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The Effect of Low-Tech Response Systems on Students' Engagement in Learning and Attitude in Under-Resourced EFL Classrooms: mini white-boards in focus

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Abstract

Higher levels of student engagement are positively linked to higher learning achievement. However, enhancing student engagement in underprivileged and crowded educational contexts, specifically where high-tech tools are not available can cause a major challenge for teachers. The current study attempts to enhance students' engagement in their learning by incorporating mini white-boards (MWs) as low-tech response systems. To this end, in a time-series design, an instruction-feedback cycle via mini white-boards was manipulated over a semester. Ten 10th-grade students, all from similar low socio-economic backgrounds and living in rural areas, participated in this study. Data were collected through observing students' behaviors using engagement checklists. An attitude questionnaire was also administered to assess students' perceptions of using mini white-boards in their learning context. Descriptive statistics were used to summarize individuals' engagement patterns across the study period. Additionally, a mixed-effects model was employed to account for individual variability and to assess the effects of the intervention on students' engagement over time. The results indicated that using mini white-boards caused significant improvements in students' overall engagement and attitude. The findings suggest that using low-tech solutions in low socio-economic settings can foster student engagement by allowing real-time feedback, collaborative interaction, and personalized participation.

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Introduction

Engagement is reported to play a pivotal role in effective teaching and learning (Lei et al., 2018). However, it is often challenging to ensure active student participation due to various factors such as large class sizes (Blatchford et al., 2003), pressure to finish teaching certain content (Tomaszewski et al., 2022), student motivation (Martin, 2008) and diverse learning needs (Zens, 2021).

In under-resourced over-crowded educational contexts, the challenge is even more serious due to systemic and infrastructural issues, which are coupled with the socio-economic status of students (UNESCO, 2018). The overcrowded classrooms limit the time and space available for engagement activities, which are essential for enhancing learning and fostering positive attitudes (Morais, 2016; Tayeg, 2015). Without such activities, students may perceive education as passive and disconnected and thus lose their motivation and reduce their cognitive investment (Skinner, 2016). High student-to-teacher ratios further complicate the situation (Harper & Quaye, 2009), and make it nearly impossible for teachers to provide personalized feedback or address diverse learning needs (Barrett & Arnett, 2018). Consequently, students who face academic challenges often disengage and lose motivation to participate in classroom activities (Harper & Quaye, 2009).

In such crowded contexts where access to resources is limited and high-tech tools are not available, low-tech interventions such as simple Student Response Systems (SRSs) offer practical solutions to effectively engage students in their learning process and foster their positive attitude toward learning. Unlike digital tools, which often depend on electricity and internet access, low-tech SRSs are affordable and easy to implement. These features make them particularly suitable for classrooms in rural or low-income areas (Lambert et al., 2006). Low-tech SRSs involve modest adjustments to the usual teacher practices in the classroom and hold significant promise for enhancing the behavioral, cognitive and emotional engagement of students (Gimbutas, 2019). The SRSs are different tools which enable teachers to collect student inputs, assess them and provide proper feedback in real-time (Gimbutas, 2019; Christle & Schuster, 2003). These systems, which include tools like signs, cards, and mini white-boards (Lambert et al., 2006), facilitate active participation in all settings, specifically in resource-constrained ones.

Among low-tech SRSs, mini white-boards (MWs) promote engagement by enabling all students to simultaneously answer questions, solve problems, or share opinions (Gimbutas, 2019). This collective involvement facilitates real-time formative assessment and allows teachers to identify gaps in understanding and provide immediate feedback (Christle & Schuster, 2003). For example, when students display their answers on MWs, teachers can quickly evaluate comprehension and adjust instruction accordingly. Using MWs would enhance students' sense of belonging in the classroom and foster a positive attitude to learning (Gimbutas, 2019).

This study aims to enhance students' engagement in learning by implementing a feedback cycle via mini white-board, where students write their responses on the mini white-boards,

receive immediate feedback on their responses and modify them instantly. The study focuses on under-privileged schools in rural and low-income urban areas of Iran, where students might come from low-income families. In such contexts, students may not have personal access to digital devices, high-speed internet, or interactive learning technologies. This study, therefore, examines the effect of using simple, low-tech tools such as mini-whiteboards on students' engagement and academic achievement without requiring significant financial investment. To this end, the study addresses the following research questions:

1: "Does using mini white-boards significantly affect learning engagement of Iranian high school female EFL learners?"

2: "What is the attitude of Iranian high school female EFL learners towards the use of mini white-boards and their effect on their learning?"

