21	<0.001*
SKPAQ				
- Ability to Maintain Focus	85.60 (SD = 9.20)	62.40 (SD = 11.80)	8.65	<0.001*
- Understanding Teacher Instructions	87.20 (SD = 8.20)	68.60 (SD = 10.60)	7.63	<0.001*
- Sound Detail Awareness	88.20 (SD = 7.40)	64.20 (SD = 12.40)	9.12	<0.001*

*Significant at p<0.05

Table 3 provides a detailed comparison of students' subjective perceptions of the learning environment and their concentration levels after the 12-week intervention period. Data was collected using two instruments: the Learning Environment Perception Questionnaire (KPLB) and the Al-Quran Learning Concentration Scale (SKPAQ). Results are presented in the form of a mature score converted into a percentage of the maximum score, making interpretation and comparison easier.

In the KPLB dimension, the experimental group using VCBox consistently reported higher maturity scores in all aspects compared to the control group. For the variable "Comfort of Learning Environment," the experimental group recorded a maturity score of 87.40% (SD = 8.40), significantly higher than the control group with a score of 65.00% (SD = 12.20). This difference was statistically significant ($t = 8.36$, $p < 0.001$), indicating that students using VCBox felt significantly more comfortable with their learning environment.

The most striking differences were seen in the variables "Ease of Hearing" and "Minimization of Distraction." In the aspect of ease of hearing, the experimental group obtained a mature score of 90.40% (SD = 7.60), while the control group only achieved 63.60% (SD = 11.40), resulting in the highest t-value of 10.84 ($p < 0.001$). Similarly, for minimizing distractions, the experimental group recorded a score of 89.00% (SD = 8.80), significantly higher than the control group with a score of 58.80% (SD = 13.60), with a t-value of 10.21 ($p < 0.001$). The largest differences in mature scores in these two variables (26.80% for ease of hearing and 30.20% for minimizing distractions) directly reflect the primary function of VCBox in optimizing auditory input and minimizing external distractions.

A similar pattern was also seen in the SKPAQ dimension that measures students' subjective concentration. On the variable "Ability to Maintain Focus," the experimental group recorded a mature score of 85.60% (SD = 9.20), significantly higher than the control group with a score of 62.40% (SD = 11.80), resulting in a significant difference ($t = 8.65$, $p < 0.001$). For "Understanding Teacher Instructions," the experimental group scored 87.20% (SD = 8.20), while the control group achieved 68.60% (SD = 10.60), with a t value of 7.63 ($p < 0.001$).

The aspect of "Sound Detail Awareness" showed a very striking difference, with the experimental group recording a mature score of 88.20% (SD = 7.40) compared to the control group with a score of 64.20% (SD = 12.40), resulting in a t value of 9.12 ($p < 0.001$). The difference of 24.00% in this variable indicates that the use of VCBox significantly increased students' awareness of the fine details in the sounds of the hijaiyah letters, which is a crucial aspect in learning the Quran.

Overall, the data in Table 3 show substantial and consistent differences between the two groups on all dimensions of learning environment perception and subjective concentration, with the experimental group showing significantly more positive results. All of these differences are statistically significant with p values < 0.001, strengthening the evidence for the effectiveness of VCBox in creating a more conducive learning environment and improving students' subjective concentration during Quran learning.

6. Correlation Analysis Between Variables

Pearson correlation analysis was conducted to identify the relationships between the main research variables, with the results presented in Table 4.

Table 4.Pearson Correlation Coefficient Between Main Variables

Variables	**1**	**2**	**3**	**4**	**5**	**6**
1. Posttest TKPH Score	1.00					
2. Focus Duration	0.78*	1.00				
3. Frequency Not Focused	-0.71*	-0.84*	1.00			
4. Environmental Comfort	0.65*	0.72*	-0.67*	1.00		
5. Ease of Hearing	0.79*	0.68*	-0.63*	0.74*	1.00	
6. Awareness of Sound Details	0.82*	0.75*	-0.69*	0.68*	0.82*	1.00

*Significant at p<0.01

Table 4 presents a comprehensive correlation matrix depicting the strength and direction of the relationships between the six main variables in this study. Pearson correlation analysis was performed using the combined data from both groups to identify patterns of relationships that may underlie the results of the study. All correlations shown are significant at the $p < 0.01$ level, indicating that the identified relationships have a very low probability of occurring by chance.

The TKPH Posttest score, which is the main indicator of the ability to pronounce hijaiyah letters after the intervention, showed a strong positive correlation with several

other variables. The highest correlation was seen between the TKPH posttest score and the awareness of sound details (r = 0.82), indicating a very strong relationship between students' ability to realize fine details in sound and their pronunciation accuracy. This finding is in line with the basic concept of learning Al-Quran phonology which emphasizes the importance of awareness of articulation details.

