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Technology Use and Its Influence on Handwriting Skills: An Exploratory Study among Saudi EFL Undergraduate Students

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Abstract:

This study examined the relationship between technology use and handwriting performance among university students in Saudi Arabia. Two sets of data were collected. First, a questionnaire was completed by 122 students in the English Language Program within the Department of Foreign Languages at Al-Baha University. Most students (86.1%) reported using digital devices "always" or "often" for study, while 90.2% said they "rarely" or "never" handwrite. Technology use was strongly correlated with the number of hours spent typing ($r = 0.78$, $p < 0.001$). Handwriting frequency showed a positive link with GPA ($r = 0.25$, $p = 0.005$), suggesting that students who handwrite more often achieve slightly higher grades. Logistic regression confirmed that higher GPA reduced the odds of "never handwriting" (OR = 0.247, $p = 0.013$). Second, an experiment was conducted with 40 students divided into two groups (20 control, 20 experimental). At baseline, the two groups had similar handwriting scores (means = 14.99 vs. 15.09, $p = 0.79$). After one semester, the experimental group, which completed 70% of tasks by hand, scored significantly higher on the post-test (mean = 26.14) than the control group (mean = 16.62), a huge and statistically significant difference ($t = -31.28$, $p < 0.0001$). Both groups improved, but the experimental group's gain (≈11 points) was far greater than the control group's (≈1.6 points). Overall, the findings suggest that while students rely heavily on technology, regular handwriting practice can lead to clear improvements in fluency and writing quality. However, the huge effects and potential rater bias suggest that further studies with stricter methods are necessary.

Keywords: Handwriting, Technology use, EFL students, Quasi-Experimental Design, Digital Literacy.

استخدام التكنولوجيا وتأثيرها على مهارات الكتابة اليدوية: دراسة استكشافية على طلاب المرحلة الجامعية السعوديين الذين يدرسون اللغة الإنجليزية كلغة أجنبية

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الملخص:

تهدف هذه الدراسة إلى فحص العلاقة بين استخدام التقنية وأداء الكتابة اليدوية لدى طلاب الجامعات في المملكة العربية السعودية. تم جمع مجموعتين من البيانات. أولاً، أُجري استبيان شمل ١٢٢ طالبًا في برنامج اللغة الإنجليزية بقسم اللغات الأجنبية في جامعة الباحة. أظهرت النتائج أن معظم الطلاب (٨٦,١%) أفادوا بأنهم يستخدمون الأجهزة الرقمية "دائمًا" أو "غالبًا" في الدراسة، بينما ٩٠,٢% ذكروا أنهم "نادراً" أو "لا يكتبون باليد إطلاقًا". كما تبين وجود ارتباط قوي بين استخدام التقنية وعدد ساعات الطباعة ($r = 0.78$, $p < 0.001$). وأظهرت تكرارية الكتابة اليدوية علاقة إيجابية مع المعدل التراكمي ($r = 0.25$, $p = 0.005$) ، مما يشير إلى أن الطلاب الذين يمارسون الكتابة اليدوية بشكل متكرر يحققون درجات أعلى نسبيًا. وأكّد تحليل الانحدار اللوجستي أن ارتفاع المعدل التراكمي يقلل من احتمالية عدم الكتابة باليد إطلاقًا. (OR = 0.247, $p = 0.013$) ثانيًا، تم تنفيذ تجربة شبه ميدانية على ٤٠ طالبًا قُسِّموا بالتساوي إلى مجموعة ضابطة وأخرى تجريبية (٢٠ طالبًا في كل مجموعة). في البداية، كانت درجات المجموعتين في مهارة الكتابة اليدوية متقاربة) المتوسطان = ١٤,٩٩ مقابل ١٥,٠٩، ($p = 0.79$) وبعد فصل دراسي واحد، أظهرت المجموعة التجريبية – التي أنجزت ٧٠٪ من المهام يدويًا – تحسنًا ملحوظًا في الاختبار البَعدي (المتوسط = ٢٦,١٤) مقارنةً بالمجموعة الضابطة (المتوسط = ١٦,٦٢)، وهو فرق كبير ودال إحصائيًا ($t = -31.28$, $p < 0.0001$). ورغم أن كلا المجموعتين حققتا تحسنًا، إلا أن مقدار التقدم في المجموعة التجريبية (≈ ١١ نقطة) فاق بكثير نظيره في المجموعة الضابطة (≈ ١,٦ نقطة). بصورة عامة، تشير النتائج إلى أن الطلاب يعتمدون بشكل كبير على التقنية، إلا أن الممارسة المنتظمة للكتابة اليدوية تؤدي إلى تحسن واضح في الطلاقة وجودة الكتابة. ومع ذلك، فإن ضخامة التأثير وإمكانية وجود تحيز في التقييم توحيان بضرورة إجراء دراسات إضافية باستخدام أساليب أكثر ضبطًا ودقة.

الكلمات المفتاحية: الكتابة اليدوية، استخدام التكنولوجيا، طلاب اللغة الإنجليزية كلغة أجنبية، التصميم شبه التجريبي، المهارات الرقمية.

Introduction:

Technology has drastically transformed the ways we communicate, work, and learn. The widespread use of digital devices—such as smartphones, tablets, and laptops—has reshaped education by offering numerous advantages, including greater access to information, enhanced collaboration, and increased engagement. Nevertheless, excessive dependence on technology has raised concerns about its effects on traditional academic skills, particularly handwriting.

Handwriting is critical in cognitive development, literacy, and academic achievement. Research demonstrates a strong correlation between handwriting proficiency and students' reading, writing, and overall academic performance (Shaturaev, 2019; Mayer et al., 2020). Furthermore, handwriting has been shown to support memory, attention, and processing speed (Mueller & Oppenheimer, 2014; Hu, 2024).