Literature Review

Under-resourced educational contexts often face several key challenges that significantly affect learning outcomes (Singh,2024). Challenges range from limited access to textbooks and stationeries (Du Plessis & Mestry, 2019) to overcrowded classrooms (Morais, 2016), and lack of technology-based teaching aids (Koranteng, 2012), all limiting opportunities for active student participation and engagement in learning. (Singh, 2024). In such contexts, teachers often struggle to provide equal learning opportunities for students, with resource constraints limiting their ability to bridge socioeconomic gaps and address diverse student needs (Singh, 2024).

Student engagement, as a critical element determining the academic success (Lei et al., 2018), is particularly challenging in under-resourced educational settings. Engagement is a multidimensional phenomenon encompassing behavioral, emotional, and cognitive aspects with each of them being vulnerable to the limitations posed by a lack of resources (Fredricks et al., 2004). Behavioral engagement is defined as the level of students' participation and involvement in the learning activities (Lei at al., 2018), and is operationalized in terms of observable behaviors. Emotional engagement focuses on feelings students experience during learning (e.g. anxiety, boredom, happiness, interest, etc.) and their emotional reactions to teachers, peers, school and learning in general (Finn, 1989). Cognitive engagement refers to self-regulation and cognitive strategies students use while working on a task (Walker, Greene, & Mansell, 2006).

Studies have shown that students' participation and engagement level in overcrowded classrooms with a high student-to-teacher ratio often decreases as teachers cannot address diverse learning needs and provide them with individualized attention (Zaman, Sajjad & Gharsheen, 2023). Moreover, in under-resourced contexts, emotional engagement can get hindered as teachers might over-rely on rote methods (Kombe & Mtonga, 2021) rather than interactive, deep learning ones. This over-reliance can lead to increased anxiety, boredom, and disengagement in students (Larouz & El Messaoudi, 2023), and affect their emotional connection. Bearing all these challenges in mind, teachers should be equipped with methods to actively involve students, even with minimal resources. Student Response Systems (SRSs) are

one type of classroom interventions that have been reported to effectively enhance behavioral, cognitive and emotional engagements in students (Gimbutas, 2019; Musti-Rao et al., 2008).

Student response systems (SRSs) are quick methods to submit a response to a question often posed by the teacher in the classroom (Gimbutas,2019). These systems let both the teacher and all the students to immediately assess the responses and identify misunderstanding. Teachers can provide immediate feedback on students' inputs and check their reaction and performance to ensure they have understood the communicated information effectively.

Empirical studies have investigated the impact of using low- and high-tech SRSs on diverse aspects of students learning and reported distinct advantages for both types (Heaslip, Donovan, & Cullen, 2013; Hunsu, Adesope, & Bayly, 2016; Kay & LeSage, 2009). The SRSs have been found to improve academic achievement (Shahba et al., 2023), promote students' learning motivation (Wu, 2019), enhance effective peer interaction (Fies & Marshall, 2006; Su et al., 2018), reduce students' stress (Stowell & Nelson ,2007), and contribute to higher participation and on-task behavior (Musti-Rao et al., 2008).

Among the low-tech SRSs, MWs are widely used in educational settings as they are cost-effective, easy to use and portable. Even students in low socio-economic contexts can make hand-made MWs at home using a page protector and an A4 sized paper. MWs (MWs) let all students simultaneously engage in classroom discussions and help teachers get immediate insight into their understanding (Wiliam & Leahy, 2015). They encourage students to take the risk of getting involved in the task by providing the immediate chance of modifying their responses without keeping a record of their work (Swan, 2006). Wenning (2005) referred to whiteboarding as an active learning process through which students can improve their communication skills. He proposed that having Socratic dialogues via MWs can make students' understanding and thinking processes clear to the teacher and students, enhance their motivation, and help them improve the classroom discourse.

In a recent investigation, Maldonado Valarezo (2024), studied the effect of mini whiteboards on student engagement during English classes in a public school in Cuenca, Ecuador. Students from 5th, 6th, and 7th grades with low participation levels in teacher-centered classrooms were the focus of this study. Two types of intervention were implemented during two cycles. During the first cycle, students used mini white-boards to respond to questions, engage in discussions, and collaborate with peers. In the second one, gamification and Think-Pair-Share strategies were used. The results of the study indicated higher student engagement when mini white-boards were used. However, the level of engagement declined over time, indicating that mini whiteboards alone are not a long-term solution and other engagement strategies are needed to sustain student involvement.

Eidissen (2023), reported the effectiveness of MWs in raising the communication level in the classroom. He used a framework described by Brendefur and Frykholm (2000) to analyze the changes in teaching practices before and after using MWs in the class. The findings indicated that MWs can cause more reflective communications in the classrooms.

