

Product Design for the Classroom:  
Case Study of a Multi-use Whiteboard

by Nydia Ruleman

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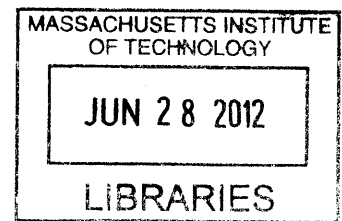
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# Product Design for the Classroom: Case Study of a Multi-use Whiteboard

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## ABSTRACT

The design of high school classrooms often does not serve the needs of instructors. The layout of the Boston urban classroom inhibits effective instruction due to physical obstructions and line of sight issues for students. A permanent lab bench commonly found in high school labs creates distance between the lecturing teacher and students. The barrier negatively impacts instruction and classroom management, according to educational literature, observation, and personal experience. The purpose of this project was to design and prototype a solution to retrofit into this classroom. The prototype was designed with the functional requirements of the user, the instructor, in mind.

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## Chapter 1: Background

This project sought to solve a problem which has been described in educational literature, observed, and experienced first-hand. Using these three sources, I will convey the problem and need for a product to solve it.

### 1.1 Proximity as a Method of Classroom Management

In the “Exploiting Proximity” section of *Tools for Teaching*, Fred Jones discusses the importance of working the crowd and strategies, such as moving the teacher’s desk, for making this technique as easy as possible. Figure 1-1 shows a traditional classroom layout. If the teacher is represented by the “X”, where is goofing off by the students most likely to occur?

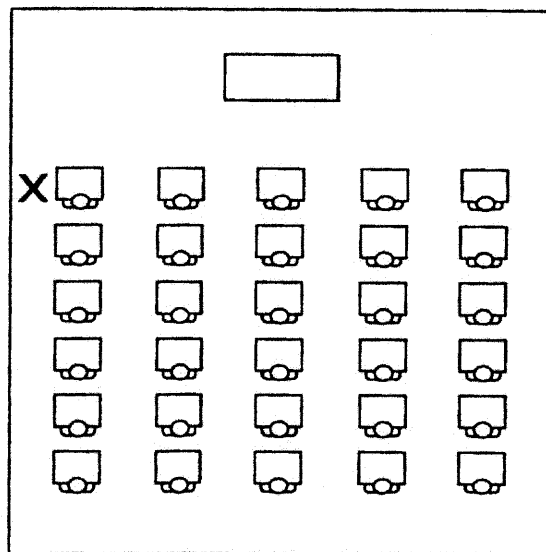


Figure 1-1: Diagram of typical classroom arrangement (Jones 29).

Goofing off is most likely to start in the back right, the farthest away from the teacher. Jones explains that students determine the psychological distance to figure out “Is the coast clear?” Students

subconsciously calculate how far away the teacher is, where the teacher is looking, and whether the teacher is preoccupied (Jones 31).

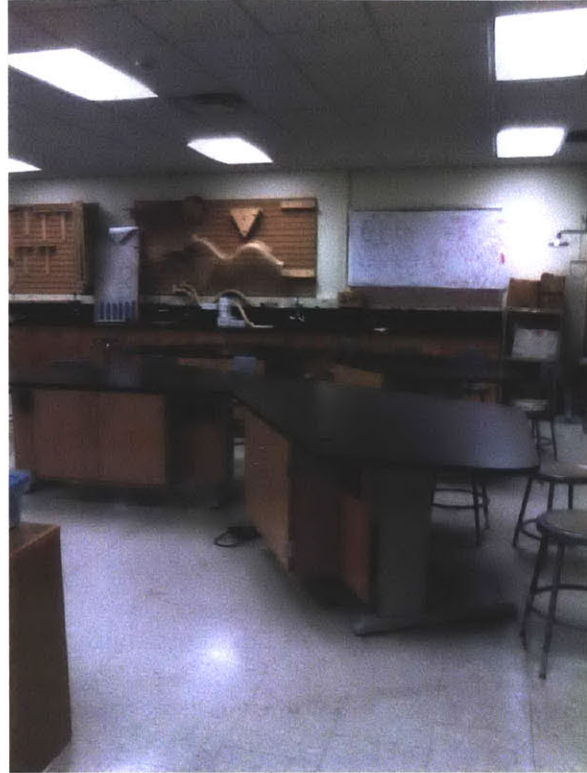
The teacher has three zones of proximity: red, yellow, and green. Within 8 feet of the teacher is the red zone, where students behave well. Extending another 6 feet is the yellow zone, in which students behave well if the teacher is facing their direction. Outside of the yellow zone is the green zone, where students are most likely to misbehave, since they more frequently determine the coast is clear. Proximity is effective in managing the students in the red zone; eye contact is effective at managing students in the green zone. Effective teachers move around to constantly change the zones of proximity and disrupt disruptions (Jones 31-32).

According to Jones, furniture is the biggest barrier to “working the crowd”, or managing the classroom through movement. The first element to classroom structure is arranging the room to facilitate mobility and proximity. To begin, Jones instructs the teacher to move his or her desk from the front of the classroom. The teacher’s desk costs 8 feet of proximity to every student in the classroom. From the typical 13 feet from the board to the first row, the distance is reduced to 5 feet. The 5 foot measurement is derived from 3 feet spacing for comfortable conversation plus 2 feet for viewing angle for students on the side (Jones 39-40). By making this simple change in furniture, the teacher increases his or her power due to the change of students from the green zone to the red zone.

## **1.2 A Particular Classroom Layout**

I did my student teaching at the O’Bryant School for Mathematics and Science in Roxbury, MA under the mentorship of Dan Smalley. I took over Mr. Smalley’s 1<sup>st</sup> and 2<sup>nd</sup> period AP Physics B class. While teaching, I recognized some problems with the classroom. Who would design a classroom like the

one pictured in Figures 1-2 and 1-3? The answer, I found out through conversations with my mentor teacher and department head, is that the room was not designed to be a classroom.



**Figure 1-2:** View from the entrance of the classroom at the O'Bryant. The photo is taken at the same depth of the chalkboard.



