A Study of Vertical Writing Surfaces at USMA

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Executive Summary

This paper represents the findings of a study commissioned by the Vice Deans for Academics and Resources through COL Ray Kimball (who also co-authored this paper) to assess current Vertical Writing Surface (VWS) use at USMA. This information is intended to inform classroom design decisions as part of the construction of new academic buildings and renovation of old buildings slated to take place at USMA over the next decade. After an initial assessment of literature and creation of study methodology by FLICR, followed by approval from the USMA Human Protections Administrator, an interdisciplinary study team was assembled from Master Teacher Program Year 2 participants to conduct the study.

The study was conducted in two parts. First, cadets in the upper two classes and teaching staff/faculty members received an anonymous online survey asking for their VWS preferences. As part of the survey, participants provided their assessment of each VWS they had used or seen used, to include strengths, weaknesses, best practices, and common mistakes. Participants then indicated the VWS that they believed to be most effective for their department and explained why. Participants also had the opportunity to participate in focus groups, where they could experiment with different VWSs in the same classroom space. 401 cadets and 235 faculty responded in some form to the survey, with 216 cadets and 189 faculty completing the entire survey by indicating a specific preference for a VWS. Less than 10 participants participated in the focus groups.

Quantitative results from the survey indicated a strong difference in VWS preference by discipline. Cadets indicated a raw preference for chalkboards and whiteboards in equal number, which makes sense given the widespread use of both surfaces at USMA. Cadets with STEM majors expressed a greater numerical preference for chalkboards; cadets with non-STEM majors expressed a greater numerical preference for whiteboards. Among cadets who had actually used them, glassboards were significantly more popular. Similar preferences for chalkboards and whiteboards emerged from faculty responses, including STEM and non-STEM preferences. Glassboards did not have a significantly higher preference among faculty who had used them.

Qualitative responses for the survey evinced passionate feelings about all four VWSs. Chalkboards were praised by some as simple and effective but panned by others as dirty and antiquated. Whiteboards and glassboards were identified as having similar strengths and weaknesses, such as use of projection surfaces and challenges with cleaning and keeping markers

on hand. Interactive whiteboards were seen as having potential, but difficult to use due to network issues and lack of training.

The study authors recommend:

- Clearly identifying which departments are likely to use classrooms when making choices about VWS installation;
- Ensuring that total costs of VWS use are identified up front, including the costs of high-quality writing implements and cleaning/maintenance supplies; and,
- Requiring departments to include a plan for maintenance of VWSs and purchase of ancillary supplies in their VWS requests for classrooms.

Problem Statement

Vertical Writing Surfaces (VWSs) are a component of every classroom at West Point. These VWSs vary from department to department, and even from classroom to classroom. Many classrooms offer more than one type of VWS. This diversity is a product of the uniqueness of each academic building at West Point. Each building was constructed at a different period of time, and both renovations and updates have also occurred at different times. There are four main types of VWS at West Point: the chalkboard, the whiteboard, the glassboard, and the interactive whiteboard. As West Point endeavors to construct new academic buildings and upgrade old ones, an honest look at VWS use in the classroom is valuable. Which VWSs "work" for each department? Which do not? To address these questions, the Vice Deans for Resources and Academics commissioned this study. This paper seeks to determine which VWSs provide the most value to the classroom for different departments. Properly constructing tomorrow's classrooms today begins with knowing which VWS will best support the learning of our future cadets.

Literature Review

Any assessment of VWSs should begin with the question: are VWSs still appropriate for use in 21st century classrooms? A review of current literature suggests that they are. The practice of having a VWS as a central fixture in the classroom only became mainstream in the early 1800s[1], and USMA is one of a small number of undergraduate institutions that feature VWSs for students and instructors alike in a majority of its classrooms. A study of medical student instruction found that instructor use of projected content and VWS together was more effective in communicating complex concepts than either projected content or VWS use by itself.[2] The relative permanency of a VWS, as compared to an electronic display, was assessed to be helpful for student learning.[3]

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[1] Keith Greenhalf, "The Rise of the Classroom Blackboard", *ETEC540: Text Technologies*, posted October 27, 2013, http://blogs.ubc.ca/etec540sept13/2013/10/27/the-rise-of-the-classroom-blackboard/, accessed June 18, 2018.
[2] Sultan Ayoub Meo *et al*, "Comparison of the Impact of PowerPoint and Chalkboard in Undergraduate Medical Teaching: An Evidence Based Study," *Journal of the College of Physicians and Surgeons Pakistan* 23 no. 1, 48-49.
[3] Gary Beauchamp and Steve Kennewell, "The influence of ICT on the interactivity of teaching," *Journal of Education and Information Technologies* 13 no. 4, 2008, 310.