Staberg et al. (2023) conducted a case study to examine how two Norwegian primary school science teachers used analogue and digital resources for formative assessment (FA) in the

classroom. They identified eight key resources, including mini white-boards. The findings revealed that teachers routinely used mini white-boards to assess prior knowledge, check understanding, and facilitate peer discussions. Moreover, they valued MWs for their practicality, ease of use, and effectiveness. The study highlighted the need for integrating reliable formative assessment tools into science education.

Macrie-Shuck and Talanquer (2022) investigated the impact of small portable white-boards on student engagement in collaborative learning within a college general chemistry course. The results of their study indicated that mini white-boards facilitated knowledge construction and increased instructor-student interactions. At the same time, mini white-boards were reported to hinder full-group collaboration. The research demonstrated that the effectiveness of small portable white-boards depends on various factors including task type and proper implementation in the classroom.

With a focus on students' performance, Gimbutas (2019) provided empirical evidence for the effectiveness of low-tech SRSs of MWs in an English language classroom. The sample of study included students with Attention-Deficit/Hyperactivity Disorder (ADHD). Students used MWs during and after reading tasks to write their responses and were asked to explain the reason for their answers. They were also assessed weekly on the content. The results of the study indicated higher engagement and learning achievement after using MWs. The use of MWs in class was also well-received by the participants. Similar results were reported in earlier studies on low-tech student response systems (Clayton & Woodard, 2007; Stowell & Nelson, 2007).

In another study, Musti-Rao et al. (2008), reported higher participation and on-task behavior rate after using MWs. They investigated the effects of MWs on participation and academic performance of college students. Students' participation was measured through response frequency and their academic performance was assessed via regular quizzes. The study suggested that while MWs effectively boost participation, their direct impact on academic performance may depend on additional instructional factors such as the quality of questions or teaching methods. The findings were in line with those of previous studies (e.g. Lambert et al., 2006; Christle & Schuster, 2003).

Although the aforementioned studies have investigated the effect of using SRSs in diverse contexts and across different subjects, in the context of English as a Foreign Language (EFL) education, research on the use of low-tech SRSs like MWs remains scarce. More specifically, their role and impact within Iran's educational system have yet to be fully explored.

This study is to help fill the gap by employing mixed-effects models to control for individual differences while reporting the effect of MWs on student engagement in learning and their attitude towards using them. Moreover, the research focuses on under-privileged areas where there is no or limited access to high technology tools and attempts to systematically measure the effect of using low-tech SRSs of MWs on high school students' engagement. Finally, the study addresses multiple skills and subskills rather than just focusing on one and uses mini white-boards to engage students in learning all skills covered in their course book. Building on these objectives, this paper reports on a trial of the low-tech but high-potential SRS, wherein we experimentally manipulated instruction-feedback loop via mini white-board enrichment

intervention. It further attempted to use SRSs not only to engage students in their own learning process but also to ensure that the feedback was correctly delivered and that the learning loop was properly implemented. This systematically compared students' behavioral engagement during targeted practice phases of each EFL class time, both with and without MWs.

Methodology

Design of the Study

A quasi-experimental single-group time-series design was used to answer the research questions and investigate the immediate effect of the intervention on participants' behavior. The design followed a structured sequence, alternating between placebo and intervention phases, which allowed us to track not only the direct impact of the intervention but also the persistence of its effect. The repeated placebo and intervention phases enabled us to carefully observe changes over time and identify any patterns of improvement.

Participants

A total of 10 female Grade-10 high school students were randomly selected out of a pool of 24 students in the same class and participated in the present study. As observing students over a 16-week period was time-consuming, this sample size was chosen to ensure manageable data collection while still capturing diverse perspectives within the class. The age of the students ranged between 15 and 16 and were all studying computer. As the participants were from an intact high school class, they were not homogenized and varied in their language proficiency levels with some of them being beginners. Two of the participants were not interested in learning English at all and believed that learning English is too difficult for them. All participants were from the same locality with similar socioeconomic status. Students were living in rural areas and could not afford high-technology tools or buy real MWs. This was the main motive behind using page-protectors instead of real MWs. All students were asked to prepare the innovated MWs at home and bring them to the class. Students who did not have page protectors at home, were given one at school.

Instrumentation

Vision 1 Book:

The book *Vision 1*, designed by the Ministry of Education for teaching English to Grade-10 learners, was used as the only source of teaching throughout the experimental period. All the teaching and practice content presented during 16 weeks was derived entirely from this book. As students were studying computer, their English book consisted of two main lessons, Lesson 1: Saving Nature and Lesson 2: Wonders of Creation. Both lessons included Get Ready, Conversation, New Words & Expressions, Reading, Grammar, Listening & Speaking, Pronunciation, Writing, and What You Learned sections.