**Figure 1-3:** Front of the O'Bryant classroom. A Smart board sits unused in the corner, due to teacher preference for a traditional writing surface.

It has all the typical science classroom furniture- stools, desks, lab bench, projector, and chalkboard. However, the permanent classroom fixtures present problems. The lab bench divides the front of the classroom from the students; a column divides the chalkboard in half. Two major problems created are distance from the students and line of sight. A teacher lecturing at the chalkboard is minimally 17 feet away from the students in the front row, farther than the desired 5 feet in Fred Jones' *Tools for Teaching*. The teacher cannot use proximity to manage students even in the front row; all students are in the green zone. When the chalkboard is in use, the teacher must be conscious to utilize only the portion in the line of sight of the students on the far side of the classroom. When the projector

screen is in use, due to the offset from the wall, even more of the board is obscured. The next section discusses the impact of this layout to classroom instruction.

### **1.3 Instructional Impact**

*The Skillful Teacher* discusses the use of classroom space and utilizing space effectively for various forms of instruction. While most of the discussion focuses on the arrangement of student desks, an applicable claim is that “teachers’ arrangements of classroom space send messages about their image of the learner and the kind of learning they intend” (Saphier and Gower 41). I was frustrated by the O’Bryant classroom layout, partly because it conflicted with philosophy of teaching. *Educational Psychology* summarizes the constructivist approach to instruction as active involvement by the students and the role of the teacher as a “guide on the side” not a “sage on the stage” (Slavin “Student-Centered and Constructivist Approaches to Instruction”). When explaining concepts on the board, I felt like I was on a stage. This divide between the teachers and students made me very uncomfortable, like I was talking at the students, instead of working with them. The distance also contributed sometimes to a lack of engagement by the students.

I noticed some of the adaptations Mr. Smalley and I had made to get around the layout. For example, we did demonstrations in front of the lab bench. We became experts at manipulating a set up while halfway facing the students. This additional effort in demonstrations was preferable to facing the students yet being behind the lab bench. Another adaptation that I noticed was I moved to the side or front of the bench whenever possible. If something needed to be added to the board, I would walk back around. Mr. Smalley often leads discussions from in front of the lab bench; however, he is limited in that he cannot write anything on the board. If he chooses to lecture at the board and senses a lack of

engagement by the students, Mr. Smalley stops and forces students to fit into the half of the room in front of the chalkboard he is using to better hold the students' attention.

#### **1.4 Attempts at a solution**

To remedy these problems, the movable classroom furniture was rearranged, a rolling whiteboard was introduced, and instructional modifications were made. Mr. Smalley rearranged the furniture so the desks are rotated by 90°. The projector was used instead of the chalk board. This created more mobility problems than it solved, so the classroom reverted back to its intended layout.

When I was teaching, I "borrowed" a large rolling whiteboard and placed it in front of the permanent lab bench. The whiteboard obscured the view of the students at the edges of the tables and forced them to relocate. In a full-sized class, this is not a viable option. I ended up placing the whiteboard angled at the side of the lab bench; however, this made maneuvering to the back of the lab bench more challenging. Eventually, the rolling whiteboard was recalled to its intended location.

Finally, attempts to limit the use of the chalkboard were made. Lectures could be delivered via power point. However, it is useful to solve problems on the chalkboard, so the teacher and students can work through each step together. Students solve these problems in different ways; also, we learn from the mistakes that a student makes. A teacher may need to generate an example on the fly, so a chalkboard is beneficial and compliments other methods of delivering a lesson.

## **Chapter 2: Product Opportunity**

### **2.1 A Product Solution: The Sliding Whiteboard**

In 2.009 in fall 2011, one team developed the Obelisk, a table with a chalkboard surface which flipped up to display the chalkboard. I thought of ways this concept could be used in the classroom. This led me to brainstorm products that I could develop to address the distance and line of sight problems in the O'Bryant classroom. An accordion-folded board could be pulled out in front of the column, or each student desk could have a whiteboard that folded up. A promising idea was a whiteboard that was attached to the permanent lab bench and moved up when it was needed. It will be referred to as the "sliding whiteboard," although other methods of actuation and writing surfaces were considered.

### **2.2 Comparing Solutions**

Based on the factors discussed earlier, a Pugh chart was developed to compare the current chalkboard set up, the attempted rolling whiteboard solution, and the product idea of a sliding whiteboard. The metrics were chosen to be ease of storage, ease of transition, permanence, good line of sight, and proximity to students. The ease of storage was important since functional space is limited in the classroom. The ease of transition included the ease with which a teacher could transition into and out of use of the product. For the rolling whiteboard, moving the board from the side of the class to the center hindered its ease of transition. For the sliding whiteboard, the ease with which a teacher could transition from discussing at the board to checking student work gives it an advantage over the built-in chalkboard. This assumed easy implementation into using the sliding whiteboard. Permanence referred to the rolling whiteboard being reclaimed, so it is no longer available for use in this classroom. The Pugh chart is shown in Figure 2-2.

	Built-in chalkboard	Rolling whiteboard	Scrolling whiteboard
Ease of storage	S	-	S
Ease of transition	S	S	+
Permanence	S	-	S
Good line of sight	S	S	S
Proximity to students	S	+	+
Total	S	-1	+2

Figure 2-1: Pugh chart of existing and potential solutions

### 2.3 Storyboard

To convey the problem and user experience that I envisioned for the scrolling whiteboard, I developed a storyboard.

