IMPROVING ENGINEERING SCIENCE COMMON ROOM WHITEBOARD USABILITY FOR LEFT-HANDERS

Word count: **1798**

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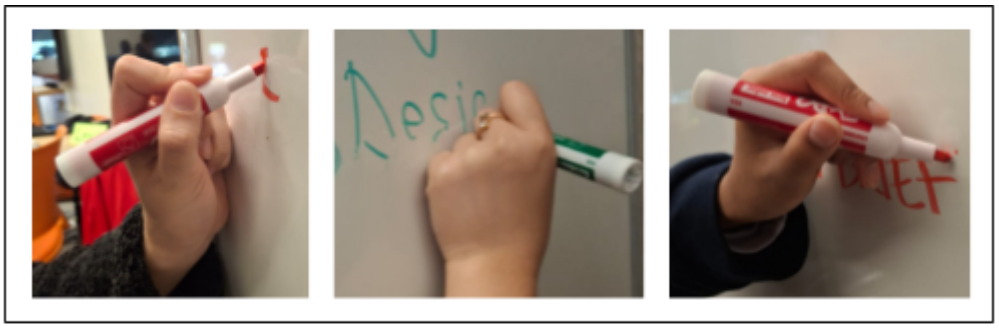
I. Introduction

This design brief frames the challenges faced by left-handed writers when using whiteboards in the Engineering Science common room. Left-handers often smudge or erase their written work unintentionally when writing rightwards [Appendix B2-3], [Appendix C]. To limit these effects, left-handers resort to uncomfortable writing postures, resulting in muscle strain and poor handwriting [3], [4], [28]. This brief defines the scope of this problem, discusses stakeholder expectations, and explores the limitations of existing designs to inform needs, goals, and objectives for improving the left-handed whiteboard experience.

II. Using EngSci Common Room Whiteboards as a Left-Handed Individual

As most language scripts in the world are right-oriented [2], left-handers' hands tend to trail over their script and rest on the board (Figure 1), smudging ink (Figure 2) and transferring residue to the palm [Appendix B3], [Appendix C]. The non-absorbent whiteboard surface causes this inconvenient writing experience. For the purpose of this design brief, the whiteboards are a fixed element of the common room that can not be replaced.



1.1 1.2 1.3

Figure 1. Observation of different left-handed pen grips used by students when using whiteboards

Observation and research shows that left-handers often adopt awkward wrist angles when writing [Figure 1.3], [Appendix B3], [Appendix C]. Even on horizontal surfaces, they exhibit greater wrist flexion than right-handers [3], increasing muscle strain and the risk of musculoskeletal disorders [3], [4], [27]. This effect is likely exacerbated on whiteboards, where the arm is unsupported and a standing stance is adopted. Awkward wrist adjustments can also reduce perceived handwriting quality [Appendix B2], [Appendix C3], [28].

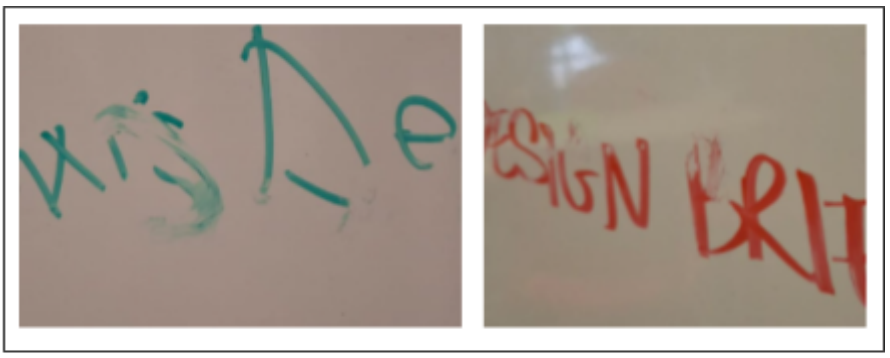


Figure 2. Observations of smudging yielded from left-handers in Fig. 1

Hence, despite posture adjustments, whiteboard writing still causes discomfort and reduced satisfaction for left-handers, emphasizing the need for a design solution.