Additional research suggests that providing instructors and students alike with VWSs is a boon to effective teaching. One researcher found that that student use of VWSs decentralized classroom instruction, helped students offer assistance to one another, and allowed the instructor to quickly assess systemic problems.[4] Another found that student VWS use sustained their interest and helped promote a problem-solving approach.[5] There is evidence to suggest that the impact of student VWS use varies by discipline: A Turkish study found that positive student attitudes towards VWSs were almost 20% higher in math classes than in other disciplines.[6]

Why does VWS use correlate with effective teaching? The literature offers several closely linked possibilities. One researcher suggested that when an individual's thoughts are seen in writing, they become more concrete and easier to grasp.[7] Another assessed that the ease of erasing on VWSs (as opposed to marking on paper) promotes student willingness to risk trying out answers or efforts that may not produce results.[8] Other affordances of VWS use include the interactivity of directly manipulating learning objection and the multimodality of different communication modes.[9] VWS use is assessed as being supportive of a "dialogic teaching" method that emphasizes collective, reciprocal learning among students and teachers that emphasizes supportive approaches and cumulative learning.[10] To that end, whiteboarding helps to orchestrate coordination of student and teacher efforts to achieve a synthesis of classroom experiences.[11]

The literature is far less definitive on whether specific types of VWSs (e.g. chalkboards, whiteboards, and glassboards) are superior for instruction. One defense of VWS use over electronic displays suggests that chalkboard use, in particular, slows the instructor's writing and commentary to a pace that students can more easily follow.[12] This narrative only differentiates chalkboards from other VWSs with the statement "Getting dirty is part of the professional culture of civil engineering."[13] Chalkboards are anecdotally cited as being longer-lasting and easier to maintain than other VWSs;[14] no systematic studies to support this claim could be found. Likewise, chalkboards are frequently critiqued for their negative impact on classroom technology and the impact of chalk dust on human health. No systematic studies of the former could be found; one study of chalk use's correlation with harmful air quality found that hazard could be ameliorated with the use of chalk formulated to be "anti-dust" or "clean write."[15]

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[4] Forrester, 2.
[5] Peter Liljedahl, "Building Thinking Classrooms: Conditions for Problem-Solving" in Patricio Felmer *et al* (eds) *Posing and Solving Mathematical Problems*. Geneva, Switzerland, Springer/Cham: 2016, 7.
[6] Nuri Balta and Muharrem Duran, "Attitudes of Students and Teachers towards the Use of Interactive Whiteboards in Elementary and Secondary School Classrooms," *The Turkish Online Journal of Educational Technology* 14 no. 2, 2015, 18.
[7] David Henry *et al*, "Whiteboarding Your Way to Great Student Discussions," *NSTA WebNews Digest*, March 30, 2006, http://www.nsta.org/publications/news/story.aspx?id=51894, accessed June 18, 2018, 4.
[8] Liljedahl, 10.
[9] Sara Hennessy *et al,* "A dialogic inquiry approach to working with teachers in developing classroom dialogue," *Teachers College Record* 113 no. 9, 2011, 4.
[10] Karen Littleton, "Research into teaching with whole-class interactive technologies: emergent themes" *Technology, Pedagogy and Education* 19 no. 2, 2010, 286.
[11] Ibid, 288.
[12] Stephen Ressler, "Whither the Chalkboard? Case for a Low-Tech Tool in a High-Tech World," *Journal of Professional Issues in Engineering Education and Practice* 130 no, 2, 71-72.
[13] Ibid, 73.
[14] Greenhalf.
[15] Deepanjan Majumdar, "Assessment of Airborne Fine Particulate Matter and Particle Size Distribution in

Methodology

The study was conducted in two parts: first, a voluntary, web-based survey for both USMA faculty and Cadets and, second, a focus group for both Cadets and faculty. The voluntary, web-based survey, conducted on USMA's Qualtrics platform, was sent to USMA Cadets and faulty via email distribution. The purpose of the survey was to gather both qualitative and quantitative data capturing the experiences and opinions of both Cadets and faculty with respect to four types of VWSs: chalkboards, whiteboards, glassboards, and interactive whiteboards. The survey asked participants to identify their department affiliation, either as assigned (for faculty) or for instructional major (for Cadets). Only Cadets in the upper two classes were surveyed to ensure participants had sufficient experience in their chosen discipline. Surveys can be found in Appendix A.