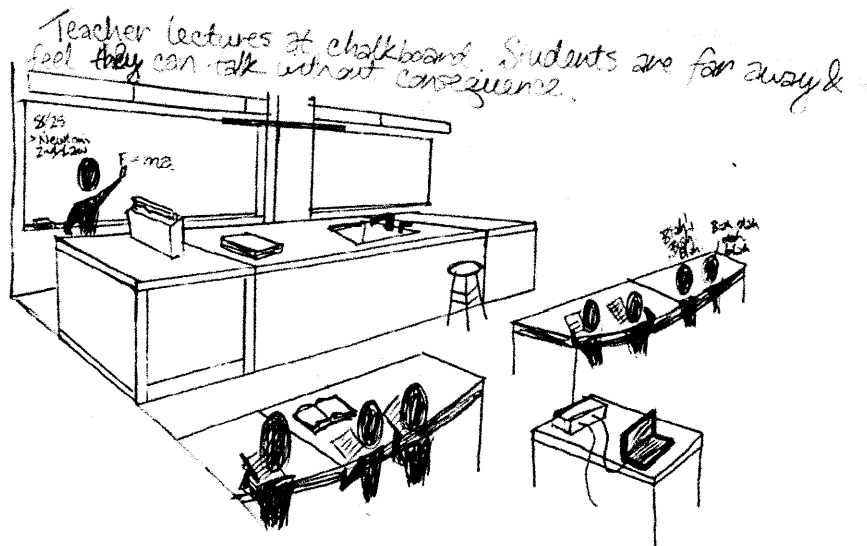


Figure 2-2: Storyboard page 1/6

Teacher uses projector to show video clip of physics concept applied. Projection screen blocks board

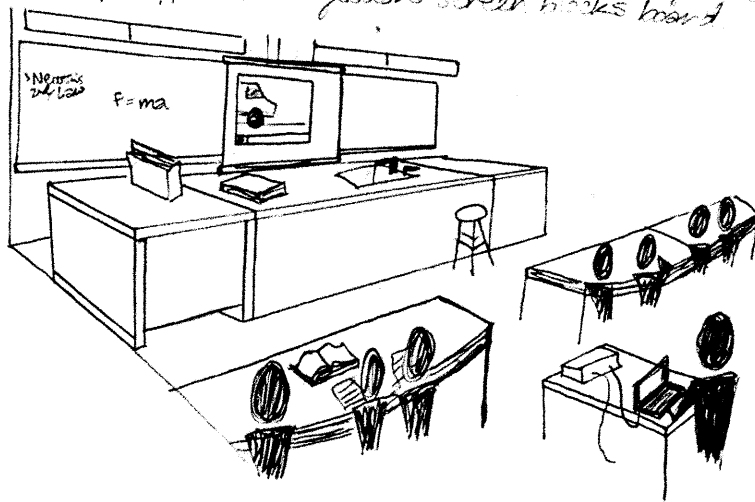


Figure 2-3: Storyboard page 2/6

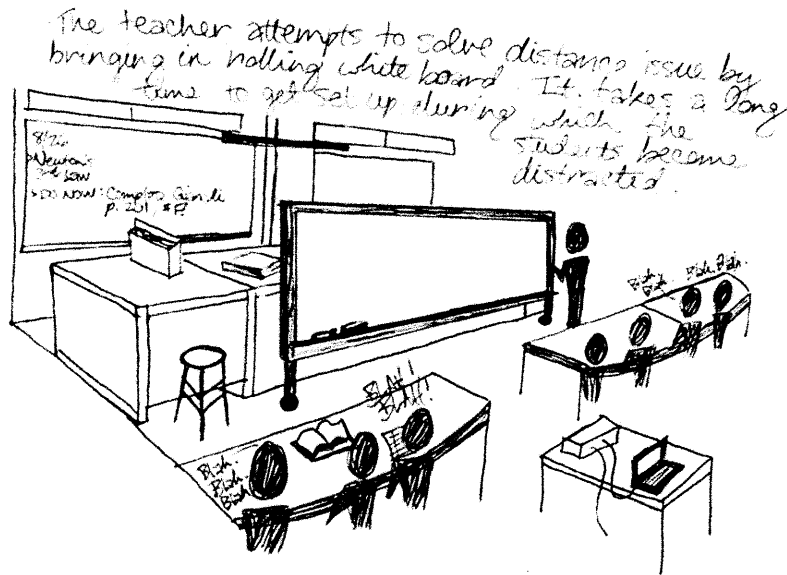


Figure 2-4: Storyboard page 3/6

A better solution: white board is attached to the permanent lab bench. Teacher can set up in 1 second.

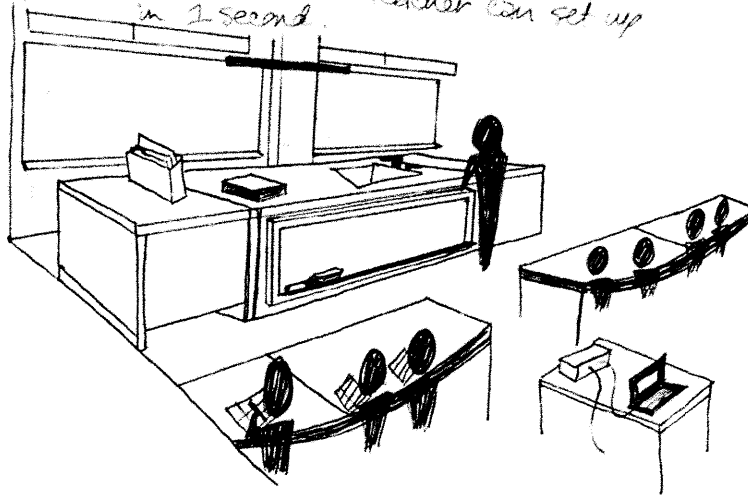


Figure 2-5: Storyboard page 4/6

Teacher can lecture & utilize proximity to students to keep them on task.