III. Defining the Working Environment

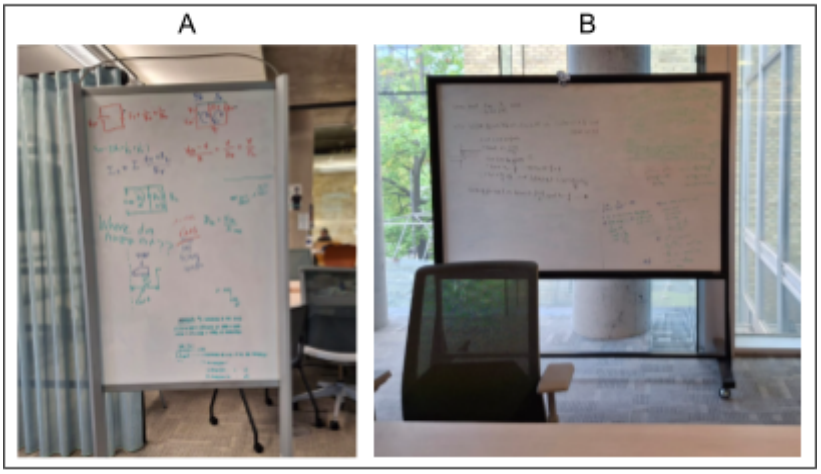


Figure 3. The 2 whiteboard models that were considered for this design brief.

The Engineering Science Common Room is an indoor space with several whiteboards, each with a tray for markers and erasers. While the board material is unconfirmed, it is likely melamine as it accounts for the majority of the whiteboard market (45%) [5].

There are 2 sizes of whiteboards in the common room; tray dimensions were found to be 5.5 ± 0.05 cm (Whiteboard A) (Figure 4) and 4.9 ± 0.05 cm (Whiteboard B). Whiteboard markers in the common room are 17.8 cm [14] in length and the eraser is 13 cm x 8 cm x 5 cm [17] . Design solutions could employ similar dimensions to maintain consistency with standard whiteboard materials, increasing users' adaptability as outlined in Norman's 'The Design for Everyday Things' [24]. Since the common room is frequently occupied by Engineering Science students studying [Appendix C3], the design must also avoid causing auditory disturbance.

Figure 4: tray of whiteboard A.

IV. Understanding Stakeholders and Their Needs

As the common room is a shared educational space, there are many who may be affected by a design solution. Below is a discussion of different stakeholders and their expectations.

a) Left-Handed EngSci Students

The primary stakeholders – users of this opportunity.

They expect to be able to write on whiteboards at the rate as right-handed peers without unintentional smudging of the writing and on the hand [Appendix B2]. The design should be easy and fast to implement into one's writing process without affecting their writing ability. To ensure this, it should prevent hand pain and should be ergonomic [Appendix C1].

b) Audiences and Group Members of Left-Handed Students

Primary stakeholders.

They expect to read the writing of the left-handed peers' work on whiteboards without issue. The design should minimize noise to avoid distraction [23]. It must be operable efficiently and quick to access, without hindering the user's working pace.

c) Right-Handed Students Writing Leftward Scripts (e.g, Arabic)

Potential primary stakeholders with similar struggles. [Appendix C3]

They wish to write with satisfactory handwriting and note minimal differences between writing left-ward and right-ward scripts [Appendix C3]. The design could either not consider handedness in design or have a right-handed alternative.

d) Facility Custodians

Secondary stakeholders

They expect that the design can not leave non-removable residue and must not require maintenance multiple times a day, as stakeholders are only on site to clean once daily [Appendix A]. Design must pass the University of Toronto APPA Cleaning Standard [29].

e) Facility Equipment Regulator

Tertiary stakeholders.

They expect the design to not damage the whiteboard or surrounding equipment. This design should pass any standards from the University of Toronto for educational spaces [31].

f) Design Team

Primary stakeholders.

They expect other stakeholders' expectations to be satisfied by fulfilling the Need, Goals and Objectives. This design should carry minimal bias from the team's perspective through in depth research and understanding of other stakeholders.

V. A Discussion of Reference Designs

While some existing products may aid with left-handed whiteboard use, each has shortcomings relative to stakeholder needs.

a) Integrated Eraser Markers

Permanent markers with integrated erasers (e.g., Faber-Castell Multimark [5]) offer a short-term solution: the permanent ink prevents smudging during writing, and the eraser on the back allows removal afterward. While Faber-Castell does not disclose its eraser formula, it is likely alcohol-based since permanent marker polymers are soluble in alcohols such as isopropanol [6].

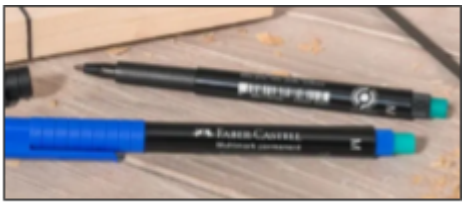


Figure 5. [5] Multimark pen with integrated eraser on back of pen, in teal.