In Lesson 1, learners were introduced to environmental themes such as Visiting the Museum of Nature and Wildlife and Endangered Animals. The grammar focus was on the future tense (will and be going to) and talking about plan, and pronunciation skills emphasized falling intonation. Topics like noun singular & plural forms, types of nouns, and noun markers were also covered. Other sections included Reading Comprehension, and Reviewing Lesson 1.

Lesson 2 focused on scientific and observational themes. This lesson highlighted adjectives, including their kinds, placement, and spelling hints. Learners practiced pronunciation skills through rising intonation. The lesson concluded with Reviewing Lesson 2. Throughout both lessons, all four main skills—reading, writing, listening, and speaking—were integrated, along with specific sub-skills like vocabulary building, grammar exercises, pronunciation techniques, and comprehension activities.

Mini White-boards (MWs)

Mini white-boards consisted of a clear plastic page protectors with A4-sized white paper inserted inside. The MWs were constructed in this way to help the instructor easily read and assess the responses. All the students were instructed on how to use the MWs.

Engagement Checklists

The engagement was measured using a student checklist. The checklist was adapted from Gimbutas (2019) and consisted of four columns, each representing one session within an interval of the experiment. Since each interval comprised four sessions, a complete checklist covered all four columns to represent the four sessions within that interval. Each session was further divided into three sub-columns to document observations at 5-minute, 10-minute, and 15-minute intervals. The experiment consisted of four intervals (Baseline1, Treatment1, Baseline2, Treatment2), and one checklist was completed for each interval. Thus, a total of four checklists were used, collectively covering 16 sessions over 16 weeks.

Attitude Questionnaire

A questionnaire adapted from Gimbutas (2019), was used to address the attitude of the learners toward using MWs in their learning. The questionnaire was consisted of 9 statements in a 5-point Likert scale format and required students to select their attitude from strongly agree to strongly disagree. The questionnaire was revised and customized for the context in which it was going to be used and some items were modified. The final questionnaire was validated through expert judgment. The Cronbach's alpha coefficient was calculated, which resulted in a reliability coefficient of 0.89.

Procedure

This study was conducted over a semester for 16 weeks. It involved intervals of students' engagement including baselines (placebo/no treatment) and **treatment** phases. The design was used to assure that changes in students' engagement level over time only attributed to the use of MWs. To this end and to obtain a solid baseline for comparison, students' initial unaltered behavior was observed over 4 weeks (weeks 1-4). During this time, student did not use MWs while participating in class activities. Following the first baseline, the first treatment phase started. Mini white-boards were presented for four weeks (weeks 5-8). During the first treatment phase, the students' behaviors while using MWs were observed and recorded. To make sure that the collected data was robust, the intervention was removed again (weeks 9-12) in the second baseline and the behaviors of the students were observed. During the second treatment phase (weeks 13-16), MWs were represented to the students and data were collected on their engagement level. In the last week of the second treatment interval, students completed

the questionnaire towards using MWs. Figure 1 shows the overall structure of the experiment, detailing each interval, the corresponding weeks, and the intervention.

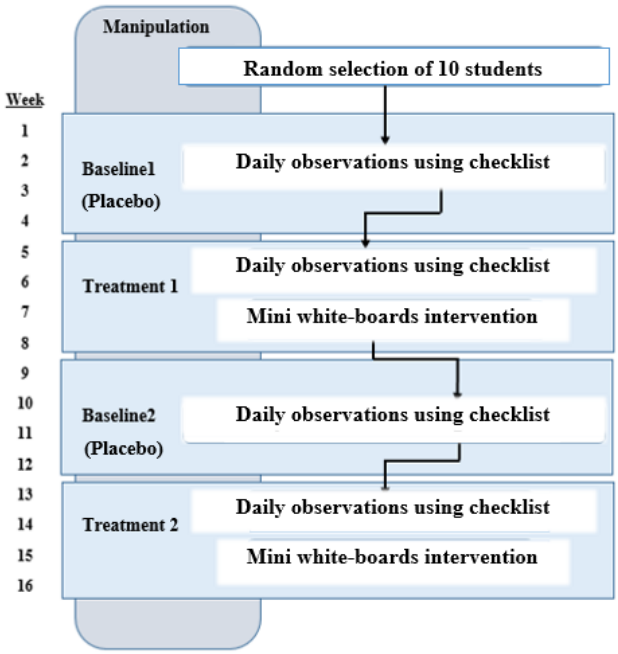

Figure 1. *Structure of the Experiment*

Baseline (Placebo) Interval

The class met once a week for about 90 minutes. However, the systematic observation and data collection was done over a 15-minute period of targeted practice phase across all sessions. During the baseline (placebo) phases, students' unaltered behavior was observed without introducing the whiteboard intervention. In these phases, students participated in oral and sometimes written question-and-answer activities and exercises. Occasionally, questions were posed orally, and students were asked to respond if they knew the answer after a waiting period. At other times, students could write their answers in their notebooks and then read them aloud. In this scenario, the next question would be introduced after receiving the correct answer from the class, and no individual feedback was provided to the students.