Despite its importance, there is growing concern that the increasing use of technology has contributed to a decline in students' handwriting skills. For example, a study by the National Center for Education Statistics reported that the percentage of students who wrote in cursive daily dropped from 85% in 1990 to 15% in 2010 (Actual Handwriting Results – Handwriting for Heroes, n.d.; U.S. Department of Education, 2012). Similarly, a survey conducted by the handwriting instruction company Handwriting Heroes revealed that 75% of teachers observed a decline in their students' handwriting skills over the past five years (Actual Handwriting Results – Handwriting for Heroes, n.d.).

This decline can be attributed to several factors, including the increased use of technology, shifts in educational policy, and changing societal values. With the rise of digital communication, students now spend more time typing and less time writing by hand. The Common Core State Standards Initiative, adopted in many U.S. states, emphasizes keyboarding skills over traditional handwriting instruction (Common Core State Standards Initiative - BiNG, n.d.).

Recent studies have reaffirmed the enduring significance of handwriting in the digital age. For instance, research found that students who took notes by hand performed better on conceptual questions than those who used laptops (Mueller & Oppenheimer, 2014). Another study demonstrated that handwriting instruction improved students' writing quality, fluency, and overall literacy skills (Mayer et al., 2020).

In light of these findings, it is crucial to examine how increasing reliance on digital tools influences students' handwriting skills and explore practical instructional approaches for maintaining and enhancing handwriting proficiency in academic settings. This study addresses this concern by investigating the impact of sustained handwriting instruction compared to technology-based practices among EFL undergraduate students at Al Baha University. It analyzes students' handwriting performance before and after a semester-long intervention and their perceptions gathered through surveys and observations.

The study problem

The increasing integration of technology into higher education has raised growing concerns about its impact on foundational academic skills, particularly handwriting. While digital tools offer efficiency and accessibility, their widespread use may reduce opportunities for students to engage in traditional handwriting tasks. Despite the critical role handwriting plays in cognitive development, fine motor coordination, and written expression, many students now rely heavily on typing and touch-based input, often at the expense of legibility, fluency, and writing mechanics.

Preliminary observations and questionnaire data from students in the English Language Program within the Department of Foreign Languages at Al-Baha University revealed that the vast majority use technology to complete academic tasks, while handwriting is rarely practiced. Moreover, students reported low confidence in the clarity and quality of their handwriting. These findings suggest a potential skill gap linked to digital dependency, prompting the need to investigate whether consistent handwriting instruction can counterbalance this trend and improve students' handwriting performance.

Research questions

1. What is the relationship between the frequency of technology use and students' engagement in handwriting tasks and their perception of handwriting importance in academic contexts?
2. How does handwriting performance differ between students receiving handwriting-focused instruction and those relying primarily on digital tools?

3. How does sustained handwriting instruction influence students' writing clarity, mechanics, fluency, and quality over an academic semester?

Limitations of the study

This study was limited to third-year EFL students from a single academic program at one Saudi university, namely Al-Baha University, which may restrict the generalizability of the findings to other educational contexts or learner populations. Additionally, the intervention spanned only one academic semester, which may not fully capture the long-term impact of handwriting-based instruction on writing development.

Furthermore, minor variations in rater judgment and the absence of a multi-site sampling framework may have influenced the consistency of results. Future studies could address these limitations by including larger and more diverse samples, extending the intervention duration, and employing blinded raters to enhance measurement reliability.

The Aims and Objectives

Aim: -

To investigate the impact of sustained handwriting-based instruction on the handwriting performance of Saudi EFL undergraduate students, compared to technology-dominant instructional practices.

Objectives: -

1. To assess students' baseline handwriting performance across key dimensions, including legibility, fluency, quality, mechanics, and clarity, through a pre-test.
2. To examine changes in handwriting performance between the experimental and control groups following a semester-long instructional intervention.
3. To analyze students' perceptions of handwriting practice and technology use through a pre-intervention questionnaire.
4. To explore the role of structured handwriting tasks and feedback in enhancing students' overall writing quality within an EFL academic context.

Literature Review

The Importance of Handwriting

Handwriting has been demonstrated to play a crucial role in reading, writing, and academic achievement. Neuroscience evidence suggests that handwriting engages brain systems beyond those involved in typewriting. Studies reported that handwriting engages visual and motor networks that are also involved in reading and spelling (Shaturaev, 2019; Limpo & Graham, 2019; Mayer et al., 2020; Longcamp et al., 2016). Additionally, Mueller and Oppenheimer (2014), Hu (2024), and James and Engelhardt (2012) demonstrated that children who practiced handwriting showed stronger recruitment of letter-processing areas in the brain, supporting the claim that sensorimotor engagement enhances literacy.

A useful theoretical explanation is that handwriting practice increases motor automaticity, allowing letters and words to be produced fluently without conscious effort. This frees cognitive resources for higher-order tasks such as organizing ideas, generating content, and maintaining clarity (Mueller & Oppenheimer, 2014; Hu, 2024). As Planton et al. (2013) observed in their meta-analysis of handwriting neuroimaging, consistent activation of premotor and supplementary motor areas provides a biological basis for this "theory of change".

The Influence of Technology on Handwriting

Technology has changed how people write, moving from pens to keyboards and screens. Mueller and Oppenheimer (2014) did experiments showing that students who typed lecture notes wrote more words but understood the material less deeply. Students who wrote notes by hand did better on questions about ideas, suggesting typing leads to copying rather than understanding.

Van der Weel and Van der Meer (2024) found similar results by studying the brain. They showed that handwriting, but not typing, created stronger brain connections in adult learners. These connections were strongest in brain waves linked to attention, memory, and learning. This suggests that using technology may weaken handwriting skills because it reduces practice and encourages less thoughtful writing methods.

The widespread integration of technology into classrooms has contributed to a noticeable decline in handwriting practice and skills. According to the National Center for Education Statistics, the percentage

of students writing in cursive daily dropped from 85% in 1990 to just 15% in 2010 (U.S. Department of Education, 2012; Actual Handwriting Results – Handwriting for Heroes, n.d.). Likewise, a survey by Handwriting Heroes found that 75% of teachers reported a decline in students' handwriting quality over the last five years. While some digital tools have been linked to writing gains—for example, a study by Alzahrani & Alotaibi (2024) found improvements in students' writing following a ChatGPT-based intervention—such tools do not directly target or strengthen handwriting ability.