However, the eraser's small surface area makes cleaning large sections slow. Enlarging it might seem effective, yet another issue remains: alcohol-based erasers degrade melamine whiteboards with repeated use, shortening board lifespan [8]. Hence, while integrated eraser markers address smudging, they are not a sustainable long-term solution – however, they may inspire chemical designs based on how they erase non-smudge ink.

b) Smudge Guards

SmudgeGuard® gloves (87% Nylon, 13% Spandex) [9] are intended for tablet users looking to reduce sweat transfer to screens; thus, they may also prevent ink smudging (Figure 6).

However, this design cannot fully prevent unintentional erasure since it may lift dry-erase ink from the whiteboard due to the design's absorbency. While inspiration can be taken from how they protect the palm, they highlight the need for a solution to prevent erasure.

Figure 6. [9] SmudgeGuard® gloves, which cover the palm, minimising ink transfer.

c) InstaMorph

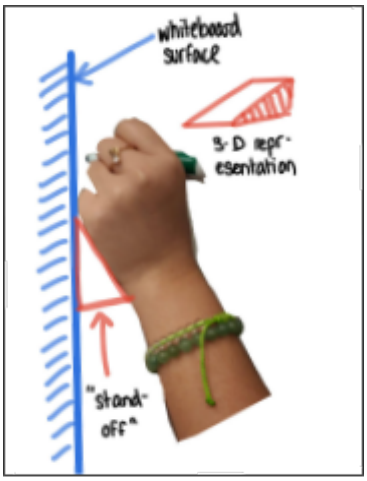


Figure 7. simple representation of what a "stand-off" might mean.

One left-hander expressing annoyance on Quora suggested using InstaMorph, forming a "custom stand-off" (Figure 7) with a lightweight polyester thermoplastic [11], to form to pivot the hand while writing on boards [Appendix B #1].

However, this task requires modeling skills and dedicated time to create a personalized product. The prolonged sensation of plastic against skin is also undesirable [21], and contact with the board risks scratches. While InstaMorph is an impractical widescale solution, the pivot concept could inspire future designs.

VI. Needs, Goals and Objectives

From the stakeholder expectations and reference design shortcomings, we can derive needs, goals and objectives necessary to deem a solution to this *splartz* "sufficient."

Need: Left-handed students are able to write on whiteboards in the EngSci common room without issue.

Table 1: Goal 1 meets primary stakeholders' needs by facilitating their use of whiteboards without harm.

	Description	**Metric**	**Justification**
Goal 1	Design must not affect the user's baseline writing ability		
Objective 1.1	Cannot inhibit the users baseline DASH-2 score by more than 15 points [16].	Score (points) on the DASH-2 (Detailed Assessment of Speed of Handwriting).	A 15 points decrease on the DASH-2 is one standard deviation, signifying a significant drop in handwriting speed [16].
Objective 1.2	Ensure there is no risk of strain injury caused by wrist extended by >90°, wrist radial abduction, >20°, and wrist ulnar abduction, >30°, outlined in ISO 11226-2000 [Appendix A] [13].	Angle of extreme wrist extension, wrist radial abduction and wrist ulnar abduction in degrees.	Reducing strain injuries when adopting a standing stance re-ensures the user's original writing ability.

Objective 1.3	Accommodate for various grip styles on the pen, namely tripod and quadropod grip styles.	Grip styles: lateral tripod, dynamic tripod, lateral quadropod, dynamic quadropod.	Ensures the design is usable by any user with differing grip styles [14]. DfErgonomics [27] emphasises to "anticipate actions."

Table 2: Ergonomics-focused goal that meets the needs of all primary stakeholders through ensuring the device is convenient to use and be around.

	Description	**Metric**	**Justification**
Goal 2	Design must be comfortable to use and have around the commons.		
Objective 2.1	Design width of at most 4.9cm.	Width (cm) of design.	Design must fit onto the marker trays (4.9cm and 5.5cm). so users can have quick access.
Objective 2.2	Design colours are distinguishable, colour difference between the design and the marker rail (silver, #C0C0C0) must have a perceptual $\Delta E^* \geq 20$ according to ISO/CIE 11664-4 [Appendix A], [12].	The Euclidean Difference (ΔE^*).	A visually distinct colour allows users to have quick access to the design.
Objective 2.4	Reduce disturbance by maintaining the common room's sound pressure level to under 60 dB.	Room's sound pressure level (dB).	Research shows that "increasing background sound pressure level to 60 dBA significantly impairs auditory working memory task performance" [22].

Table 3: Goal 3 caters to primary stakeholders. Research suggests that smudging leads to lower legibility in left-handed children [28]; hence, we assume that by reducing smudging, one increases legibility. Further research could be done to confirm.