Treatment Interval (Mini white-boarding)

During targeted-practice phase of each session, the teacher presented different prompts to formatively assess students, probe their understanding of certain content and address their misconceptions or misunderstandings. Students were asked to work individually during white boarding activities; however, they were allowed to consult peers before writing their responses while working on certain types of activity. The whiteboarding activities included all skills and subskills and were broadly categorized into summarizing, translating, reflecting, sentence making, identifying errors, vocabulary building, listening comprehension, and writing practice. The attempt was made to utilize a variety of prompts to support skill integration and engage the students in formative assessment cycle, where through formative feedback the gap between students' current knowledge and the desired goals and status is reduced.

Students were informed that the teacher would wait before asking all participants to hold up their MWs. Students had 3 to 5 seconds to respond to multiple choice questions and 5 to 15 seconds to respond to the majority of open-ended ones. They had to write their answers on the page-protectors as MWs using markers and hold it up till the teacher provided them with proper feedback. The learners could immediately modify their answers based on the teacher's initial feedback and hold the MW up again to let the teacher assess their improvement. Common misconceptions or misunderstandings were addressed through whole-class feedback. the cycle continued till the students reached the correct answer. Table 1 presents sample teacher prompts, whiteboarding activities and the skills/subskills they've addressed.

Table 1. *Examples of Language Prompts by Skills/Subskills and Types of Activity*

Type of Whiteboarding Activity	Skill/Subskill	Whiteboard Prompt
Summarizing	Reading	Read the short passage about "A Wonderful Liquid" and try to create a concept map
Ordering adjectives	Writing	Order these adjectives to complete the sentence (Persian, young, big): *"I saw a ……cat,*
Vocabulary	Vocabulary	Write the plural form of each word: e.g., *child → (children), wolf→ (wolves).*
Reflecting on learning	All	Write three words/phrases/sentences/point you've learnt today.
Listening comprehension	Listening	Listen to the audio clip and complete these sentences: 1. She bought …… 2. It was …….
Sentence Making	Sentence Making	Use the comparative form of "Tall" and write a sentence.
Error identification	Grammar	Underline the grammatical errors in the paragraph and suggest corrections on the whiteboard.
Translation	Translation	Translate this Persian sentence into English: سرباز شجاع از کشور ما دفاع خواهد کرد

In order to best clarify the process through which MWs were used to engage students in their learning and to show how students were provided with immediate feedback, a sample dialogue is presented below:

Teacher: Translate this Persian sentence into English and write it on your MWs. You have 15 seconds to write the sentence. I will then ask you to hold up your MWs.
سرباز شجاع از کشور ما دفاع خواهد کرد.

[Students write their initial sentences on their mini white-boards. One student writes: soldier brave defend country

Teacher: Okay, how do we order adjectives in English?

Student: hmm…. *[student thinks for a few seconds]*

Teacher: *Does* the adjective come before or after the noun?

Student: Oh, I see! before the noun *[Student rewrites: brave soldier defend country.]*

Teacher: Great! Now, look at the structure of the verb. What does "خواهد" tell us?

Student: It shows that the action is in the future tense.

Teacher: Exactly! So how do we combine "خواهند" and "دفاع کرد" in English?

Students: We use "will" with the base form of the verb. So, "دفاع خواهد کرد" becomes "will defend."[*Student rewrites: brave soldier will defend country.]*

Teacher: Great! But don't forget the article before brave soldier. What would it be in this case?

Student: A?

Teacher: are we talking about any soldier or a known one?

Student: Oh, known one! the! *[Student rewrites: The brave soldier will defend country.]*

Teacher: Okay, what else is missing?

Student: *[after few second*s] Oh! Our country! *[Student rewrites: The brave soldier will defend our country.]*

Teacher: Excellent! Let's work on another sentence.

Monitoring

Three observers including the teacher and two trained students monitored the performance of selected students across all sessions. The teacher had defined certain on-task behaviors as exact instances of engagement and all observers had to deduct 1 point for each instance of any other behaviors rather than the selected ones. The engagement was operationally defined as exhibiting the following behaviors:

1.Attentiveness to instructions

2.Writing on the mini white-board

3.Promptly displaying white-boards

4.Interacting with peers

5.Focusing on the assigned task

6.Asking for help, clarification, or explanations from the teacher

7.Engaging with feedback and correcting mistakes.