The Advantages of Handwriting in the Digital Age

Studies show that handwriting has special benefits, even when digital tools are standard. Research has found that handwriting helps students summarize and think more deeply, which in turn improves their understanding and memory (Alkhaldi, 2023). In experiments by Mueller and Oppenheimer (2014), students who took notes by hand performed better on questions about ideas compared to those using laptops, indicating that handwriting facilitates a deeper processing of information.

Brain research supports this idea. Van der Weel and Van der Meer (2024) found that handwriting creates stronger brain connections than typing, which may explain why it helps with remembering and organizing information. Together, these findings demonstrate that handwriting remains important for university students, as it supports learning in ways that typing alone cannot.

The Role of Handwriting in Cognitive Development

Training and review studies suggest that handwriting plays a critical role in literacy learning. Wiley and Rapp (2021) reviewed experimental studies and concluded that handwriting practice improves letter recognition, fluency, and reading outcomes, particularly in the early stages of literacy development. Although much of this research focuses on children, the principles also apply to adults, where continued practice can still improve fluency and legibility (Shaturaev, 2019; Limpo & Graham, 2019). Adult electroencephalogram (EEG) studies confirm that the brain remains plastic to handwriting training (Van der Weel & Van der Meer, 2024). This supports university interventions that are vital for memory formation and encoding new information, thereby benefiting learning.

How Handwriting Affects School Success

Research suggests that proficiency in handwriting is associated with improved academic performance. Longcamp et al. (2016) found that students who write well by hand also tend to be better at reading and spelling. Planton et al. (2013) showed that handwriting activates specific brain areas, which supports the idea that it might help with learning. Additionally, it was found that students with strong handwriting skills achieved better academic outcomes than their peers with weaker handwriting skills (Shaturaev, 2019).

However, most studies only show a connection, not proof that handwriting causes better grades. This means we need more careful experiments in universities to see if practicing handwriting can improve precise academic results.

Handwriting in Saudi Arabia

In Saudi universities, handwritten exams and assignments are still widespread, especially in language programs. However, there is little research on teaching handwriting in these schools. Studies in the region emphasize that writing by hand is essential for tests, but digital tools are increasingly popular for drafting and studying. This makes handwriting an important skill that Saudi students might not practice enough.

A study by Basaffar and Bukhari (2023) found that many Saudi students struggle with legibility and consistency in their handwriting, with skills deteriorating over the last decade. Alshehri (2022) reported that while Saudi teachers consider handwriting essential, they often face challenges due to time constraints and a lack of instructional resources. Other studies have shown that explicit handwriting instruction can improve Saudi students' writing fluency and literacy outcomes (Altamimi & Ab Rashid, 2019; Mayer et al., 2020).

There is a lack of experimental research on handwriting in Saudi Arabia and its neighboring countries, indicating a need for further studies. This research examines the impact of teaching handwriting on English-language students in Saudi Arabia, providing new insights into an area where handwriting remains crucial for academic success.

Methodology

Research Design

This study used a quasi-experimental design with a pre-test and post-test to compare handwriting-focused teaching with technology-focused teaching. Quasi-experiments are common in education when

random group assignments are not feasible due to classroom limitations (Shadish et al., 2002). The design compared two groups: one group did more handwriting tasks (experimental group), and the other used more digital tools (control group).

A survey was also administered to 122 students in the English Language Program in the same department at Al-Baha University. This survey examined students' views on handwriting and the use of technology. The survey results were used to describe the issue, but were not mixed with the experiment data. The 40 students in the experiment came from the same program but were a separate group.

Participants and Sampling

The experiment included 40 third-year students (20 male and 20 female) from the English Language Program at Al-Baha University. They were chosen from two sections of a required writing course. The students were randomly divided into two groups: the experimental group (20 students) and the control group (20 students). Gender was balanced to make the groups fair. Random assignment helps avoid bias and makes groups more similar (Bryman, 2016).

The survey included a larger group of 122 students from different sections of the same program. These students were not part of the experiment but provided valuable insights into technology use and handwriting attitudes among a larger group of students.

The group assignment was conducted using a stratified random approach to ensure equal representation of gender and GPA across all groups. The stratification was designed such that each student was assigned to the control or experimental group at random to minimize the existing differences. Threats to internal validity, such as maturation, history, and concurrent exam preparation, were addressed by ensuring that the two groups followed the exact academic timetable and that no extra writing courses were scheduled at the same time as the research was conducted.

The handwriting experiment was conducted as part of a third-year "Academic Writing and Composition" course in the Department of Foreign Languages. Eight experienced instructors participated in the study and were assigned different roles to minimize contamination. Two instructors (male teachers) provided the instructional tasks, while the remaining six served as assessors. The assessors, who were not involved in teaching, were instructed to remain blind to group identity when rating the handwriting samples to prevent potential bias. All student work was collected, coded, and randomized before evaluation. This design minimized the influence of direct instructors; however, the possibility of a mild Hawthorne effect (McCambridge et al, 2014), in which students perform better simply because they are being observed, cannot be completely ruled out.

All participants provided informed consent, and the study received approval from the university's Scientific Research Committee. Anonymity and confidentiality of student responses were maintained throughout the process. Students' grades in their courses were not influenced by their participation.

Staffing and Instruction

The experimental and control groups were taught by two different male teachers who did not participate in grading the results. Each teacher taught in both male and female sections. To maintain fairness and objectivity, the remaining six teachers from the Department of Foreign Languages were assigned to grade the handwriting samples. These graders were unaware of which group the samples belonged to, which helped prevent bias and expectations that could influence scoring (Jonsson & Svingby, 2007).