	Description	Metric	Justification
Goal 3	Ensure no unintentional movement of the ink on the surface of the whiteboard occurs		
Objective 3.1	No accidental contact between design and surface of the whiteboard within 27.73s [19] of the ink being applied.	Ink's drying time (seconds), contact points.	Ensures no unintentional smudging can occur before the ink is dry [19], maintaining legibility.
Objective 3.2	No accidental contact between design and surface of the whiteboard after 27.73s of the ink being applied.	Ink's drying time (seconds), contact points.	Ensures no writing is erased after ink drying [19] so written work can be read.

Table 4: Goal 4 reduces the messiness of the writing experience – an inconvenience mentioned by left-handers [Appendix B, C].

	Description	Metric	Justification
Goal 4	Ensure no ink residue is left on the hand after use of the device		
Objective 4.1	Zero points of contact between the hand of the user and the surface of the whiteboard.	Hand-whiteboard contact points.	Ensures no ink is able to rub off onto the skin of the user, fulfilling stakeholder's expectation.

Table 5: Goal 5 designs for maintenance, satisfying custodians and regulatory staff through reduced damage and stains to whiteboards.

	Description	Metric	Justification
Goal 5	Design must not damage the whiteboard.		

Objective 5.1	Any nicks on the whiteboard surface must be “no greater than 0.005″ (0.01270 cm) in depth and 0.010″ (0.0254 cm) in width.”	Depth and width of nicks (inches/cm).	PTI Technologies’ Surface Inspection Acceptance Criteria allows for surface irregularities below 0.005″ in depth and 0.010″ in width on “non-functional surfaces”, which a whiteboard falls under [25].
Objective 5.2	Any staining from the design should have $\Delta E^* \leq 1.9$ with whiteboard surface.	The Euclidean Difference (ΔE^*).	Ensures color changes remain below the perceptible threshold in a dental study where 50% of participants noticed differences in dentures [26]; design must be below this to avoid visible staining.

VI. Next Steps

In conclusion, left-handed smudging on boards and palms when using EngSci common room whiteboards is a documented issue. A design team addressing this challenge must maintain regular communication with primary stakeholders to ensure that left-handers are satisfied with the final outcome. While literature is available on left-handed struggles, further primary research within the common room environment may benefit the design team. Through divergent thinking and rigorous testing to meet goals and objectives, a design team can effectively address the needs of left-handers and develop a practical solution.

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See Appendix A for relevant source extracts.

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VIII. Appendices

Appendix A: Relevant Source Extracts

[3] Page 1

1.66±1.19% in right-handers. [Conclusion] As a result of this study, it was discovered that left-handers used more wrist flexion in performance of the writing task with the dominant upper extremity than right-handers, and that the left-handers activated the wrist and shoulder muscles more than the right-handers. These results indicate a potential danger of musculoskeletal disease in left-hander.

[4] Page 1

Results All the derived variables were highly correlated, greater angles and greater forces being associated with greater velocities and higher repetitiveness. A multivariate linear regression model for the prediction of the prevalence of musculoskeletal disorders of the wrist was constructed (R = 0.904). Height, weight, seniority, angles in radial-ulnar deviation, and forces were significant and independent predictors of the prevalence. **Conclusions** The prevalence of wrist disorders is significantly linked to wrist angles in deviation and to forces exerted. Due to their high correlation with force, the repetitiveness indices and velocities, as defined, do not appear to play an additional role. Further research is needed to find alternative ways of characterizing repetitiveness.

[6]

But what if the board gets stained? It's important to remember that the polymers in both permanent and dry erase markers are water-resistant, so the best way to clean any stubborn smears on your board is to add a little squirt of alcohol. The most effective options contain at least one of the solvents used in the markers themselves, such as isopropanol. This is found in rubbing alcohol as well as nail varnish remover and should quickly disperse the ink before it evaporates, allowing you to rub it off. Since isopropanol is found in dry erase pens, drawing over a whiteboard stain and then rubbing with a cloth can also help remove it.

[21] Page 5

First, we find that greater brush stiffness decreases pleasantness. Indeed, most prior works on pleasantness tend to use only a smooth brush and vary velocity, but changing brush stiffness decreases pleasantness much more, comparatively, than change in velocity. Work is still required to understand exactly why. A likely possibility, is a higher activation of c-nociceptors [27] in conjunction with c-tactile afferents when increasing brush stiffness. In alignment, in our instrumented

The stiffest brush used in this paper was made of "stiff, synthetic plastic," while the others were not, hence supporting that the sensation of plastic on skin is typically seen as undesirable.