All observers had the checklist with the name of the participants on it to record their engagement. During baselines (placebo/ no treatment intervals), however, none of the students in the class used mini white boards. Any behavior outside of the predefined actions was categorized as off-task behavior and thus a dash sign was put in the check list to indicated that a point was deducted from the total score for that interval. The teacher and the trained observers scored each individual by counting the number of off-task behaviors during each five-minute interval for a 15-minute period. Students who demonstrated all engagement behaviors during a 15-minute session, received maximum possible score (15).

Results

The first research question focused on student engagement. As discussed above the engagement scores for each session were calculated for individuals and then descriptive statistics were conducted on the acquired data to gain an overall insight into the general performance pattern of the participants during each interval. Table 2, below, shows the mean scores and standard deviations (SD) for each individual in all four intervals.

Table 2. *Descriptive Statistics of Student Engagement Scores*

	Baseline 1		**Treatment 1**		**Baseline 2**		**Treatment 2**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Student1	8	0.82	10.75	1.25	8.75	0.95	12.50	0.57
Student2	7.5	1.71	10.25	0.95	7.25	0.95	13.00	1.82
Student3	8.75	1.30	12	0.81	8	0.81	11.75	1.70
Student4	7.25	0.50	8.75	0.95	6.50	1.29	10.50	1.12
Student5	7.75	1.26	11.75	0.95	9.50	0.57	13.50	1.29
Student6	13.75	0.96	14.75	0.50	13.75	0.81	15	0.00
Student7	4.75	1.70	8.75	0.95	5	1.15	10	0.81
Student8	9.5	3.20	12.50	1.91	10.50	1.73	12.75	0.95
Student9	11.5	2.29	12.75	1.50	11.00	1.41	14.00	0.81
Student10	9.25	0.96	11.50	1.29	9.75	0.95	13.50	1.29
Total	8.8	1.47	11.37	1.1	9	1.06	12.65	1.03

As indicated in Table 2, the students showed higher mean engagement score in the treatment intervals compared to the baselines. Looking at overall performance of the participants, an obvious increasing trend can be detected within and between intervals. At **the first baseline**, the group mean was **8.8** (SD = 1.47), indicating that in general students were not highly engaged in the learning process before introducing the MWs. In the first treatment phase, where mini white-boards were presented, the mean score increased to**11.37** (SD = 1.1), showing effectiveness of intervention and higher engagement level for the whole group of participants. At the second **Baseline**, when the intervention was withdrawn, the group mean decreased to **9.00** (SD = 1.06). Although the overall mean in the second baseline was lower compared to the mean of the first treatment interval, a slight increase in baseline means could be seen. In the second treatment phase, the mean increased to 12.65 and confirmed the overall effectiveness of the intervention.

In addition to the descriptive statistics and in order to gain a better insight, a linear mixed-effects model was also conducted. The model predicted student scores based on the **condition** (Baseline 1, Treatment 1, Baseline 2, and Treatment 2) and **week** (Week 1 to Week 4) while accounting for **random effects** due to individual student differences. Including "week" as a variable in the model allowed us to detect if scores naturally improved or declined over the four weeks, perhaps due to factors like cumulative learning or fatigue. A random intercept for students was included to account for individual variability. Results can be seen in Table 3.

Table 3. *Results of the Linear Mixed-Effects Model for Student Engagement Scores*

Predictor	Estimate	Std. Error	DF	t-value	p-value
Intercept	8.20	0.8146	143	10.07	<0.001
Condition (Baseline 2)	0.70	0.7392	143	0.95	0.3452
Condition (Treatment 1)	2.90	0.7392	143	3.92	<0.001
Condition (Treatment 2)	4.05	0.7392	143	5.48	<0.001
Week	0.24	0.1909	143	1.26	0.2106
Condition (Baseline 2)	-0.19	0.2699	143	-0.70	0.4826
Condition (Treatment 1)	-0.13	0.2699	143	-0.48	0.6308
Condition (Treatment 2)	-0.08	0.2699	143	-0.30	0.7674

The fixed effects of the model indicated significant improvements in engagement scores during Treatment 1 ($\beta = 2.90$, SE = 0.74, t (143) = 3.92, $p < 0.001$) and Treatment 2 ($\beta = 4.05$, SE = 0.74, t (143) = 5.48, $p < 0.001$) compared to Baseline 1. The effect of week was not statistically significant ($\beta = 0.24$, SE = 0.19, t (143) = 1.26, $p = 0.210$), confirming the effectiveness of intervention and indicating that cumulative learning was not a determining factor.