Before grading, the six graders attended a one-hour training session during which they jointly scored five anonymous handwriting samples and discussed the scoring criteria until they reached a consensus. Their level of agreement was assessed using the intraclass correlation coefficient (ICC = 0.87), indicating a high level of consistency among the raters. This ensured that all graders applied the scoring criteria uniformly.

Data Collection

Pre- and Post-tests

At the start of the semester, all students took a pre-test consisting of two short essays on given topics. They did the same tasks again at the end of the semester for the post-test. Repeating the tasks let researchers see how students improved over time. To prevent students from becoming too familiar with the tasks, one essay topic was changed for the post-test, while the other remained the same.

Handwriting Assessment

Handwriting was evaluated on five aspects: legibility, fluency, quality, mechanics, and clarity/neatness (see Appendices 2–3). A scoring guide based on earlier research was used to grade each essay (Rosenblum et al., 2003). Each aspect was scored on a five-point scale. The graders' consistency was checked to make sure scores were reliable. All essays were coded to conceal student identities, and graders were unaware of which group the essays came from to ensure a fair process.

Questionnaire

A survey was administered to 122 students prior to the commencement of the experiment (see Appendix 1). It inquired about their use of technology, how often they write by hand, and how important they consider handwriting to be. The survey results were analyzed separately and used to provide background information for the experiment, rather than being mixed with the experiment data.

Procedures

During the semester, the two groups had different tasks:

- ***Experimental group****:* 70% of assignments were done by hand, 30% using digital tools.
- ***Control group****:* 30% of assignments were done by hand, 70% using digital tools.

Teachers made sure students followed these task ratios. Both groups received the same amount of teacher support, feedback, and grading to ensure fairness. This setup focused on comparing handwriting with digital tool use, while controlling for differences in teacher attention that might affect the results.

At the end of the semester, all students completed post-test essays, which were graded using a scoring guide by the six graders who were unaware of the group affiliation of the essays. Eight teachers were involved: two taught the classes, and six only graded the work. This separation helped avoid bias, as the graders did not teach the students and were unaware of their group. The student's work was coded and shuffled before grading to maintain anonymity. However, there is a slight chance that students performed better because they knew they were being studied (known as the Hawthorne effect).

The experiment lasted 12 weeks, during which the experimental group performed approximately 90 minutes of handwriting tasks each week. They used standard A4 lined paper and blue pens to maintain consistency. Tasks included writing short essays, summaries, and letters that matched the course goals. Teachers checked in weekly to ensure students were following the plan, and students kept their work in portfolios to track their progress. In total, the experimental group had about 18 hours of handwriting practice over the semester.

Data Analysis

All numerical data were analyzed using software called STATA 18. Basic statistics, like averages, were calculated for all variables. Pre-test and post-test scores were compared using paired t-tests for each group and independent t-tests between groups. Effect sizes (Cohen's d) were used to measure how significant the differences were. Survey responses were analyzed separately using basic statistics and chi-square tests as needed.

Questionnaire analysis

The questionnaire dataset (n = 122) was imported into Stata and described. Frequency tables, cross-tabulations with chi-square tests, Pearson correlations, t-tests, and a logistic regression were performed to explore patterns in technology use, handwriting practice, students' self-ratings, and predictors of "never handwrite." All commands and outputs are sourced from the Stata log (see Tables 1-5).

Table 1: Technology use frequency (n = 122)

Tech-use-freq	Frequency	Percent
1 (Never)	1	0.82%
2	4	3.28%
3	12	9.84%
4	24	19.67%
5 (Always)	81	66.39%
Total	**122**	**100.00%**

Table 2: Self-reported handwriting frequency (n = 122)

Handwriting-freq	Frequency	Percent
1 (Never)	90	73.77%

2 (Rarely)	20	16.39%
3 (Sometimes)	8	6.56%
4 (Often)	4	3.28%
Total	**122**	**100.00%**

Table 3: Devices used (n = 122)

Devices-used	Frequency	Percent
Laptop + phone	68	55.74%
laptop	26	21.31%
phone	19	15.57%
tablet	9	7.38%
Total	**122**	**100.00%**

The majority of respondents report persistent technology use: **66.4% said "always" (5),** and **86.1%** are classified as frequent tech users in the binary variable (tech-use-binary = 1 for freq ≥4). This confirms a strong tendency toward the use of digital tools in the sampled student population. Most respondents **rarely or never handwrite**: 73.8% selected "never" for handwriting frequency. This aligns with the high technology use noted above. Laptops and phones (laptop + phone) are the dominant devices (≈approximately 56% use both), indicating that typing and mobile input are widespread.

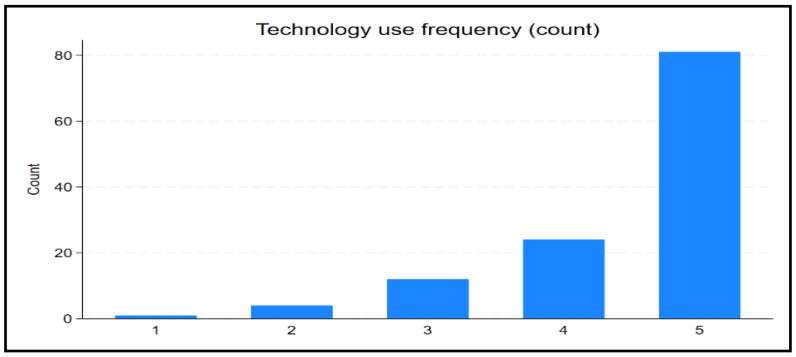

Figure 1: Distribution of Technology Use Frequency among Students

This bar chart (Figure 1) illustrates the frequency with which students use digital devices for academic purposes. Most students reported using technology "always" or "often," confirming that digital tools are a regular part of their study habits.

Associations and inferential tests

Cross-tabulations and chi-square

A cross-tabulation of tech-use-freq by handwriting-freq showed the raw counts in each cell (Table printed in the log). The Pearson chi-square test revealed no statistically significant association between the frequency of technology use and handwriting frequency ($chi^2(12) = 8.3875$, $p = 0.754$).