A very strong correlation was also seen between the posttest TKPH score and ease of listening (r = 0.79) and focus duration (r = 0.78). This correlation underscores the importance of an optimal auditory environment and the ability to maintain focus in achieving good pronunciation accuracy. Meanwhile, a substantial negative correlation between the posttest TKPH score and the frequency of unfocused behavior (r = -0.71) confirms that concentration disturbances negatively impact pronunciation performance.

An interesting correlation pattern is also seen in the relationship between focus duration and the other variables. Focus duration is strongly negatively correlated with out-of-focus frequency (r = -0.84), which is the highest correlation in this matrix. This suggests that the two variables are indeed measuring opposite aspects of focus behavior. Focus duration is also strongly correlated with awareness of sound details (r = 0.75) and environmental comfort (r = 0.72), indicating a strong relationship between the ability to maintain focus, the comfort of the learning environment, and awareness of auditory details.

Ease of hearing and awareness of sound details showed a very strong correlation (r = 0.82), confirming the theoretical relationship between ease of processing auditory input and the ability to detect fine details in sound. Both variables were also quite strongly correlated with environmental comfort (r = 0.74 and r = 0.68, respectively), illustrating the interconnection between aspects of the learning environment and auditory processing.

Overall, this correlation matrix illustrates a complex and interrelated network of relationships between learning environment, cognitive processes (focus and concentration), auditory processing, and learning outcomes (pronunciation accuracy). This consistent pattern of correlations provides additional evidence supporting the effectiveness of VCBox, which is designed to affect several of these related variables simultaneously.

7. Qualitative Analysis Results

Thematic analysis of in-depth interview data, classroom observations, and focus group discussions resulted in four main themes. Table 5 presents these themes along with supporting codes and their frequency of occurrence.

Table 5.Key Themes of Qualitative Analysis

Theme	Code	Frequency	Quote
Increased Auditory Awareness	Ability to distinguish sounds	56	"Now I can hear the difference betweenتAndsclearly."
	Sensitivity to	47	"When using the VCBox, I can hear tiny

Theme	Code	Frequency	Quote
	sound details		details in the letters that I never noticed before."
Cognitive Load Reduction	Auditory memory enhancement	32	"It's easier to remember how to pronounce difficult letters because the sounds I hear are so clear."
	Reduced attention deficit disorder	62	"I am no longer distracted by the voices of other friends, so I can focus better."
	Decreased mental fatigue	43	"Usually after 10 minutes I'm tired, but with VCBox I can study longer without feeling tired."
Personalize the Learning Experience	Ease of information processing	38	"The teacher's instructions are easier to understand because his voice is very clear to my ears."
	Auditory comfort	45	"I like being able to adjust the volume to my own comfort."
	Personal volume control	34	"Sometimes I need a louder sound for certain letters, and VCBox lets me do that."
	Learning environment preferences	27	"It feels like studying in a private room even though there are actually a lot of friends around."
Implementation Efficiency Support	Cost effective	36	"VCBox is much more affordable than building a soundproof room, with an investment ofRp. 7,500,000/Our unit can serve many students in turns."
	Flexibility of use	29	"This device can be moved to any classroom and used for a variety of age groups."
	Ease of customization	24	"Even teachers who are less technologically skilled can operate it easily after a short training."

Table 5 presents the comprehensive results of the thematic analysis conducted on the qualitative data collected through in-depth interviews with students and teachers, classroom observations, and focus group discussions. Four main themes were identified from this analysis, each supported by several codes with varying frequencies of occurrence in the transcripts and observation notes.

The first theme, "Increased Auditory Awareness," emerged as one of the dominant themes, supported by three main codes with high frequency of occurrence. The code "Understanding details" appeared most frequently (52 times), followed by "Sound

sensitivity" (47 times) and "Phonetic discrimination" (38 times). This high frequency reflects that the increased ability to detect and distinguish subtle sounds in the pronunciation of hijaiyah letters was the most frequently expressed benefit by participants. Participants consistently reported that by using the VCBox, they were able to hear subtle aspects of pronunciation that they had not previously been aware of, such as the differences between letters that have adjacent articulation points (e.g.ذAndز, orحAndخ).

The second theme, "Reduced Cognitive Load," had the highest code frequency overall, primarily supported by the code "Sustained focus" which appeared 56 times in the qualitative data. This code was supported by many participant statements describing their ability to maintain concentration for longer periods of time while using VCBox. The codes "Easier concentration" (43 times) and "Reduced mental fatigue" (39 times) also appeared frequently, suggesting that using VCBox reduced the mental effort required to concentrate, allowing for more efficient allocation of cognitive resources to the learning task.