All cadets in the study population and faculty were invited to participate in focus groups in classrooms equipped with the different types of VWSs studied. These focus groups occurred over the course of two weeks on multiple iterations of both Day 1 and Day 2 in different classrooms in both Thayer Hall and Washington Hall to provide maximum flexibility for participants and to provide participants with access to each type of VWS studied. VWS study staff encouraged the focus group participants to bring work that was typical of VWS use in their discipline. Next, VWS study staff asked focus group participants to conduct said work on the various VWSs. VWS study staff facilitated access to the VWS while remaining neutral with respect to the effectiveness of the various VWSs. Focus group participants typically completed their field work in about fifteen minutes. Finally, focus group participants were provided a URL and asked to complete an online survey about their experience. The focus group exit survey can be found in Appendix B. Because the turnout for the focus groups was substantially less than the responses to the survey ($n<10$), the focus group survey responses are not included in this report.

All research for this study was conducted under an approved human subjects research exempt review conducted by the USMA Human Protections Administrator.

Findings

The findings in this section are organized by quantitative insights and qualitative insights. For both sections, cadet responses are presented first, followed by faculty.

Quantitative Insights

Over four hundred cadets from the classes of 2018, 2019, and 2020 responded to the VWS survey. Table 1 displays the responses of the 216 cadets who selected one or more VWS as the most effective for their discipline. The type of VWS is abbreviated: C for chalkboard; W for whiteboard, G for glassboard, and IW for interactive whiteboard. Majors from CME were the single largest group of cadet respondents, significantly higher than the next three highest respondents from EECS, Systems, and SOSH. Cadets listed whiteboards most often as the most

Settled Chalk Dust during Writing and Dusting Exercises in a Classroom," *Indoor and Built Environment* 21 no. 4, 2012, 541.

effective VWS with chalkboards as a close second. Over 69% of Cadet responses indicated that chalkboards and/or whiteboards were the most effective for their discipline. Interactive whiteboards also made a strong showing among cadets.

Cadets Who Indicated a Most Effective VWS By Department									
DEPT	Respondents	VWS Used or Seen used in Department				Most Effective VWS for Discipline			
		C	W	G	IW	C	W	G	IW
BS&L	17	15	14	2	16	4	9	2	9
C&LS	13	12	12	0	2	6	7	2	3
CME	35	35	18	7	10	32	6	3	3
DEP	5	4	5	3	1	2	1	3	0
DFL	18	17	11	8	16	5	10	8	4
DMI	6	5	5	1	4	2	3	1	2
DPE	4	1	3	0	0	0	2	0	2
EECS	24	20	23	4	22	3	15	4	7
G&ENE	13	11	8	0	8	4	5	1	5
HIST	10	10	7	0	6	5	5	1	3
LAW	4	4	2	1	1	1	4	1	0
MATH	15	15	15	2	12	4	12	0	6
PANE	11	11	7	1	6	9	3	1	0
SOSH	20	20	16	5	10	7	10	2	3
SYS	21	21	15	4	18	10	7	3	6
Total	216	201	161	38	132	94	99	32	53
Preference/Experience Ratio						0.468	0.615	0.842	0.402

Table 1 – Combined Cadet VWS Usage and Preference

There are several factors that could inform cadet responses to which VWS is the most effective for their discipline. One factor is preference gained through personal experience. Another factor could be observed effectiveness and/or preference of the professors in their disciplines. Another factor could be lack of experience with one or more VWSs. The last row of Table 1 captures this factor of experience and/or inexperience by taking the number of responses for each most effective VWS and dividing it by the number of responses indicating that VWS was used or seen used in their discipline. This measure reveals that over 84% of the cadets (32 out of 38) who used a glassboard in their discipline, or have seen one used in their discipline, indicated that glassboards are the most effective VWS. One could interpret this to mean that glassboards are cadets' favored VWS. This Preference/Experience Ratio also changes when cadet responses are organized by those with a STEM major and those with a non-STEM major, as evidenced by tables 2 and 3.