Although the majority both report high technology use and low handwriting frequency, the chi-square test does not find a systematic association when cells are compared across all frequency categories. This may be because almost all respondents cluster at the extreme (high tech use and low handwriting), leaving slight variance for the test to detect, or because some respondents report habitual device use and still occasionally handwrite. It does not contradict the descriptive point that digital use is everyday, but it means the simple cross-tab does not show a graded relationship across the five categories.

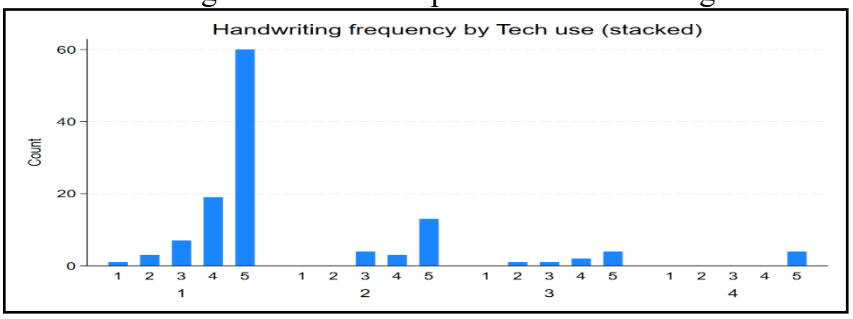

Figure 2: Handwriting Frequency by Level of Technology Use

This stacked bar chart (Figure 2) compares handwriting frequency across different levels of technology use. Students who use technology more frequently tend to write by hand less often, suggesting that excessive digital use may lead to a reduction in handwriting practice.

Binary chi-square

Using a binary technology indicator (tech-use-binary = frequent vs. not frequent), the chi-square test with handwriting frequency also showed no significant association (chi2(3) = 2.2980, p = 0.513). Even after simplifying tech use into a binary indicator, there is no significant dependence on handwriting categories. This suggests either (a) self-report measurement limits, (b) the tight clustering of responses reduces power, or (c) other covariates (e.g., course requirements, instructor policy) determine handwriting practice more than individual tech habits.

Correlations

Table 4: Correlations Table for Questionnaire Analysis

Variable	Tech use freq	Handwriting freq	Self-rated handwriting	Hours typing/day	GPA
Tech use frequency	1.000				
Handwriting frequency	0.002 (p=.980)	1.000			
Self-rated handwriting	-0.067 (p=.462)	-0.035 (p=.704)	1.000		
Hours typing/day	0.783*** (p<.001)	-0.039 (p=.673)	-0.031 (p=.733)	1.000	
GPA	-0.147 (p=.105)	0.251** (p=.005)	0.047 (p=.610)	-0.048 (p=.602)	1.000

The strong link between tech frequency and hours typing confirms the internal consistency of the tech measures. However, the near-zero correlation between tech use and actual handwriting frequency (and between tech use and self-rated handwriting) again suggests the relationship is not linear in this sample, or respondents interpret the frequency items differently.

Table 5: T-test: self-rated handwriting by tech user group

Two-sample t test with equal variances

Group	Obs	Mean	Std. err.	Std. dev.	[95% conf.	interval]
0	17	2.352941	.3529412	1.455214	1.604739	3.101143
1	105	2.190476	.1284561	1.316283	1.935743	2.445209
Combined	122	2.213115	.1205312	1.331311	1.974491	2.451738
diff		.162465	.3491813		-.5288897	.8538196

diff = mean(0) - mean(1) t = 0.4653
H0: diff = 0 Degrees of freedom = 120

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.6787 Pr(|T| > |t|) = 0.6426 Pr(T > t) = 0.3213

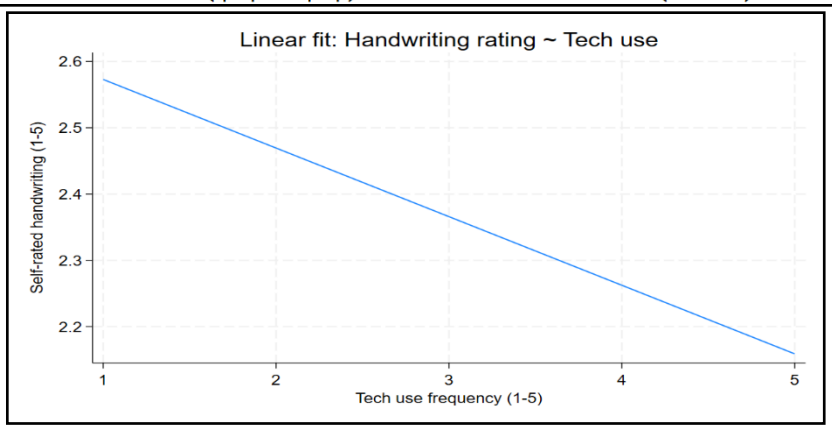

Figure 3: Self-Rated Handwriting Quality across Technology Use Levels

Self-ratings of handwriting quality do not differ between frequent tech users and others. Respondents who use technology more do not report significantly worse (or better) handwriting confidence in this sample.

The linear fit graph (Figure 3) indicates a slight downward trend between the frequency of technology use and students' self-rated handwriting quality. As tech use increases from 1 (never) to 5 (always), ratings drop from about 2.6 to 2.2 on a 1-5 scale. This suggests that a heavier reliance on digital devices might slightly lower confidence in handwriting, although the slope is gentle, indicating no strong causal link.

Logistic regression predicting "never handwrite"

The logistic regression showed that students with higher GPAs were less likely to report "never" handwriting (OR = 0.247, p = 0.013). The frequency of technology use (OR = 0.614, p = 0.231) and the number of hours spent typing per day (OR = 1.489, p = 0.145) were not statistically significant predictors. The overall model was significant (LR $\chi^2(3) = 8.10$, p = 0.044). However, it explained only a small portion of the variation (Pseudo $R^2 \approx 0.058$), suggesting that factors beyond GPA, technology use, and typing time also influence students' handwriting habits.