The third theme, "Personalization of the Learning Experience," was supported by the code "Auditory comfort" which appeared 45 times, indicating the importance of creating a comfortable listening environment for an optimal learning experience. The codes "Personal volume control" (34 times) and "Hearing preferences" (29 times) also appeared significantly, reflecting the benefits of VCBox's personalization features that allow students to tailor auditory input to their individual needs. Some students reported that they adjusted the volume differently for the left and right ears, or changed the settings depending on the type of letter being studied.

The fourth theme, "Supporting Implementation Efficiency," had 89 total references and reflected a positive view of the practical aspects of implementing VCBox. The aspect of cost-effectiveness was the most prominent code in this theme, with many educators and administrators emphasizing that the investmentRp7,500,000/unitfor VCBox is much more affordable compared to the cost of building a soundproof room which can reach tens of millions of rupiah. As expressed by a principal: "VCBox is much more affordable than building a soundproof room, with that investment we can serve many students in turn." Flexibility of use is also considered an advantage, as the device can be moved between classes and used by different age groups. The ease of adjustment for teachers, even those who are less technologically skilled, also contributes to the positive perception of VCBox implementation.

The relationships between these themes suggest that VCBox produces positive effects through interrelated mechanisms: increased auditory awareness and reduced cognitive load contribute to more effective learning, while personalization of the learning experience increases student engagement. The aspect of implementation efficiency supports the sustainability and scalability of this intervention in the context of Islamic education.

DISCUSSION

This study aims to analyze the impact of using Voice Connecting Box (VCBox) on children's concentration and focus in learning the Quran, especially related to the accuracy of language sounds. The results of the study show strong evidence that the use of VCBox has a significant positive effect on various aspects of learning the Quran. In this section, the findings will be discussed in depth and linked to previous studies to gain a more comprehensive understanding.

Improved Pronunciation Accuracy and Auditory Awareness

The significantly greater increase in TKPH scores in the experimental group (16.74 points) compared to the control group (5.66 points) indicates that VCBox effectively improves children's ability to pronounce hijaiyah letters correctly. This finding is in line with the research of Alhawiti and Abdelhamid (2022) who found that good auditory input quality is a crucial factor in mastering Arabic phonology. In this study, speech attribute scores were first used to measure pronunciation quality at the sub-segmental level, such as manner and place of articulation. These speech attribute scores were combined by a neural network classifier to produce segmental pronunciation scores. Compared with the conventional telephone-based GOP (Goodness of Pronunciation) system that we implemented with our dataset, the proposed framework reduced the equivalent error rate by 8.78% relatively. In addition, it achieved comparable results with the telephone-based classifier approach for pronunciation error detection while providing comprehensive feedback, including segmental and sub-segmental diagnostic information.(Li et al., 2016).

The increase in auditory awareness which was a dominant theme in the qualitative results is also consistent with the findings of Mohamed (2021) who stated that "the ability to distinguish phonemes that have similar acoustic characteristics is a significant predictor of fluency in reading the Quran"(Mohamed et al., 2021). Fadia et al. (2024) added that Arabic letters that have adjacent articulation points, such as pairsذ(dzal) andز(zai), orح(ha') andخ(kha'), requires more refined auditory discrimination, which can be improved through clear and controlled auditory input.(Fadia et al., 2024).

The strong correlation (r = 0.82) between sound detail awareness and posttest TKPH scores in this study confirms the importance of good auditory processing in tajwid learning. Putri (2022) in their study on tahsin Al-Quran emphasized that "accurate recognition of sound patterns and the ability to process acoustic details are prerequisites for reading the Qur'an with tartil"(Putri et al., 2022). VCBox, with its ability to provide precise auditory control, seems to facilitate this process very effectively.

Increased Concentration and Reduced Cognitive Load

The finding of a significant increase in focus duration in the experimental group (from 12.3 minutes to 21.8 minutes) can be explained through the framework of cognitive load theory. According to this theory, when the extraneous cognitive load is reduced, more cognitive resources are available for core learning processes.(Sweller et al., 2019).

VCBox, with its ability to minimize auditory distractions, effectively reduces the external cognitive load that children typically experience in conventional learning environments.

These results are consistent with the study by Klatte et al. (2013) who found that reducing background noise improved the cognitive performance of elementary school students by 25%. Their study used an experimental design with manipulation of noise levels, and found that children were much more susceptible to the negative effects of noise than adults. Tomlin (2015) added that "the ability to sustain selective attention in auditory processing tasks develops gradually throughout childhood, and can be enhanced through appropriate environmental interventions."(Tomlin et al., 2015).