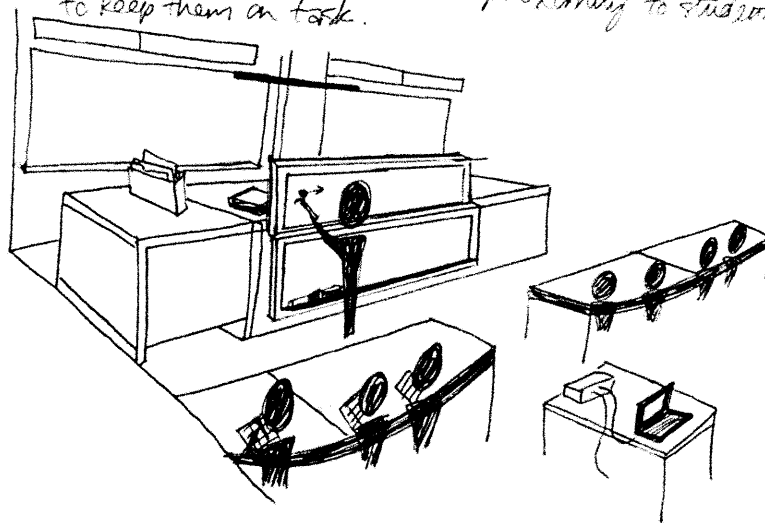


Figure 2-6: Storyboard page 5/6

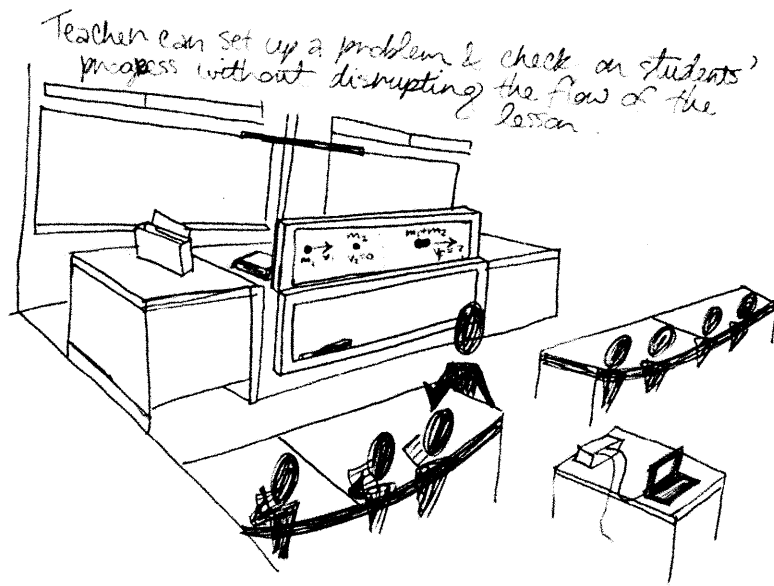


Figure 2-7: Storyboard page 6/6



## Chapter 3: Design Exploration

### 3.1 Functional Requirements

Through discussions with Mr. Smalley and based on personal experience, functional requirements for the scrolling whiteboard were developed.

- Easy to transition into use
- Easy to transition out of use
- Holds position at top
- Withstands writing force
- Provides sufficient board space
- Allows for messy desk
- Operable by one person
- At eye level of students

### 3.2 Brainstorming

The moving mechanism and locking mechanism were brainstormed; sketches are shown in Figures 3-1 and 3-2. For the moving mechanism, a mechanical system was desired over an electrical system. A sliding drawer mechanism was chosen to move the whiteboard from storage into use. The locking mechanism needed to support the weight of the dry erase board. Also, it needed to unlock both sides of the board simultaneously to be easily operable by one person. The locking mechanism would be implemented and tested once the moving mechanism was constructed.

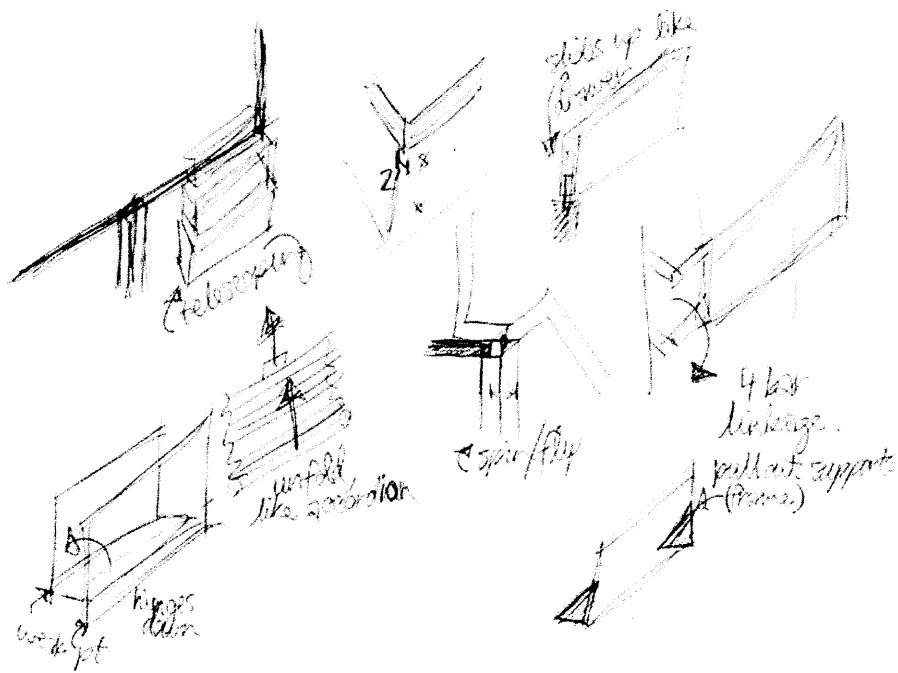


Figure 3-1: Sketches from a brainstorming session on moving mechanisms with David Parell.