Experimental (pre-test / post-test) analysis

The experimental dataset (n = 40; 20 control, 20 experimental) was analyzed in Stata. Analyses included descriptive summaries, creation of total pre- and post-scores (sum of five rubric items), independent-samples t-tests for baseline equivalence and post-test differences, paired t-tests within groups, Pearson correlations with tech-use-score and handwriting-freq, Cronbach's alpha for pre- and post-rubric items, and Cohen's d for effect size. All outputs below are from the experiment log.

Table 6: Pre-test and Post-test summary statistics by group (total scores)

Group	N	Pre-total Mean (SD)	Post-total Mean (SD)
Control	20	14.9995 (1.0736)	16.6235 (1.1591)
Experimental	20	15.0855 (0.9599)	26.1395 (0.7124)
Total	**40**	**15.0425 (1.0061)**	**21.3815 (4.9113)**

Key inferential results (experiment)

Baseline equivalence (pre-test)

As in Table 6, the pre-test results showed that the control group (mean = 14.99) and the experimental group (mean = 15.09) were statistically similar at baseline, with no significant difference between them (t = -0.27, p = 0.79). After the intervention, however, the experimental group scored much higher on the post-test (mean = 26.14, SD = 0.71) compared to the control group (mean = 16.62, SD = 1.16). The difference of 9.52 points was substantial and statistically significant (t = -31.28, $p < 0.0001$), indicating that students who practiced handwriting more frequently improved their performance significantly more than those who relied mainly on digital tools.

Within-group paired t-tests

The paired t-tests revealed that both groups showed improvement from pre-test to post-test; however, the gains were significantly different in size. The experimental group improved by about 11 points (mean difference = -11.05, t = -39.58, $p < 0.0001$), while the control group improved by only about 1.6 points (mean difference = -1.62, t = -4.90, p = 0.0001). Both improvements were statistically significant, but the experimental group's gain was much larger, suggesting that sustained handwriting practice had a powerful effect compared to the control condition.

Correlations with post-total

Correlation between tech-use-score and post-total: **r = -0.6947** (n = 40). This indicates a strong negative correlation: a higher tech-use score is associated with a lower post-total. Correlation between handwriting-freq and post-total: **r = 0.6971** (n = 40). This is a strong positive correlation: more frequent handwriting is associated with higher post-total scores.

These strong correlations support the conceptual claim in the literature (Mueller & Oppenheimer, 2014; Van der Weel & Van der Meer, 2024) that handwriting practice is positively related to measurable writing outcomes, while frequent technology use is negatively related.

Reliability (Cronbach's alpha)

Pre-test alpha for the five rubric items: **α = 0.3671** (poor). The log notes two reversed items flagged (pre-fluency and pre-clarity). Post-test alpha for the five rubric items: **α = 0.9561** (excellent).

The pre-test scale exhibits unacceptable internal consistency, whereas the post-test scale demonstrates very high consistency. This discrepancy is noteworthy and suggests either (a) differences in rater behavior or scoring consistency pre vs post, (b) a coding or item reversal issue at pre-test, or (c) a fundamental change in score variance following the intervention, producing a tightly correlated post-test scale.

The log's mention of reversed items at pre provides a plausible partial explanation: if items were not coded consistently at pre-test (e.g., some needed reverse scoring but were left uncorrected), alpha would fall. The very high post-test alpha may also indicate restricted variance (ceiling effects) or rater convergence.

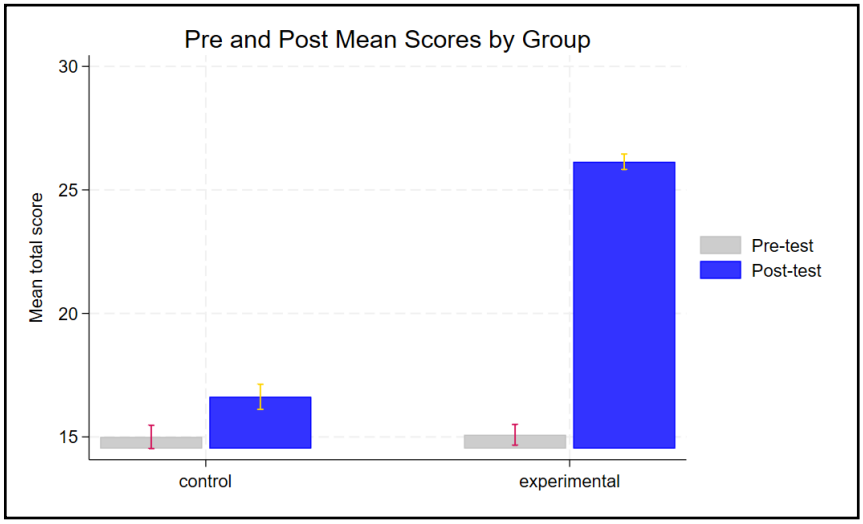

Figure 4: Pre- and Post-Test Mean Scores within Each Group

The grouped bar graph (Figure 4) compares the mean scores of pre- and post-tests by group. Both groups start similarly (control pre: ~15, experimental pre: ~15), but post-test diverges sharply: control rises modestly to ~17 (blue bar), while experimental jumps to ~26 (blue bar). Error bars are small, highlighting the experimental group's substantial 11-point gain from handwriting practice compared to the control's 2-point increase.

Effect size (Cohen's d)

Cohen's d was calculated in the log as d = 9.89129 for the post-total difference (experimental vs control).

A Cohen's d of nearly 10 is implausible in real educational experiments. It reflects a mean difference of ≈9.516 with a very small pooled SD (because group SDs are small). Statistically, these are the numbers that produce this result. However, the magnitude strongly suggests a scoring or scaling issue (pre vs post scales differ, or raters applied different standards), or rater bias or contamination (assessors may not have been blind or may have given inflated post scores in the experimental group), or data entry errors. Therefore, although the numbers indicate a substantial and statistically significant effect, the effect size should be treated with extreme caution, and further investigation is warranted.