[12] Page 7

The CIE 1976 a,b colour difference, ΔE^*_{ab}, between two colour stimuli is calculated as the Euclidean distance between the points representing them in the space according to Formulae (19) or (20):

$$\Delta E^*_{ab} = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2 \right]^{1/2} \quad (19)$$

or

$$\Delta E^*_{ab} = \left[(\Delta L^*)^2 + \left(\Delta C^*_{ab}\right)^2 + \left(\Delta H^*_{ab}\right)^2 \right]^{1/2} \quad (20)$$

https://subscriptions-techstreet-com.myaccess.library.utoronto.ca/products/834704

[13] Page 7

Table A.1 — Indications of the limits of joint ranges of motion

Postural parameter	Range of motion limit	Reference	
		Table	Figure
Upper arm external rotation	90°	5	8
Elbow flexion	150°	7	11
Elbow extension	10°	7	11
Forearm pronation	90°	7	11
Forearm supination	60°	7	11
Wrist radial abduction	20°	7	11
Wrist ulnar abduction	30°	7	11
Wrist flexion	90°	7	11
Wrist extension	90°	7	11
Knee flexion	40°	8	12
Ankle dorsiflexion	20°	8	12
Ankle plantar flexion	50°	8	12
NOTE All the figures mentioned are with, respect to an upright standing posture with the arms hanging freely, and the palms of the hands facing the body.			

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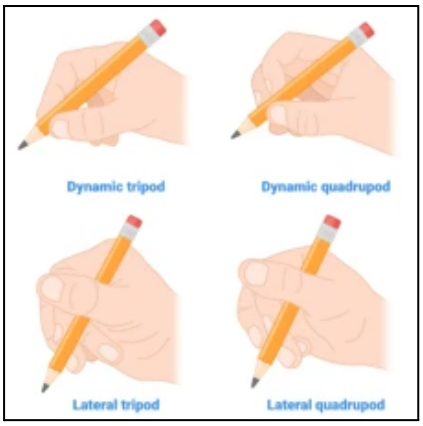
[14] Page 8



https://www.medbridge.com/blog/identifying-pencil-grasp-style-why-it-matters

[19]

In the Drying Time test, the mean time for each of the three inks is indicated above, ink trial 1 has a mean time of 11.45 seconds, 16.37 seconds for ink trial 2, and 27.73 seconds for the industrial ink, respectively, dry on a whiteboard surface. These results show that industrial ink is the most effective in terms of absorbency since it does not dry out too quickly, while ink trial 1 was the least absorbent ink from the absorbency test.

[23]

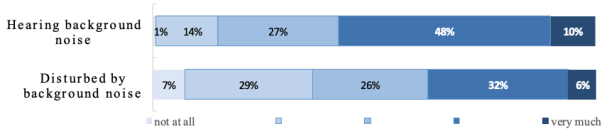


Figure 2.3 Background noise perception and disturbance in open-plan study environments (n=496).

[24]

A discussion of why using similar sizes as a physical constraint will help users intuitively use any solution.

major construction rule. The sizes and shapes of the parts suggested their operation. Physical constraints limited what parts would fit together. Cultural

and semantic constraints provided strong restrictions on what would make sense for all but one of the remaining pieces, and with just one piece left and only one place it could possibly go, simple logic dictated the placement. These four classes of constraints—physical, cultural, semantic, and logical—seem to be universal, appearing in a wide variety of situations.

Constraints are powerful clues, limiting the set of possible actions. The thoughtful use of constraints in design lets people readily determine the proper course of action, even in a novel situation.

[28]

The left-handed children all showed non-standard hand positioning when using the whiteboards, with the higher ability child displaying the 'hook' (Clark 1966; Dallman 1976; Mac Intyre and Mc Vitty 2004) writing position, the middle ability child holding her hand in the air to avoid the ink from smudging, and the lower ability child smudging his hand over the writing as he writes from left to right (Figure 5).

When the children used the magnetic writing boards, there was a clear difference in many of the children's writing.

The left-handers produced better quality writing: the /l/ clearly visible in the higher ability left-hander's writing, the lower and middle ability left-handers producing much clearer writing, and the middle ability left-hander's writing not sloping downwards to the same extent as when the whiteboard was used. Interestingly,

Left-handers produced better writing on magnetic boards than whiteboards, indicating that the issue of poor hand grip due to smudging led to poor handwriting.