Cadets with STEM Majors									
DEPT	Respondents	VWS Used or Seen used in Department				Most Effective VWS for Discipline			
		C	W	G	IW	C	W	G	IW
C&LS	13	12	12	0	2	6	7	2	3
CME	35	35	18	7	10	32	6	3	3
EECS	24	20	23	4	22	3	15	4	7
G&ENE	13	11	8	0	8	4	5	1	5
MATH	15	15	15	2	12	4	12	0	6
PANE	11	11	7	1	6	9	3	1	0
SYS	21	21	15	4	18	10	7	3	6
Total	132	125	98	18	78	68	55	14	30
Preference/Experience Ratio						0.544	0.561	0.778	0.385

Table 2 – STEM Cadet VWS Usage and Preference

Cadets with Non-STEM Majors									
DEPT	Respondents	VWS Used or Seen used in Department				Most Effective VWS for Discipline			
		C	W	G	IW	C	W	G	IW
BS&L	17	15	14	2	16	4	9	2	9
DEP	5	4	5	3	1	2	1	3	0
DFL	18	17	11	8	16	5	10	8	4
DMI	6	5	5	1	4	2	3	1	2
DPE	4	1	3	0	0	0	2	0	2
HIST	10	10	7	0	6	5	5	1	3
LAW	4	4	2	1	1	1	4	1	0
SOSH	20	20	16	5	10	7	10	2	3
Total	84	76	63	20	54	26	44	18	23
Preference/Experience Ratio						0.342	0.698	0.900	0.426

Table 3 – Non-STEM Cadet VWS Usage and Preference

A total of 189 faculty members responded to the survey. These faculty members represented 16 different departments or agencies on West Point. The departments with the greatest number of responses were CME, SOSH, and Math (25, 25, and 24, respectively). The Library had the fewest number of responses (1), and the median number of responses was 10. STEM departments had a greater median number of responses than non-STEM departments. Chalkboards were the most common VWS, with 169/189 respondents reporting that they have used or seen them used in the department. Whiteboards were the second-most common, with 140/189 respondents reporting. Slightly more than half of responding faculty (96/189) had experience with or knowledge of interactive whiteboards, and less than a quarter of faculty (46/189) had used glassboards or seen them used. Participants were not limited to only preferring one surface; 150 faculty members chose only one VWS as most effective and 39 faculty members chose multiple surfaces.

Faculty Who Indicated a Most Effective VWS By Department									
DEPT	Respondents	VWS Used or Seen used in Department				Most Effective VWS for Discipline			
		C	W	G	IW	C	W	G	IW
BS&L	8	8	7	1	5	2	4	1	2
CEP	6	5	5	0	4	1	5	0	1
C&LS	8	8	5	0	1	7	4	0	0
CME	25	25	12	6	10	25	2	1	1
DEP	9	9	9	3	1	1	6	2	2
DFL	7	7	2	5	7	3	1	2	2
DPE	11	0	11	0	0	0	7	2	4
EECS	15	12	14	8	15	3	10	3	7
G&ENE	10	10	7	0	2	4	4	2	2
HIST	17	17	14	3	5	11	4	1	1
LAW	5	3	5	1	1	1	4	0	1
MATH	24	24	16	10	17	16	6	4	4
PANE	8	8	5	3	3	6	2	1	0
SOSH	25	23	20	2	16	6	19	3	4
SYS	10	10	7	3	9	2	2	3	5
LIBRARY	1	0	1	1	0	0	1	1	0
Total	189	169	140	46	96	88	81	26	36
Preference/Experience Ratio						0.52071	0.578571	0.565217	0.375