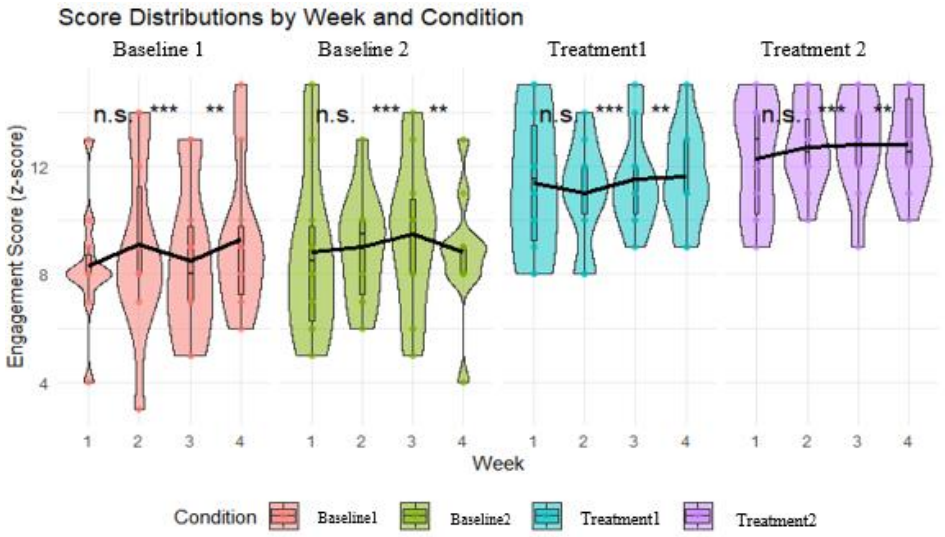

Figure 2. *Using Mini White-boards Enhances Learning Engagement*

Figure 2 shows mean engagement scores (z-scores) across four weeks for four experimental conditions: Baseline1, Baseline 2, Treatment 1, and Treatment 2. The ordinate (y-axis) represents engagement scores as z-scores, while the abscissa (x-axis) represents weeks (1 through 4). Engagement scores during Baseline 1 showed some fluctuations from week to week, though a major shift occurred in Week 3 and Week 4 as scores increased significantly compared to the earlier weeks. A similar trend was also observed for Baseline 2. For the Treatment 1 condition, there was no significant difference in mean scores between weeks, indicating that the level of engagement did not vary during the treatment stage. Finally, for Treatment 2 scores, the range was moderate and a substantial improvement was recorded

between Week 1 and Week 4. This pattern may indicate that the treatments were effective in maintaining consistent engagement particularly in the treatment 2 condition.

In addition to the above findings, descriptive statistics were employed to analyze the questionnaire data and address the second research question. The results of the questionnaire indicated general positive attitude of students towards using MWs. As indicated by the means, participants generally found mini white-boards beneficial in multiple aspects of their learning experience. However, they agreed more strongly with Question 7 ("MWs make learning English more interactive and engaging.") which can be reflecting their recent positive experience with MWs. On the other hand, the student showed slightly less agreement with Question 9 ("I would like to use mini white-boards in the future"). Although the related mean suggests student's general positive attitude towards using MWs in the future, the high standard deviation (SD = 0.98) indicates that some of the students were not totally satisfied with their experience. This variation highlights the importance of personal opinions and preferences in using pedagogical tool, while referring to the fact that some students may have encountered challenges when using MWs.

Table 4. *Results of Attitude Questionnaire*

Item	M	SD
The use of mini white-boards reduces my anxiety during English lessons.	4.3	0.64
Mini white-boards help me organize my thoughts better.	4..2	0.75
Mini white-boards help me identify and correct my mistakes based on immediate teacher Feedback.	4.1	0.83
I feel more confident answering questions using mini white-boards.	4.1	0.70
It is easier to participate in class activities when using mini white-boards.	4.2	0.87
When I use mini white-boards, I better understand what I am learning in class	4.2	0.75
Mini white-boards make learning English more interactive and engaging.	4.6	0.49
I enjoy using mini white-boards.	4.3	0.78
I would like to use mini white-boards in the future	4.0	0.98

Discussion

his study provides empirical evidence on the benefits of using MWs to engage high school students in the learning process and improve their language learning experience. Results indicated that incorporating MWs in an EFL class, would lead to higher engagement, deeper understanding of the concepts, less anxiety and more joy.