[30]

Meeting Spaces (Auditoriums, Seminar / Conference Rooms, and Lounges)	DAILY	2 x PER WEEK	WEEKLY	BI WEEKLY	MONTHLY	ANNUALLY	AS NEEDED
• Wash chalkboard or whiteboards & rails	X						

[31] Section III

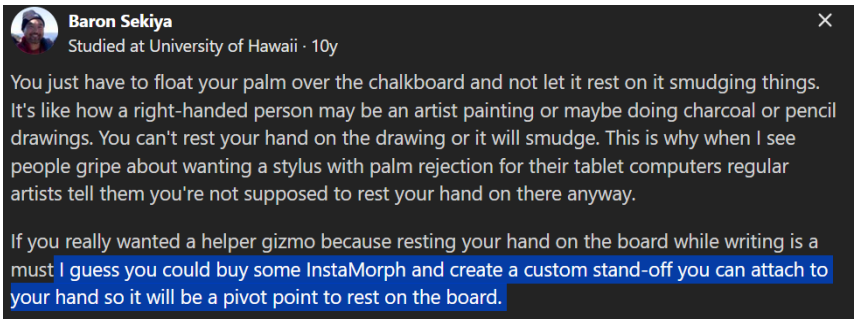
III. **Other Charges**

1. The University may, as a condition of bookin where the building would normally be closec arranged by the University.
2. The University at its discretion may assess a normally the responsibility of the group bool
3. Over and above the rental charge and secur
   a. Use of public address, audio-visual or oth
   b. Additional caretaking costs or extraordina
   c. Special arrangements with parking and gr
   d. Special setups where applicable; and/or
   e. Damage or undue wear and tear.

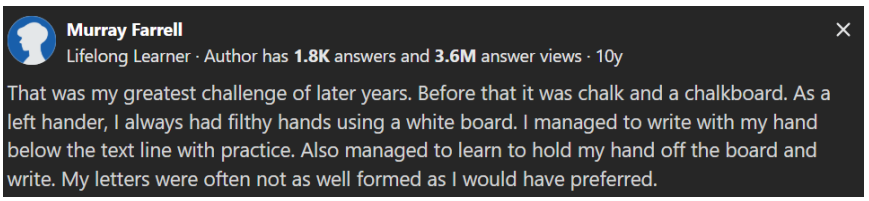
[31] Section V

7. The reserving organization agrees to ensure that no alterations to or tampering with University fabric, utilities or facilities will occur without explicit permission of an authorized University officer. If any such work is approved, it may only be carried out by persons authorized by the University.
8. Only props and displays constructed of nonflammable materials may be used within a University building.
9. No open flame, heating apparatus and/or cooking apparatus may be used without explicit permission of an authorized University officer.

Appendix B: Left-handed Narrative Accounts

1. 

From reference [10]

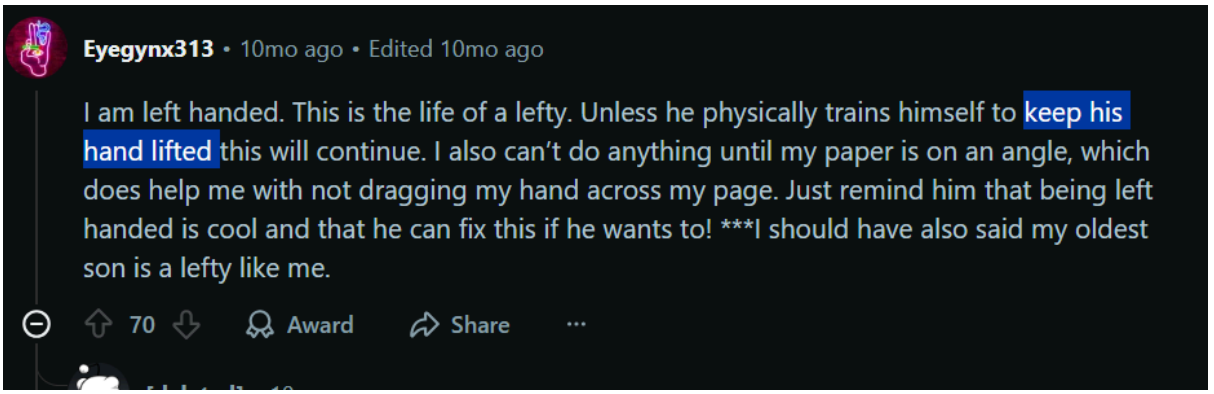
2. 