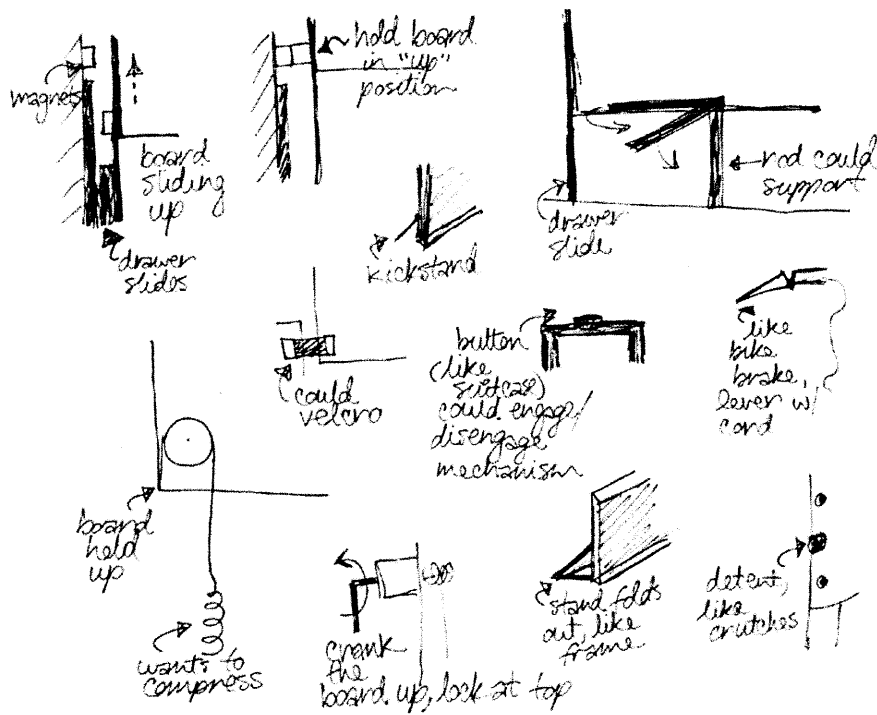


Figure 3-2: Sketches from a brainstorming session on locking mechanisms with Danielle Hicks.

### 3.3 Concept Sketch

Depicted in Figure 3-3, the sliding whiteboard has a minimalist form factor. The traditional look is consistent with the rest of the furniture in the classroom. The mechanisms for moving and locking would be exposed to engage student curiosity since they could see how the whiteboard worked. Also, the assemble-it-yourself, IKEA-style of the sliding whiteboard created a learning opportunity for students to participate in the fabrication of the prototype.

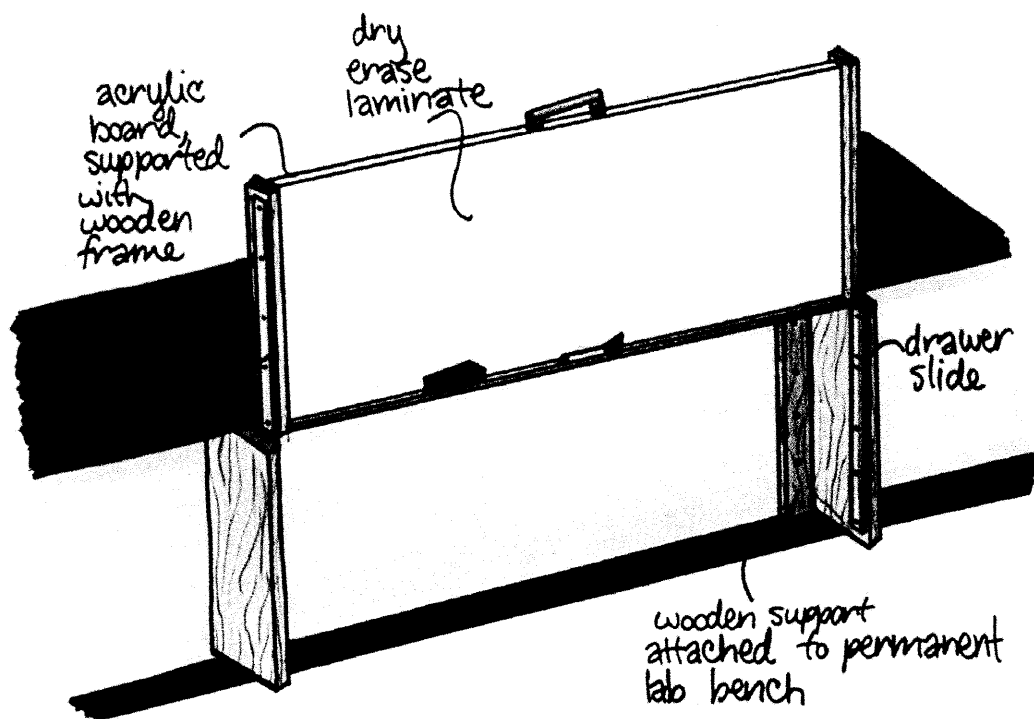


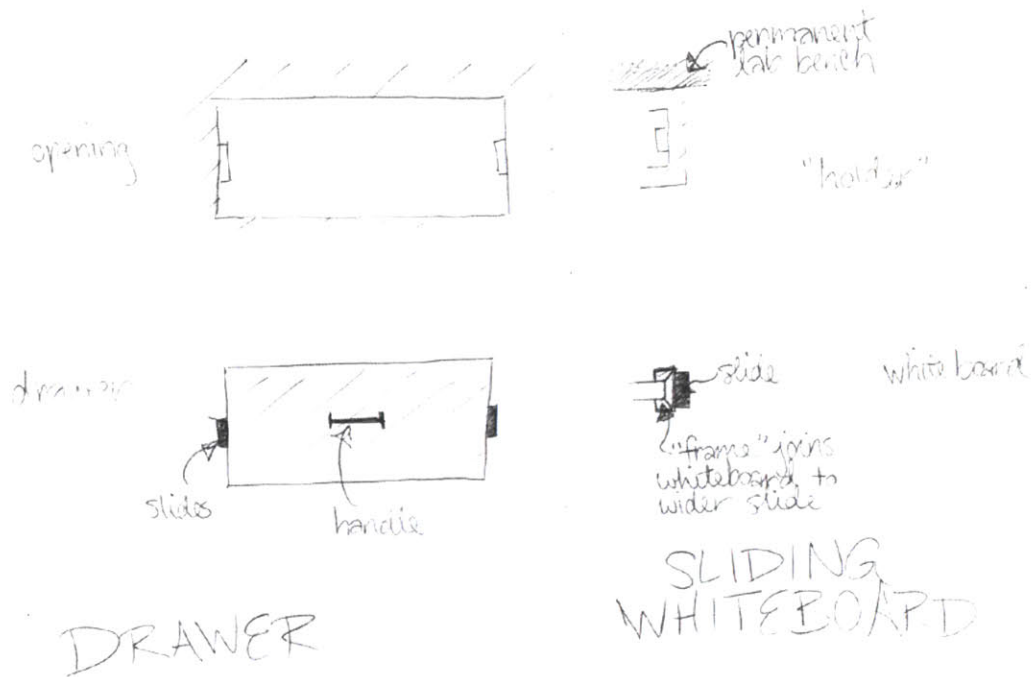
Figure 3-3: 2D concept sketch of the sliding whiteboard