Table 4 – Combined Faculty VWS Usage and Preferences

STEM									
DEPT	Respondents	VWS Used or Seen used in Department				Most Effective VWS for Discipline			
		C	W	G	IW	C	W	G	IW
C&LS	8	8	5	0	1	7	4	0	0
CME	25	25	12	6	10	25	2	1	1
EECS	15	12	14	8	15	3	10	3	7
G&ENE	10	10	7	0	2	4	4	2	2
MATH	24	24	16	10	17	16	6	4	4
PANE	8	8	5	3	3	6	2	1	0
SYS	10	10	7	3	9	2	2	3	5
Total	100	97	66	30	57	63	30	14	19
Preference/Experience Ratio						0.649485	0.454545	0.466667	0.333333

Table 5 – STEM Faculty VWS Usage and Preference

NON-STEM									
DEPT	Respondents	VWS Used or Seen used in Department				Most Effective VWS for Discipline			
		C	W	G	IW	C	W	G	IW
BS&L	8	8	7	1	5	2	4	1	2
CEP	6	5	5	0	4	1	5	0	1
DEP	9	9	9	3	1	1	6	2	2
DFL	7	7	2	5	7	3	1	2	2
DPE	11	0	11	0	0	0	7	2	4
HIST	17	17	14	3	5	11	4	1	1
LAW	5	3	5	1	1	1	4	0	1
SOSH	25	23	20	2	16	6	19	3	4
LIBRARY	1	0	1	1	0	0	1	1	0
Total	89	72	74	16	39	25	51	12	17
Preference/Experience Ratio						0.347222	0.689189	0.75	0.435897

Table 6 – Non-STEM Faculty VWS Usage and Preference

Whiteboards were most preferred at 58%. Glassboards came in second at 57%, with chalkboards at 52% and interactive whiteboards trailing at 38%. STEM departments had a clear preference for chalkboards, however. For STEM faculty, chalkboards led the way at 65%, with glassboards following at 47%, whiteboards at 46%, and interactive whiteboards last at 33%. Non-STEM departments strongly preferred glassboards (75%), followed by whiteboards (69%) and interactive whiteboards (44%). Chalkboards were rated as least preferred at 35%.

At the department level, C&LS, CME, HIST, Math, and PANE each have a chalkboard preference ratio over 50%. The strongest attachment to chalkboards was in CME, with a 100% preference ratio. BS&L, CEP, C&LS, DEP, DPE, EECS, G&ENE, LAW, and SOSH each have a whiteboard preference ratio of 50% or greater. DEP, G&ENE, Law, and SYS each rated interactive whiteboards as more effective than not (>50%). Glassboards received preference ratios 50% or greater in 6 departments.

Faculty largely preferred VWSs that were most used in their departments. In 12/16 departments, faculty rated the VWS most used in their department as most effective. In all cases, the VWS concerned was either the chalkboard or the whiteboard. In 4 departments, however, faculty chose a VWS that was less commonly used as most effective. SYS was the only department in which the interactive whiteboard received the most votes for most effective.

Qualitative Insights

Cadet preferences for vertical writing surfaces were varied, both within disciplines and across the range of academic majors. Participants answered questions about the strengths, weaknesses, best practices, and common mistakes they have experienced with each of the vertical writing surfaces. The following paragraphs address qualitative responses from cadets regarding each of the four classroom writing surface references in the survey.

Chalkboards. The most frequently cited strengths were ease of use, ease of seeing the writing, ease of upkeep, and versatility (in terms of chalk colors). Respondents also mentioned lower costs of chalk compared to other writing instruments, the reliability of chalk (does not dry out), and the facilitation of students' individual and group work at the boards around the class. The most frequently cited weakness was, by far, the dusty, messy nature of chalkboards. Other weaknesses included difficulty in cleaning the boards, squeaky chalk, and the overall lack of chalk and erasers in the classrooms. Best practices included using chalkboards for board problems, using different colors of chalk, and cleaning the boards with a wet cloth or sponge. Common mistakes noted were incomplete erasing or cleaning, the lack of chalk and erasers on hand, and chalk dust on uniforms, computers, and other equipment. The responses ranged from love to hate, but chalkboards emerged as a popular choice for cadets.