From reference [10]

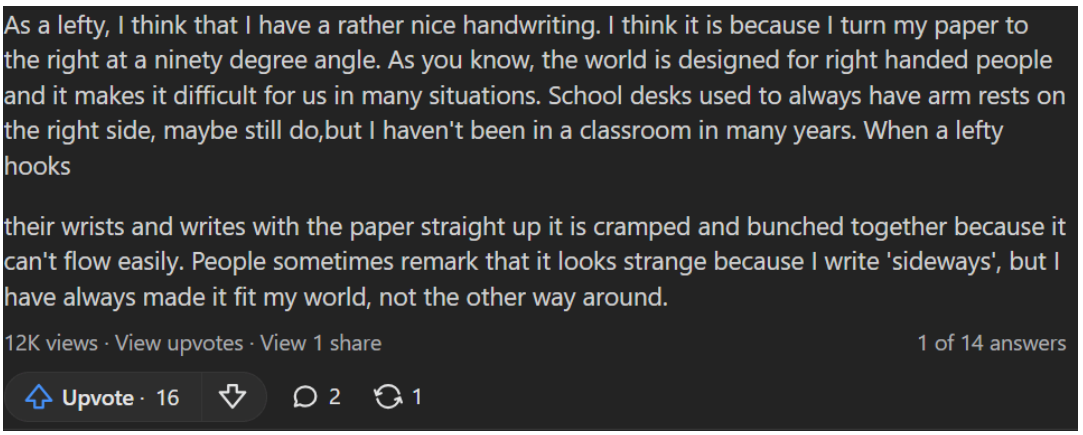
3. 

Source: *https://www.reddit.com/r/Parenting/comments/1hnket6/my_leftie_son_is_struggling_with_dragging_his/*

An account of a similar issue to smudging on a whiteboard due to the non-absorbent nature of the surface of a snowboard. Details the annoyances of smudging.

4. 

Source: see #3

5. 

Source: https://www.quora.com/Why-do-the-majority-of-left-handed-people-have-bad-handwriting

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Appendix C: Transcript of Interviews

1. Left-Hander 1

[Interviewer]: When you write on whiteboards, does smudging of the writing ever happen? If so, what do you do to avoid it?

[Anonymous]: "Yes – but what I do is lowkey hard to explain. I use my pinky to prop my hand up. That causes my pinky to be kinda stuck in position and causing discomfort if I write for a while."

[Interviewer]: Do you think this issue is something that bothers you often?

[Anonymous]: "Not as much as pen and paper, because the ink doesn't dry fast enough most of the time. Whiteboard is still an issue though. For writing on paper, I used these "magic" pens that don't smudge, so that idea for whiteboards sounds cool."

2. Left-Hander 2

[Interviewer]: Could you explain some of the challenges you face in general as a left-handed individual that are not experienced by right-handers?

[Anonymous]: "Almost everything is designed for right-handed people. Like things you as a rightie have never even thought of. I'm talking about doors, scissors, binders (you know the ones with the coils)…also I always have to write like [displays ocular occlusion from position of left hand writing] to see what I'm writing. Which sucks if you have just finished writing an idea and you end up smudging all of it. Especially during [references an exam with only pens]. I got ink all over my face and I didn't realize it until after."

[Interviewer]: We are focusing our attention on whiteboards. Could you tell us about your experience with writing on whiteboards as a left-handed individual?

[Anonymous]: “Every time I go to write something, I end up messing up what I have already written. I’m mostly fine when using portable whiteboards, like the one I use as my calendar with tape and stuff, but I don’t really use any wall whiteboards. So just let me think here. I think it is just a super uncomfortable experience because you almost have to contort your body and your hand so that you aren’t smudging, and my wrist gets sore pretty quickly.”

[Interviewer]: So what would you say is the biggest challenge if you had to pick one?

[Anonymous]: “Accidentally erasing stuff I have written, getting whiteboard markers on my hands and face (though that doesn’t happen too frequently), and like the awkward writing contorting [mimes increased flexion]. This is something that no-one ever talks about, but is honestly so not inclusive for [left-handed people].”

3. Right-Hander EngSci Student who has written in Arabic script

[Interviewer]: Do you typically face issues when writing on whiteboards in English?

[Anonymous]: “No, I usually don’t face any issue when writing on whiteboards. If I’m being picky, it’s annoying when whiteboards sometimes don’t have an eraser on hand and I end up erasing the writing with the side of my hand because it’s inconvenient to go and find one.”

[Interviewer]: You have experience writing Arabic before. Did you ever face challenges writing Arabic on vertical whiteboards?

[Anonymous]: “For sure. In school, whenever I had to answer Arabic questions in front of the class on whiteboards, I’d have to angle my hand away from the board so that my palm wouldn’t ruin what I was writing. I never really thought about how I don’t have to do that for English, but I always felt like my handwriting on whiteboards for Arabic was much worse than on paper. Because I always angled my hand when writing, my sentences would end up completely crooked. By the time I finished a line, I’d realise the whole thing was slanted – like I’d started with the first word of a sentence at the top of the whiteboard, and somehow the last word was halfway down.”

[Interviewer]: What do you mean by “ruin” your writing?