Specifically, our findings showed that in under-resourced contexts where high-tech tools are not available, students can benefit from whiteboarding to effectively interact with the teacher and engage in the learning process. The mean engagement score was higher in the treatment intervals (1,2) compared to the baselines. The mean engagement score in the first baseline increased significantly to 11.37 in the first treatment interval for which the instructor combined the targeted practice phase with whiteboarding activities. The same increasing pattern was observed for the second baseline and treatment intervals, confirming the effectiveness of the intervention. This scholarly study makes a novel contribution to the field of education, as it empirically investigates the impact of the whiteboarding strategy in an under-resourced high school EFL course.

Moreover, unlike much of the existing research on MWs, this study tried to enhance engagement not only by the use of MWs but also by providing personalized feedback in addition to whole-class ones and developing deep thinking by engaging students in the iterative process of inquiry, reflection, and refinement. Results from the students' questionnaire align with the objectives students are expected to meet in an EFL classroom, such as promoting purposeful interaction, enhancing effective learning, and boosting students' self-confidence. Based on the students' responses, MWs were effective not only in engaging them behaviorally but also emotionally and cognitively. From a cognitive perspective, students had the chance to organize their thoughts, receive immediate feedback and reflect on their responses. Using MWs they were able to focus on chunks of information and more deeply understand the content they were learning.

Mini white-boards were also effective in emotionally engaging students. According to the results, the students experienced lower levels of stress and anxiety while participating in classroom activities. Students also reported themselves to be more confident while using MWs. Such results indicate that MWs can serve as an effective pedagogical tool to improve the learning experience and engagement level of students in language classrooms. The findings of this study, along with related research (Gimbutas, 2019; Schaffner et al., 2015), provide growing evidence which supports the need for teachers to move towards using formative assessment techniques and tools such as MWs to increase engagement and enhance learning in their classrooms. Research consistently highlights the drawbacks of rote learning and supports the outstanding role of repetition for long-term retention (Carrier & Pashler, 1992). However, repetition without having the opportunity to actively engage with the material, get timely feedback and ask questions might not lead to internalization of the knowledge and deep learning, specifically in language learning context (Bitchener & Storch, 2016; Lyster & Ranta, 2013). Using tools like MWs offers a way to address these challenges. The implementation of these tools would lead to active participation, and enables teachers to assess students' understanding in real-time and correct misunderstandings immediately. This approach promotes repeated engagement and active recall and would lead to deeper learning.

While traditional assessments like quizzes and exams still have their place, integrating formative assessments and formative feedback though MWs would create more dynamic learning environment and improve learning outcomes (Hattie & Timperley, 2007). These findings are consistent with previous research that highlights the effectiveness of using student response systems (SRSs) in classrooms (Clayton & Woodard, 2007; Fies & Marshall, 2006; Nagro et al., 2018; Penuel et al., 2007; Preszler et al.,2006; Shahba et al., 2023; Stowell & Nelson, 2007; Su et al., 2018; Wu, 2019). The findings of this research are more specifically in line with the findings of Christle and Schuster (2003), Gimbutas (2019), Lambert at al. (2006), and Musti-Rao et al. (2008), indicating the positive effect of using MWs on students' engagement, participation and achievement.

Although the result of the study reflected the positive contribution of MWs, it is still not possible to exclude individual variability. Whereas the level of engagement for most students increased during the intervention phases, some students experienced fluctuations. The declines and fluctuations can suggest that although MWs are generally effective, their impact might get

moderated by other factors such as personal traits, external distractions, or motivational status and class dynamics. For instance, though Student 3 showed a general upward trend, a slight decline from her engagement mean of 12.00 in the first Intervention to 11.75 in the second Intervention can be seen. In sum, these results confirm our hypothesis by providing good evidence that the MWs significantly increase the level of student engagement in class.

Conclusion

Teachers in resource-constrained contexts can achieve substantial learning gains and enhance engagement by adopting simple, low-cost tools like mini white-boards. In fact, teachers can integrate real-time feedback into their formative assessment cycle easily and promote a student-centered approach in which learners take ownership of their learning. In such an interactive learning environment, students would efficiently assess their own learning status and try reducing their knowledge gap through collaborating with self, peers, and the teacher.

This study was an attempt to underscores the importance of accessible, low-cost tools in transforming traditional classrooms in under-resourced settings into dynamic learning environments. We assume that since MWs proved effective in such constrained conditions, they could also offer scalable and practical solutions for similar educational environments. Future research with larger sample sizes can enhance generalizability of the findings. Moreover, the researchers can go a step further by looking into the use of diverse formative assessment tools in other levels of educational institutions, such as primary or university-level classes. In EFL context, the effect of different types of white-boarding prompts on learning distinct skills/subskill can be compared. Since sustainability in students' learning is considered as a core aspect of education, future studies can extend the research period to at least a year and examine the long-term effects of using mini white-boards.

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