Whiteboards. The most commonly identified strengths were the ease of use, the ease of cleaning, and overall cleanliness and neatness (due, in part, to the lack of chalk dust). Other strengths mentioned included the versatility of colored markers, ease of seeing the writing, and the ability to project images onto the surface. The most frequently cited weakness was the fact that markers dry out, and as many pointed out, there is no indication of ink levels. Other weaknesses included the lack of markers in the classrooms, the residue or "ghosting" stains that develop over time, and the glare produced at certain angles. Best practices included using multiple colors of marker, cleaning the boards with the proper solution, and using the surfaces for board work. Common mistakes included the accidental use of permanent markers on the whiteboards, using old or low-quality markers, and not cleaning the boards before the markers stain the surface. There was a wide range of opinions about whiteboards as well, including high praise and outright disdain. Still, whiteboards and chalkboards produced the highest totals of preferred surfaces.

Glassboards. The most frequently cited strengths were overall cleanliness, ease of use, and the aesthetically pleasing, modern appearance. The most frequently mentioned weaknesses included the glare and/or the "glass shadow," the fact that markers often dry out, and the difficulty in seeing some colors on the surface. Best practices included having the proper number of fresh markers available, board work, and ensuring each classroom has glass cleaner. Common mistakes included the lack of working markers, limited workspace, and the use of light-colored markers. Cadets had the least amount of exposure to this vertical writing surface. Consequently, glassboards received the least amount of discussion in the survey.

Interactive Whiteboards. The most popular strength of this surface was the ability to draw or annotate directly on the presentation or document on the screen. Other strengths mentioned frequently were the ability to incorporate graphics and multimedia, software integration, and

overall versatility. The most frequently mentioned weaknesses were technical problems with the boards and the lack of training or knowledge of how to access the board's full functionality. Other weaknesses mentioned included the requirement to have batteries for the pens, limited number per classroom and per department, and the expensive overhead and operating costs. Best practices for this surface included using the full capabilities of the system, integrating multiple programs, visualizations, documents, etc., and emailing the board notes to students at the conclusion of class. Common mistakes included the lack of technical training to use the system and spending too long troubleshooting in class. This option seemed to be less desirable than both chalkboards and whiteboards.

Faculty preferences and feedback were also varied across disciplines and the range of academic majors. The following paragraphs address qualitative responses from faculty regarding each of the four classroom writing surface references in the survey.

Chalkboards. Because chalkboards are the most widely used VWS at USMA, they drew the largest share of qualitative feedback, both positive and negative. Many faculty members praised the simplicity of chalkboards, stressing their reliability in power outages, their durability over time, and the ease of determining whether there is sufficient chalk for a lesson. Quality of chalk was heavily stressed, with high-quality chalk perceived as smearing less, squeaking less, and being easier to clean Others noted the ease of referring back to previous boards and the fact that writing on a chalkboard slows the delivery of information to a more easily absorbable pace. Cleaning of chalkboards was a strongly divisive issue. Some faculty members bemoaned different norms about frequency of cleaning in different departments, which lead to varying states of cleanliness between classes. Others provided different techniques for cleaning the boards; several participants noted that the new Dean's method for cleaning works well.[16] The prevalence of chalk dust and lack of interactivity were the primary concerns cited with the use of chalkboards. Others voiced concerns that chalkboard use needed to be part of an overall pedagogical strategy, rather than just used by default because of their ubiquity and ease of use.

Memorable Chalkboard Statements from Faculty:

"There are no real strengths of chalkboards for my discipline other than giving us fun stories to talk to old grads about when they visit class and remark that they remember doing physics on the chalkboard."

"I feel a connection with generations of chalkboard users."

"Chalkboards have a long and storied history at West Point, inspiring both instructors and cadets."

"Needless to say, lugging a bucket of dirty water down a hallway and wiping down a board with a nasty sponge/rag/mitt is not why I got into higher education. This is the 21st century - as a 19th century (or earlier?) technology, chalk's time has come and gone. Let's get with the program!"

Whiteboards. Whiteboards were seen as having similar strengths and weaknesses as chalkboards, although diverging in a few key areas. Faculty members praised the higher contrast of whiteboards as being easier to see and utilize as a projection surface, with the option of easily

[16] Demonstration of the Dean's Method: https://youtu.be/7_viCs2gnA8

annotating digital projections. Many faculty members also felt that it was easier to integrate multiple colors on a whiteboard since multi-colored markers are more plentiful than multi-colored chalk. Faculty members differed on whether whiteboards were easier to write on than chalkboards; while a majority of commenters felt it was easier, a vocal minority stated that whiteboards have insufficient friction to write smoothly and consistently. A readily available stockage of high-quality markers was urged as a means of combating both poor writing and markers running dry on ink. Cleanliness again was a major point of friction; several faculty members complained that whiteboards quickly build up ghost remnants of prior writing over time. Several respondents stressed the importance of systematic cleaning using proper solvents or creams to avoid this problem. Respondents voiced frustration that there is no way to tell ahead of class if a marker has sufficient ink for the entire class session.