## Chapter 4: Sketch Model

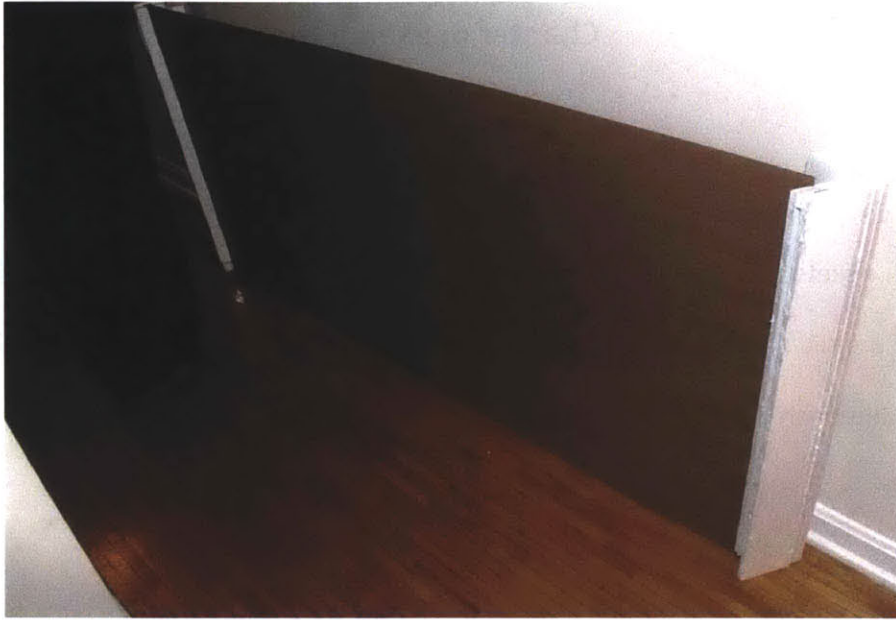
### 4.1 The Model

With a sketch model, I sought to resolve the geometry of the whiteboard and explore the feasibility of the sliding mechanism. Converting the sliding drawer mechanism, I developed the design of the sliding whiteboard.



**Figure 4-1:** Converting a horizontal drawer to a vertical, scrolling whiteboard.

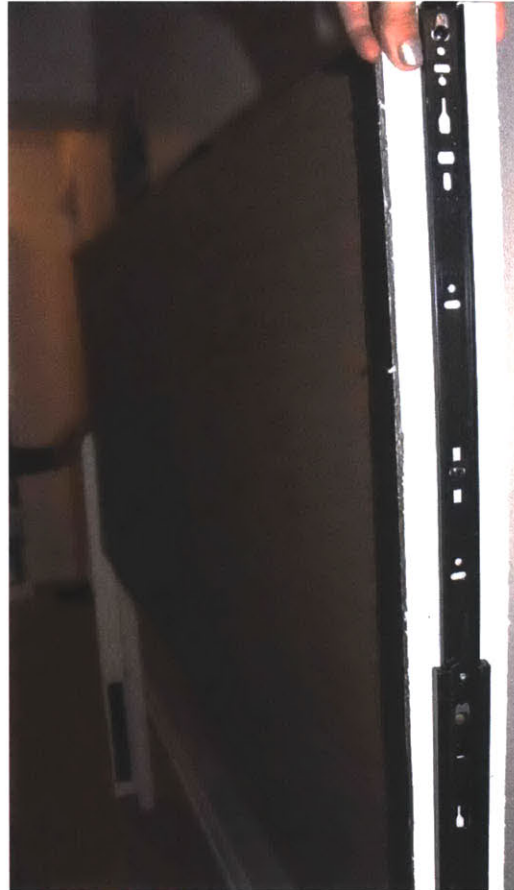
With  $\frac{1}{2}$ " foamcore, cardboard, and 26" Accuride drawer slides, I constructed a sketch model, shown in Figures 4-2 through 4-4. Since the countertop overhangs the lab bench, a spacer was built into the holder to allow the whiteboard to slide up.



**Figure 4-2:** Sketch model in rest position. Thanks to Gloria Satgunam for helping with this photo shoot.



**Figure 4-3:** Front view of sketch model sliding mechanism.



**Figure 4-4:** Side view of sketch model in raised position.

## 4.2 Takeaways

The sketch model revealed that the geometry would work with the constraints of the lab bench. However, when the sketch model was tested in front of the permanent lab bench, the 26" drawer slides were determined to be too short. The height of the board was appropriate for writing but was not easily visible from the back row. In the prototype, the design was modified to optimize the height.

With the moving mechanism constructed, it was easier for me to explore the locking mechanism. Multiple slides move in the extended position, so it would be easier to lock the board in place than to lock each slide.



## Chapter 5: Prototype

### 5.1 Design Rationale

The longest readily available drawer slides were 28" over-travel slides, which measured 29.5" fully extended. This height, as previously mentioned, was desired to promote ease of viewing by students in the back row. A poplar frame was chosen due to ease of construction and sturdiness. An 1/8" Masonite board measuring 28" by 6' was the backing for a dry erase surface. The board is dry erase over chalkboard because of Mr. Smalley's strong preference for the lack of dust and smoother writing.