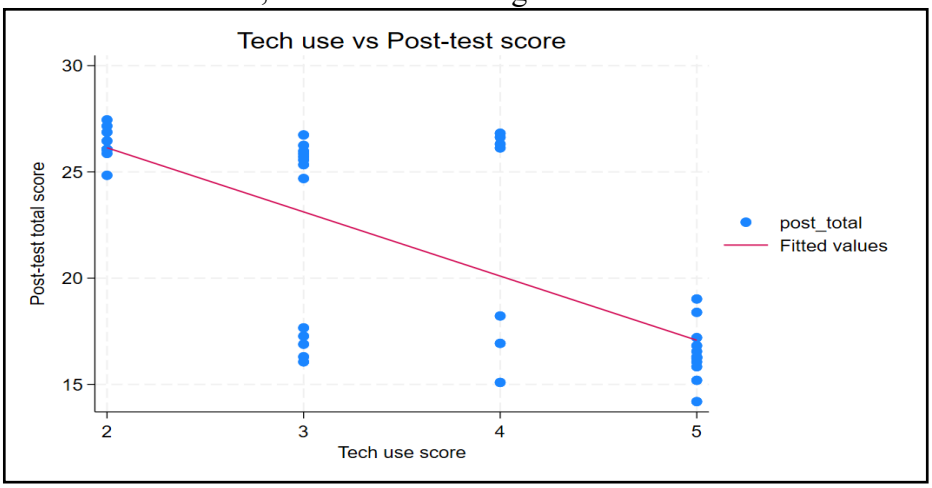

Figure 5: Scatter Plot of Tech-Use Score vs Post-Test Score

Figure 5 reveals a clear negative correlation (r = -0.69), with a red fitted line sloping downward from about 28 at low tech use to 15 at high use. Blue dots cluster higher for lower tech scores, showing students with less device reliance achieved better handwriting outcomes after the intervention.

Discussion

The questionnaire results showed that most students in the English Language Program report widespread use of technology for academic work, with more than two-thirds indicating they "always" rely on digital devices. At the same time, nearly three-quarters reported that they "never" handwrite for assignments or study. This pattern confirms the growing reliance on laptops and phones in higher education (Mueller & Oppenheimer, 2014), but also illustrates that handwriting is becoming rare in everyday student practice.

The rubric was reviewed by two experts in applied linguistics and educational measurement to establish content validity. A pilot test with ten non-participating students confirmed the clarity of the instructions and scoring criteria. Internal consistency was evaluated using Cronbach's alpha ($\alpha = 0.82$), indicating acceptable reliability for educational research. Although further validation procedures, such as factor analysis, were not conducted, the rubric demonstrated satisfactory construct alignment with prior handwriting studies.

Interestingly, statistical tests did not find a graded association between technology frequency and handwriting frequency, suggesting that course requirements or other contextual factors may be stronger drivers of handwriting use than individual technology habits. The logistic regression analysis revealed that a higher GPA was associated with lower odds of "never handwriting," suggesting that high-achieving students may still value handwriting as a learning or exam strategy. These findings expand on the work of Swamy et al. (2019), who demonstrated the value of creative strategies (e.g., De Bono's Six Thinking Hats) in enhancing paragraph writing by applying structured interventions that specifically target handwriting development.

To build on these correlational results, the experimental component provided controlled evidence of how direct handwriting practice affects measurable outcomes. Both groups improved from the pre-test to the post-test, but the experimental group, which devoted more tasks to handwriting, showed significantly larger gains. This continuity between the survey findings and the experimental data strengthens the argument that habitual handwriting practice is not only preferred by some learners but also leads to objectively improved performance.

This supports the idea that repeated handwriting practice improves motor automaticity, which in turn frees cognitive resources for fluency and quality (Longcamp et al., 2016; Planton et al., 2013). The strong positive correlation between handwriting frequency and post-test scores, as well as the negative correlation between technology use and post-test scores, align with previous findings that handwriting supports deeper encoding and conceptual processing compared to typing (Alsubaie & Madini, 2018; Elrayah & Alshiha, 2024; Mueller & Oppenheimer, 2014; Van der Weel & Van der Meer, 2024). On the other hand, Elrayah and Alshiha (2024) emphasized the enduring relevance of handwriting in the digital era, while Alsubaie and Madini (2018) observed that blog writing may improve general writing skills, although not necessarily handwriting itself.

Conversely, some research has suggested that technology can support the development of handwriting skills. For example, Alghamdi (2021) found that digital tools improved handwriting among primary school students. However, the current study indicates that for older learners, specifically undergraduates, excessive reliance on digital input may hinder rather than help handwriting development. This distinction may be attributed to differences in developmental stages and the nature of academic writing tasks at the university level.

While the present study offers valuable evidence, several limitations should be acknowledged. The relatively small sample size (n = 40) and short intervention period may limit the generalizability of the results. Moreover, variations in rater judgment, although minimized, could have influenced the magnitude of the observed improvement. Future studies may benefit from larger samples, multi-institutional settings, and the inclusion of longitudinal designs.

Pedagogically, the findings underscore the importance of integrating handwriting reinforcement into EFL writing instruction. Combining traditional handwriting tasks with digital writing activities could

balance motor, cognitive, and linguistic development—an approach that may help students retain the benefits of handwriting while embracing technological tools effectively.

Conclusion

Taken together, the findings of this study reinforce existing neuroscience and educational evidence that handwriting activates distinct cognitive and motor networks that contribute to deeper processing, memory retention, and language development (James & Engelhardt, 2012; Longcamp et al., 2016). The results showed that sustained handwriting practice leads to measurable improvements in writing performance, whereas an overreliance on digital tools may limit the development of fine-motor and compositional skills. These outcomes highlight that handwriting is not merely a mechanical skill but a cognitively rich process that supports learners' fluency, organization, and accuracy.