[Anonymous]: “I didn’t want my writing to get smudged or erased, and I didn’t want to have to wash marker off my hands after every lesson because of that either.”

[Interviewer]: Do you use the EngSci common room whiteboards now at U of T?

[Anonymous]: “Rarely. I don’t really go to the common room much, it’s really crowded whenever I’ve tried to go and my friends and I can never find enough seats.”

[Interviewer]: Would you use a design to prevent whiteboard pen smudging?

[Anonymous]: “If I was still writing Arabic often, and something made writing Arabic on whiteboards as easy as writing English – then yes.

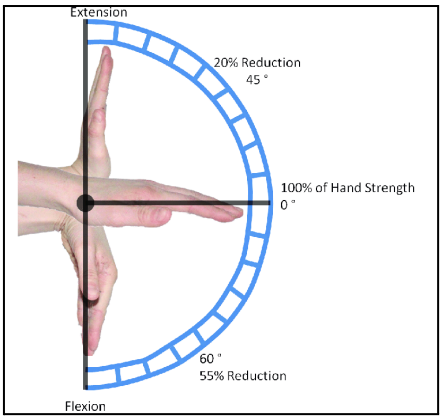
Appendix D: Glossary

1. *Splartz*: an annoyance or an irritant, or a minor problem in your lives, or an opportunity for something that could be better if only we did something about it.

2. Left-hander: An individual who prefers to use their left hand for tasks such as writing, which involve handedness.

3. Wrist Extension: A term describing upwards motion of the wrist.

4. Wrist Flexion: A term describing downwards motion of the wrist
   See image below to visualise flexion and extension angles.



Visual representation of wrist flexion and angles of wrist flexion. *Source: https://www.researchgate.net/figure/Reduction-of-hand-strength-at-different-angles-of-flexion-extension_fig17_317984098*

5. Grip types: lateral tripod; dynamic tripod; lateral quadrupod; dynamic quadrupod. See image below.

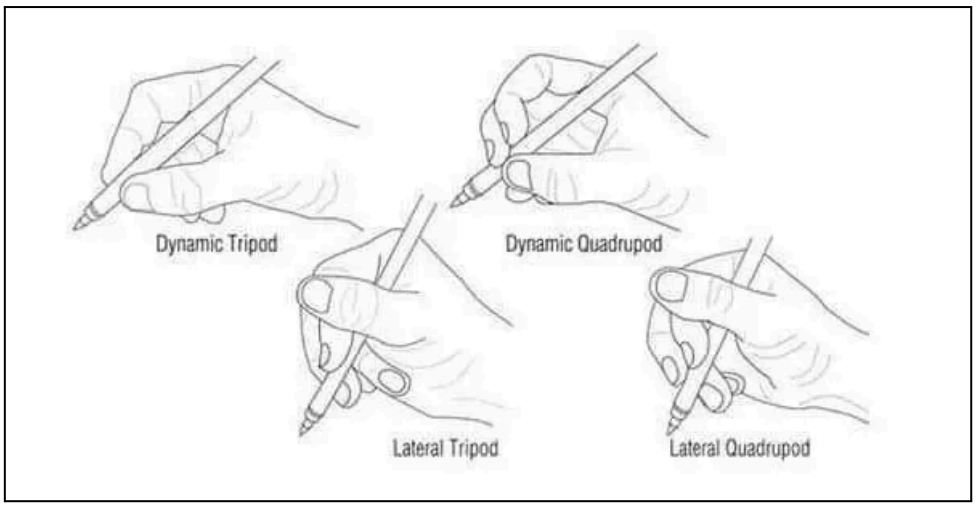
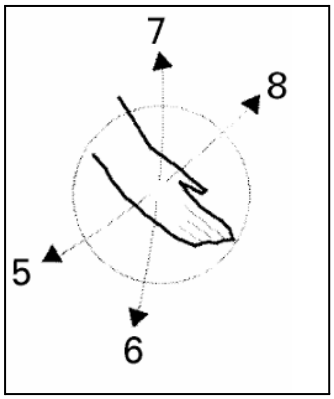


Illustration of grip types.
Source: *https://www.themanual.com/culture/different-types-of-pencil-grips/*

6. Wrist Ulnar Abduction: little finger moved towards the forearm (ulnar bone)

7. Wrist Radial Abduction: thumb moved towards the forearm (radial bone)



5	Wrist ulnar abduction: little finger moved towards the forearm (ulnar bone)
6	Wrist flexion: palm of the hand moved towards the forearm
7	Wrist extension: back of the hand moved towards the forearm
8	Wrist radial abduction: thumb moved towards the forearm (radial bone)

[13]

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