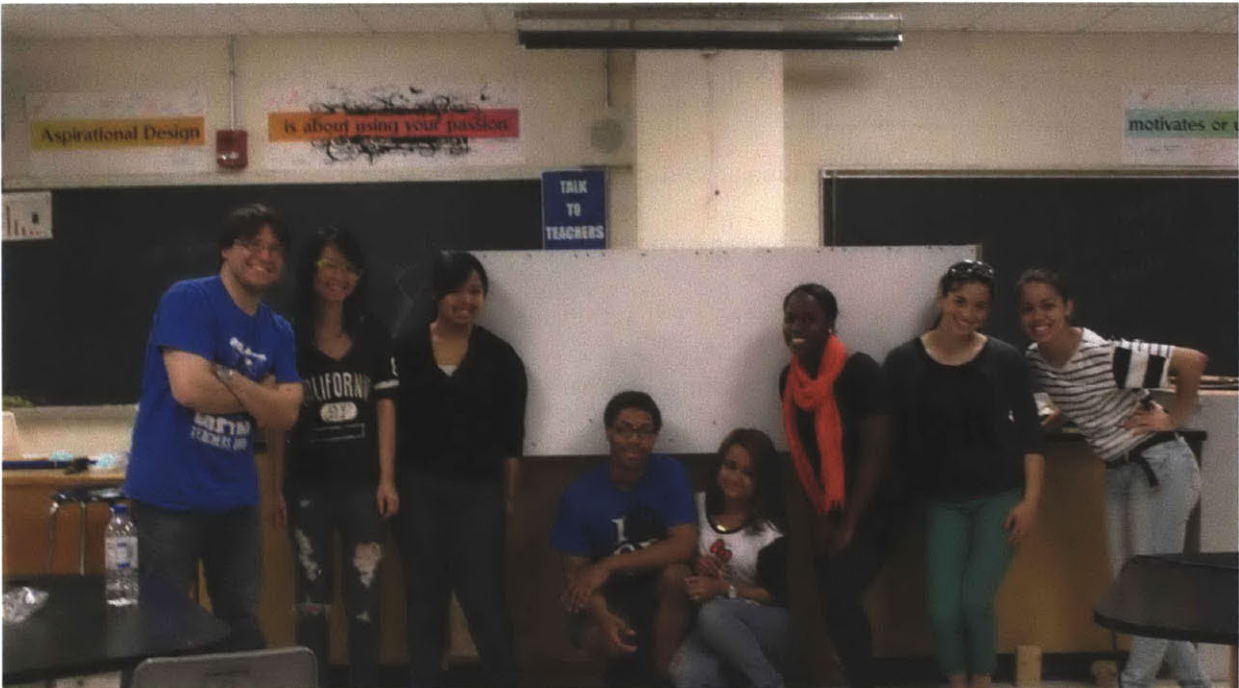
With consultation from the Pappalardo staff, a gate latch was selected to lock the board in the raised position. A gate latch would be placed on both sides and joined so that the latches could be undone together. The benefits of the latches are that they are strong enough to support the weight of the board and drawer slides and are self-latching. Photographs showing the prototype are shown in Figure 5-1 and in the Appendix.



**Figure 5-1:** Prototype of sliding whiteboard

## 5.2 Installation

After construction in Pappalardo, the prototype was ready to be installed in Mr. Smalley's classroom at the O'Bryant. Since the AP Physics students had completed the AP exam, their labor was available. The mechanically minded students said they enjoyed the hands-on installation process, which is documented in Appendix B. The installed prototype, with the students who helped, is shown in Figure 5-2.



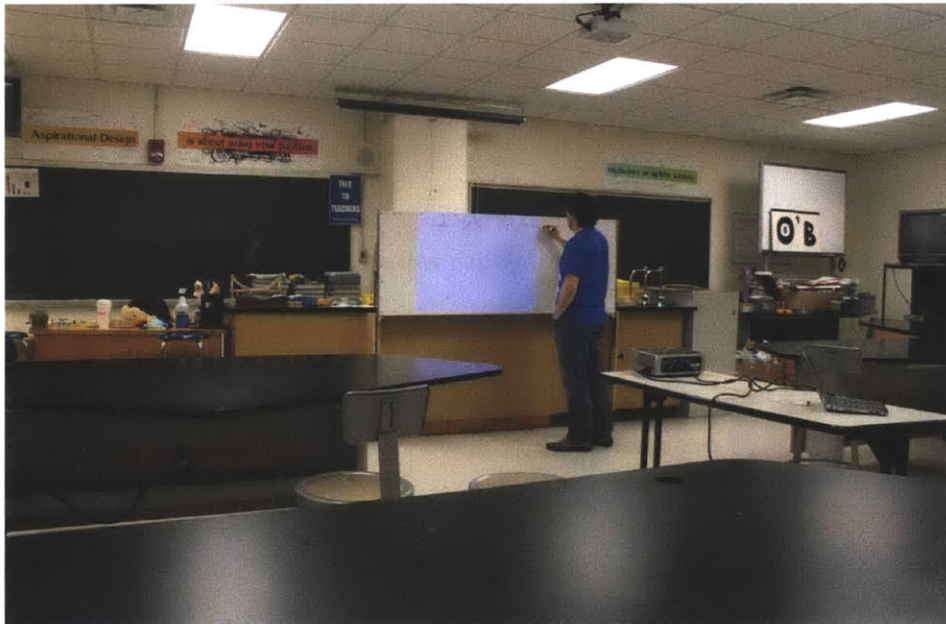
**Figure 5-2:** Installed prototype with students. Photo credit to Linh.

## Chapter 6: Evaluation

### 6.1 User Feedback

Three O’Bryant high school science teachers and I evaluated the prototype based on its usability and impact on classroom management and instruction. The whiteboard space was perceived to be limiting. We found the board was a little heavier to lift than desired. Mr. Smalley also pointed out he would like to be able to lift it with one hand, so he could switch the boards while still conversing and gesturing to students.

Mr. Smalley and I wrote on the board to compare the experience with that of a traditional whiteboard. The board does bounce when writing, particularly near the center of board. The dimensions are also smaller which requires the students to keep up with the teacher’s pace. Overall, Mr. Smalley found “no appreciable difference” between writing on the two whiteboards. He would give a whole lecture on the sliding whiteboard as is.