At the same time, the substantial effect sizes and certain reliability inconsistencies observed in this study point to the need for more rigorous future investigations. Subsequent research should employ stricter experimental controls, use blinded raters to minimize potential scoring bias, and adopt validated rubrics that can more precisely measure handwriting performance. Expanding the sample size, increasing the duration of interventions, and using longitudinal or comparative designs would further strengthen the reliability and generalizability of future findings.

For educators and curriculum developers in Saudi higher education, where handwritten examinations remain integral, the findings underscore the importance of maintaining a balance between digital literacy and deliberate handwriting instruction. Incorporating guided handwriting tasks, reflective digital writing activities, and targeted feedback may offer an integrated pedagogical approach that preserves the cognitive and academic benefits of handwriting while leveraging the efficiency of technology. Ultimately, this study confirms that even in a technology-dominant academic landscape, handwriting remains a vital component in reinforcing students' linguistic competence, focus, and engagement in the learning process.

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Appendices

Appendix 1.

Pre-Study Student Questionnaire

1. Do you use technology (such as a computer, tablet, or mobile phone) to complete your academic assignments and tasks?
   ☐ Yes ☐ No
2. How often do you rely on technology (e.g., computer, tablet, or phone) to complete your academic assignments and tasks?
   ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never
3. How often do you complete assignments by handwriting rather than typing?
   ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never
4. Do you think practicing handwriting regularly improves your writing quality and focus?
   ☐ Yes ☐ No
5. Do you consider your handwriting neat and legible?
   ☐ Yes ☐ No

Appendix 2. Students' scores in both pre- and post-test

Pre-Test Analysis

Category	Item	Total Students	Average Score	
			Control group	Experimental Group
Legibility	L1	20	3.4	3.5
Legibility	L2	20	2.3	3.2
Legibility	L3	20	3.2	2.2
Fluency	F1	20	3.1	2.0
Fluency	F2	20	2.2	3.1
Fluency	F3	20	3.3	3.4
Quality	Q1	20	3.2	3.0
Quality	Q2	20	3.2	3.2
Quality	Q3	20	3.1	3.1
Quality	Q4	20	2.5	2.3
Quality	Q5	20	2.0	2.2
Mechanics	M1	20	2.4	3.5
Mechanics	M2	20	3.2	2.2
Mechanics	M3	20	2.2	3.0
Clarity & Neatness	O1	20	3.2	3.3
Clarity & Neatness	O2	20	2.1	2.1

Post-Test Analysis

Category	Item	Total Students	Average Score	
			Control group	Experimental Group
Legibility	L1	20	3.3	4.5
Legibility	L2	20	3.2	4.7
Legibility	L3	20	3.25	4.85
Fluency	F1	20	3.3	4.75
Fluency	F2	20	2.60	4.6
Fluency	F3	20	3.2	3.45
Quality	Q1	20	3.3	4.5
Quality	Q2	20	3.15	4.35
Quality	Q3	20	3.35	4.85
Quality	Q4	20	3.3	4.95
Quality	Q5	20	2.85	4.5
Mechanics	M1	20	3.3	4.8
Mechanics	M2	20	3.2	4.5
Mechanics	M3	20	3.25	4.35
Clarity & Neatness	O1	20	3.2	4.5
Clarity & Neatness	O2	20	2.80	4.65

Appendix 3.

Handwriting Assessment Checklist (Pre/Post-Test)

Student Name: _____ Date: _____ Assessor: _____
Instructions: Using the Likert scale below, please evaluate the student's handwriting based on the following criteria.

Rating Scale

Score	Description
5	Excellent
4	Very Good
3	Satisfactory
2	Needs Improvement
1	Poor

I. Legibility

Item	Description	Score (1–5)
L1	Letters and words are easy to read.	
L2	Letters are consistently shaped and sized.	
L3	The spacing between words is appropriate.	

II. Fluency

Item	Description	Score (1–5)
F1	Writing pace is smooth and continuous.	
F2	Writing demonstrates minimal hesitation or interruption.	
F3	Sentences and words are written without excessive correction or rewriting.	

III. Quality

Item	Description	Score (1–5)
Q1	Letters and words are proportioned and appropriately aligned.	
Q2	Overall, handwriting shows attention to detail.	
Q3	Capitalization and punctuation are used correctly.	
Q4	Spelling is accurate	
Q5	Sentence structure is grammatically correct.	

IV. Mechanics

Item	Description	Score (1–5)
M1	The student uses correct letter formation and stroke direction.	
M2	Proper posture and paper positioning are demonstrated.	
M3	Writing tools are used effectively.	

V. Overall Clarity and Neatness

Item	Description	Score (1–5)
O1	Writing is visually organized and easy to follow.	
O2	Handwriting is neat and aesthetically pleasing.	

Total Score: _____

Optional Comments:

_____
_____
_____

مجلة جامعة الباحة
للعلوم الإنسانية

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المحتويات

المملكة العربية السعودية

وزارة التعليم

جامعة الباحة

وكالة الجامعة للدراسات العليا والبحث العلمي

مجلة جامعة الباحة للعلوم الإنسانية

تصدر عن جامعة الباحة

مجلة دورية ـ علمية ـ محكمة

الرؤية: أن تكون مجلة علمية تتميز بنشر البحوث العلمية التي تخدم أهداف التنمية الشاملة بالمملكة العربية السعودية وتسهم في تنمية القدرات البحثية لأعضاء هيئة التدريس ومن في حكمهم داخل الجامعة وخارجها.

الرسالة: تفعيل دور الجامعة في الارتقاء بمستوى الأداء البحثي لمنسوبيها بما يخدم أهداف الجامعة ويحقق أهداف التنمية المرجوة ويزيد من التفاعل البناء مع مؤسسات المجتمع المحلي والإقليمي والعالمي.

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