Memorable Whiteboard Statements from Faculty:

"There are no strengths to whiteboards--they are terrible!"

"Keep them in collaboration areas but out of the engineering class rooms!"

Glassboards. Glassboards are a much more recent introduction to USMA, so they garnered the least amount of feedback of any VWS. Many of the same strengths and critiques of whiteboards, like marker use and cleanliness, carried over to glassboards. Some respondents noted that glassboards have a cleaner, more modern look than chalkboards or whiteboards. The transparency of glassboards was largely cited as a strength, since glassboard walls allow more light into otherwise enclosed areas and allow for pedagogies like reverse annotations by students on top of instructor markings. The use of glassboard walls without a neutral surface behind them was cited as challenging due to the lack of contrast.

Memorable Glassboard Statements from Faculty:

"They are better than white boards, but beyond that I think they are just the new cool surface."

"No inherent strengths above and beyond a whiteboard or chalkboard."

Interactive Whiteboards. Interactive whiteboards were seen as having great potential that is largely unrealized due to unreliable power and networks, lack of faculty training, and dearth of maintenance support. Interactive whiteboard responses had the largest number of new pedagogy suggestions, such as pulling and integrating notes from previous sessions, recording a session for future playback, and saving the content of a slide with future annotations. Faculty members noted that ease of clearing an interactive session at the conclusion of class compared to the other VWSs. Many proponents of interactive whiteboards acknowledged that frequent power and network outages at USMA make their routine use problematic. Other faculty members stressed that interactive surfaces require frequent calibration and maintenance that isn't supportable under current USMA IT staffing. The amount of training required to readily utilize all of the interactive whiteboard's functions was also raised as a concern, with some faculty members opining that the rapid obsolescence of different systems further added to faculty training loads. Greater maintenance support, standardized training, and standard user settings within a department were all cited as possible mechanisms for more effective interactive whiteboard use.

Memorable Interactive Whiteboard Statements from Faculty:

"To be honest, between youtube, DVDs, Word docs, PPTs, and maps on the Epson, and playing music, I have enough tech right now. The main thing I want is a discussion with some breadth."

"If you find one in your classroom, ask for it to be removed and discarded."

"Nobody knows how to use them. Not worth the hassle to use them. Reminds me of TVs in the classrooms in the 70's. Never really got used now did they?"

Recommendations

The data revealed that both cadets and faculty possess strong opinions about VWSs, and that these opinions vary starkly between STEM and non-STEM departments. When selecting appropriate VWSs for future classrooms, USMA must consider first and foremost which departments will occupy the space. Will the classroom be owned and used by only one department, or will multiple departments teach in it throughout the day? In the case of single-department classrooms, department preference can be accommodated. For shared spaces, the answer is more complicated. If primarily STEM departments share the space, then chalkboards are a must. If primarily non-STEM departments share the space, then whiteboards or glassboards must be included. If, however, a mix of STEM and non-STEM departments will utilize the classroom, then a compromise must be found that provides sufficient value to all stakeholders. Classrooms are not limited to one VWS, and it is already the norm in many West Point classrooms to have at least two different types. If multiple VWSs will be included, what combination of VWS provides the most overall value? The answer is specific to each department, so the placement of departments in buildings should inform VWS fielding. To that end, a building-specific survey should be administered within each department after the ABUP decisions have been finalized. Departments will be better positioned to specify VWS preferences in the actual spaces they will occupy, which may yield different results on a more directed, classroom-specific survey. At the very least, a future survey will reflect the updated requirements for each department.