**Figure 6-1:** User testing the prototype

A discussion with Mr. Smalley illuminated the three main benefits he perceived in the sliding whiteboard: line of sight, proximity to students, and transitions. The line of sight for students on the edge of the class is still limited. However, the student experience of adjusting to see the board is improved. Because the board is now in the center of the classroom, Mr. Smalley no longer has to have the whole class fit into one half of the room. Now, students only have slide over a bit, “a small price to pay” according to Mr. Smalley.

The benefit of being near the kids so he can “stay on them” is important to Mr. Smalley. Students can be more involved in the class. Students will also not be detached from what he has written on the board, like he believes they currently are when he moves from the chalkboard to in front of the lab bench.

Finally, there is an efficiency advantage since Mr. Smalley no longer has to maneuver around the lab bench. Since the chalkboard would not be used, Mr. Smalley could have the projection screen always down. The sliding whiteboard eliminates these transitions that interrupt the flow of the Mr. Smalley’s lesson, or “comedy routine.”

## **6.2 Future Improvements**

There are some simple modifications which will be made to the existing prototype. First, the gate latches have not been coupled. The prototype takes two people or one struggling person to lower the board. Second, there is no handle to facilitate raising of the board. Third, there is nowhere to store dry erase markers and an eraser.

If another version of the board were to be created, the board space should be increased. This would be enabled with longer drawer slides, since there is an additional 5.5” available vertically on the

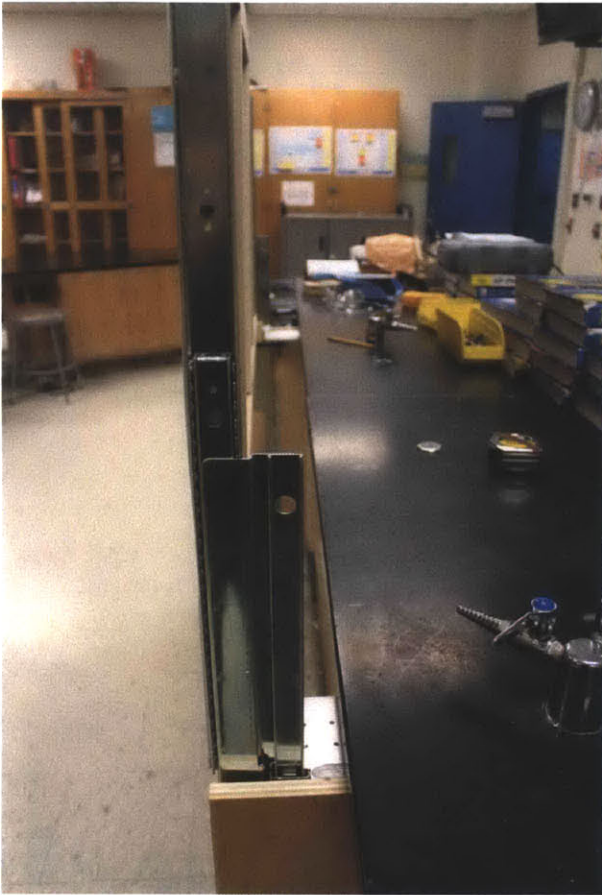
lab bench. A second board should be added to provide even more space and added convenience for the teacher. More students would also be able to write up solutions to homework or classwork problems without having to erase. The addition of the second board could be facilitated without too much extension in depth since there is currently more space than necessary.

The extra board space would also enable the white board to be used as a projector, a possibility that Mr. Fornaro mentioned. Teachers at the school already use white boards as projection screens so they can annotate powerpoints. The projection area on the prototype was too small for students to view easily, but the additional space would enable projection as another benefit to the whiteboard.

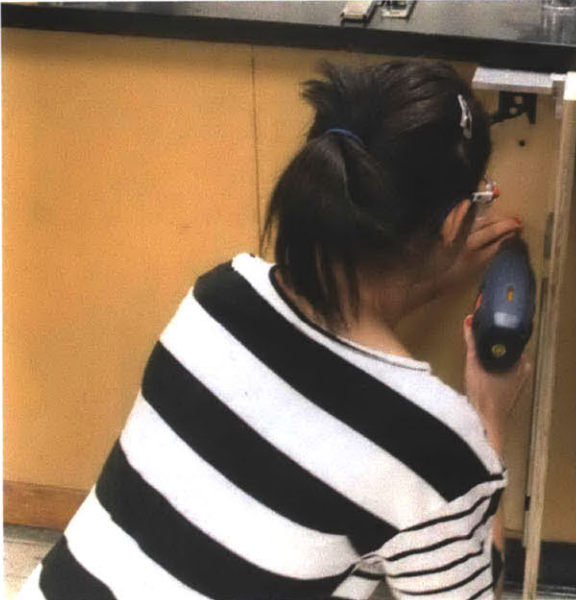
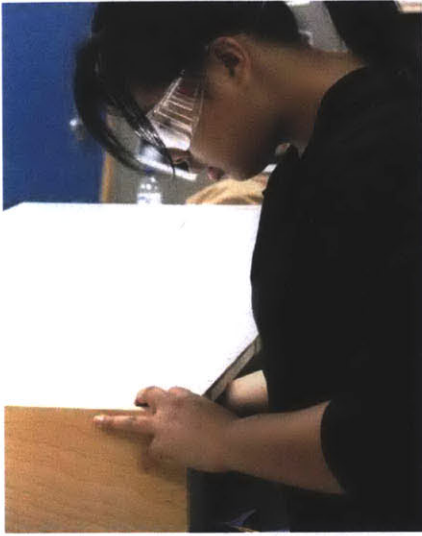
Mr. Smalley also mentioned more flexibility of board height. He would prefer the board to stop when he lowered it so he could briefly reference something on a second board. The board could also adjust extension to adapt to different teacher heights.



## Appendix A: A Closer Look at the Prototype



## Appendix B: The Installation as a Learning Opportunity



Sally (top left) adds books underneath the whiteboard to stabilize it. Yu Ling (top right) pre-drills the board before attaching it to the frame. Ambar (bottom left) screws the supports into the lab bench. Michael (bottom right) aligns the board to the frame. Photo credits to Josie.

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