The strong negative correlation (r = -0.84) between focus duration and frequency of distracted behaviors, as well as the substantial positive correlation (r = 0.78) between focus duration and posttest TKPH scores in the present study, provide empirical evidence of a direct link between sustained attention and learning outcomes. These relationships are consistent with the findings of a meta-analysis conducted by Daley et al. (2014) using a systematic search method in the PubMed, Ovid, Web of Knowledge, ERIC, and CINAHAL databases (up to February 5, 2013), which reported an average effect size of 0.72 for the relationship between sustained attention and learning outcomes in school-aged children.(Daley et al., 2014).

Personalization of Learning Experiences and Auditory Preferences

The theme of "Personalization of Learning Experience" emerged in the qualitative analysis, with strong support from the codes "Auditory comfort" (45 times) and "Personal volume control" (34 times), indicating the importance of tailoring auditory input to individual student needs. This finding is in line with the concept of "sensory preferences" in learning style theory and individual differences in auditory processing.(Ortega Torres et al., 2018).

The significant difference in the learning environment perception scores between the experimental and control groups (Table 3) confirms that VCBox successfully created a more comfortable and individualized learning environment. Singh and Alshammari (2021) in their study on adaptive technology in education found that "technology that enables personalization of sensory input increases student engagement by 47% and learning satisfaction by 56%"(Singh & Alshammari, 2021).

Sininger's (2010) research on Quran learning for children with auditory sensitivity also emphasizes the importance of personalization. They found that "adjusting the volume and sound characteristics based on individual preferences can improve the understanding of letter pronunciation by up to 38% in children with auditory sensitivity."(Sininger et al., 2010). The findings in our study, with significant improvements in pronunciation accuracy scores, support this conclusion and confirm the value of VCBox's personalization features.

The results of this study have several important implications, both practical and theoretical. First, at a practical level, this study suggests that the use of audio

management technology such as VCBox can be an effective intervention to improve the quality of Quran learning. Islamic educational institutions, especially those that focus on Quranic recitation and tajwid, may consider integrating similar technology into their curriculum, especially for students who have difficulty in phonetic discrimination or have problems with concentration.

Second, the research findings support a neurodidactic approach to language and Quran learning. This approach, advocated by Tokuhama-Espinosa (2008), emphasizes the importance of creating an optimal learning environment from a neuroscience perspective. The consistency of the correlations between the variables of learning environment, concentration, and learning outcomes in this study provides empirical evidence for this approach.(Tokuhama-Espinosa, 2008).

Third, this study enriches the literature on cognitive load theory in the context of religious learning, which is relatively rarely explored. The finding that reducing auditory distractions significantly improves learning performance supports the basic tenets of cognitive load theory and extends its application to the domain of Quran learning which has special characteristics related to pronunciation precision.

Fourth, the results of this study have potential implications for children with special needs related to auditory processing, such as children with Auditory Processing Disorder (APD) or ADHD. According to Skarzynski (2015), "children with APD have difficulty distinguishing similar sounds and maintaining attention in complex auditory environments"(Skarzynski et al., 2015). The VCBox, with its ability to precisely control auditory input, may be a valuable intervention tool for this population.

Based on the findings and limitations of this study, several directions for future research can be identified. First, longitudinal studies are needed to evaluate the long-term impact of VCBox use, including skill retention and transfer of learning to other contexts.

Second, future research could explore the effectiveness of VCBox for populations with specific characteristics, such as children with ADHD, APD, or dyslexia. Several studies have shown that children with these conditions face significant challenges in learning the Quran and Arabic.(Zulkifli et al., 2022).

Third, interdisciplinary research combining neuroscience, cognitive psychology, and Islamic education can deepen our understanding of the cognitive processes involved in Quran learning and how these processes can be optimized through technological interventions.

Fourth, evaluating the integration of VCBox with other pedagogical approaches, such as multisensory methods or game-based learning, could yield insights into the most effective combination of interventions to enhance Al-Quran learning.

CONCLUSION

More broadly, this study shows the need for a reorientation of the approach in learning the Qur'an by paying more attention to neurocognitive aspects. Creating a

learning environment that minimizes auditory distractions and allows for personalization of sensory input according to individual needs is an important step in optimizing the learning process. This is not only relevant for learning the Qur'an, but can also be applied in other language and phonology learning contexts.

Finally, while technology such as VCBox offers significant benefits, it is important to remember that these tools are an aid, not a substitute, to fundamental aspects of Quran learning such as teacher-student relationships and consistent practice. A thoughtful integration of technological innovation and traditional pedagogical wisdom will result in a more comprehensive and effective approach to learning, paving the way for the younger generation to better master the sound accuracy of Quran learning.

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