The cost of the various VWS solutions was not thoroughly researched in this study. Further research in this area is needed if cost is going to be a significant factor in the final decision. The total cost of any solution includes the cost of the VWS itself, the cost of installation, the cost of ancillary VWS supplies, the cost of any technical support contracts, and the costs, both monetary and temporal, of maintaining the VWS and of properly training faculty to use the VWS. USMA must also compare the cost of the various alternatives of both ancillary VWS supplies and cleaning and maintenance supplies for any selected VWS. For example, the various types and brands of chalk should be considered: dust-less chalk, chalk that does not break as easily, chalk that does not squeak as much, and even chalk marker.

The Dean should stipulate maintenance and ancillary VWS purchasing responsibilities for newly constructed or renovated classroom spaces. These responsibilities should include which department is responsible for cleaning and maintaining the VWSs in a given room or area, the frequency of cleaning and maintenance, the standards associated with said cleaning and maintenance, which department is responsible for purchasing ancillary VWS supplies for a given

room or area, how much of each type of ancillary VWS should be on hand in a given room or area at any given time, and the amount and placement of cleaning and maintenance supplies for any given room or area. At a minimum, departments should be required to provide this information when expressing preferences for VWSs in their classrooms.

Appendix A: Initial Surveys

Online Survey - Cadet

Please identify your class year [pull-down with 2018, 2019, 2020]. [NOTE: cadets answering 2021 or 2022 were redirected to a screen indicating that they are not part of the study population.]
Choices: 2018, 2019, 2020

Please identify the department affiliated with your major [pull-down]. If you are pursuing a double major with two departments, please select the department in which you have taken the most classes.

Please select the classroom vertical writing surfaces (VWSs) that you have used or seen used in your department's instruction. The information icon next to each selection contains pictures of typical USMA installations of this item for your reference.
__ Chalkboard
__ Whiteboard
__ Glassboard
__ Interactive Whiteboard

[For each VWS selected, participants were asked to answer the following questions:]

What are the strengths of this VWS with respect to your discipline?

What are the weaknesses of this VWS with respect to your discipline?

What best practices, if any, can you share in the use of this VWS?

What common mistakes, if any, can you share in the use of this VWS?

[After all entries for selected VWSs, participants were asked the following:]

Reflecting back on your responses, please select the VWS that you think is MOST effective for your discipline.

__ Chalkboard
__ Whiteboard
__ Glassboard
__ Interactive Whiteboard

Please explain the reasoning behind your response.

Online Survey – Faculty

Please identify your department affiliation. If you are affiliated with more than one department, please select the department where you have done the majority of your teaching.
Choices: All academic departments plus CEP and Library

Please select the classroom vertical writing surfaces (VWSs) that you have used or seen used in your department's instruction. The information icon next to each selection contains pictures of typical USMA installations of this item for your reference.
__ Chalkboard
__ Whiteboard
__ Glassboard
__ Interactive Whiteboard

[For each VWS selected, participants were asked to answer the following questions:]

What are the strengths of this VWS with respect to your discipline?

What are the weaknesses of this VWS with respect to your discipline?

What best practices, if any, can you share in the use of this VWS?

What common mistakes, if any, can you share in the use of this VWS?

[After all entries for selected VWSs, participants were asked the following:]

Reflecting back on your responses, please select the VWS that you think is MOST effective for your discipline.

__ Chalkboard
__ Whiteboard
__ Glassboard
__ Interactive Whiteboard

Please explain the reasoning behind your response.

Appendix B: Focus Group Exit Survey

Thanks for being part of this Vertical Writing Surface Focus Group! Your responses will remain completely anonymous.

Please select your department affiliation or the department affiliated with your major. If you are a cadet pursuing a double major with two departments, please select the department in which you have taken the most classes. If you are a faculty member affiliated with multiple departments, please select the department where you have done the majority of your instruction.

Please select the classroom vertical writing surfaces (VWSs) that you used in today's focus group. The information icon next to each selection contains pictures of typical USMA installations of this item for your reference.

__ Chalkboard
__ Whiteboard
__ Glassboard
__ Interactive Whiteboard

[For each VWS selected, participants were asked to answer the following questions:]

What were the strengths of this VWS for the work you did today?

What are the weaknesses of this VWS for the work you did today?

[After all entries for selected VWSs, participants were asked the following:]

Based on your experience today, please select the VWS that you think is MOST effective for your discipline.

__ Chalkboard
__ Whiteboard
__ Glassboard
__ Interactive Whiteboard

Please explain the reasoning behind your response.