Whiteboarding can give you the H.O.T.S.*

* Higher Order Thinking Skills

««« By Dave Doucette

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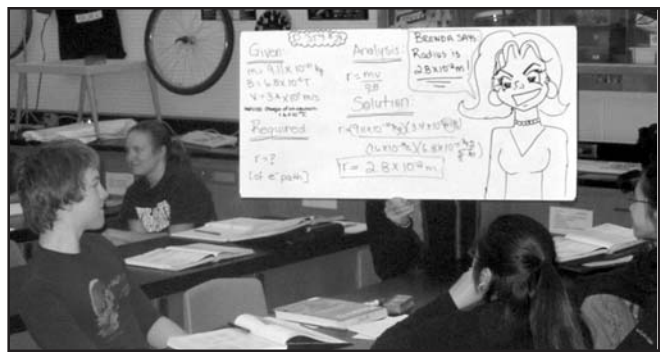
Curriculum Connection: All grades, all subjects.

Prelude

Keshia stood, intently scribing in her notebook, "A hawk, flying at 2 km/s sees a mouse on the ground and, not having lunched, accelerates at 5 km/s/s for 6 seconds. What was the hawk's speed when it pounced on its lunch?" She paused after writing, burst out laughing and expelled, "Ten kilometres a second? What kind of a hawk is this? Is this superhawk?" Her group members paused to consider the values given. "What happens when it hits the ground at..." she stopped a moment to calculate "...32 km/s? Can you imagine?" They chuckled at the visual image. "Who wrote this question?"

"Did you see the question about the snake? It had a displacement of, like, 500 m in a time of 10 s. That's, like, fifty metres a second. What drugs is that snake on?" Kiv called out from across the room, standing with his group. The class erupted. "Hey, that was my snake." Replied Katia from the back of the room. They chuckled, then resumed scribing the student-generated questions into their notebooks.

"Move to the next station once you have the questions copied ", I instructed the class, "Don't stop to answer questions ...just leave a space after each question for your solutions." They shuffled from station to station, copying down the often unintentionally outrageous questions from the small whiteboards. Each station featured one of six kinematics equations, such as average velocity equals displacement divided by time [$V_{av} = \Delta d/\Delta t$]. Student teams were instructed to create two or three questions requiring students to rearrange formulae and solve problems, using simple whole number values solvable without calculators. This was day three of a new semester of grade 11 physics. So far it had been quite a week. Whiteboarding was integral in establishing an inclusive active-learning atmosphere while reducing the stress of semester startup – for them and for me.



Senior physics students presenting a homework problem to the class on a large whiteboard. Note the artistic license, arguably evidence of multiple intelligences at work... or at play!

Answers to questions were written on the front blackboard. Complete solutions were not provided and pod

members were encouraged to challenge answers. Challenges were defended with detailed solutions, revealing occasional solution errors and producing lively discussion on numerical analysis. Clever variations of problem-solving techniques were also generated, one resulting in a spontaneous round of applause.
“Its ten to eleven!” Keshia called out in alarm, “I can’t believe how fast this class goes. I love this class.” I tend to forgive outbursts of that nature – I might even actively encourage them.

Setting the Stage

Establishing a student-centered active-learning culture is the hidden curriculum in these semester startup activities. Whiteboarding is key in achieving this goal.

Whiteboards are white tile boards (50 cm x 78 cm) which are written upon by colored markers and erased by whiteboard erasers or cloth. A single large whiteboard is preferable for groups, though they can also be cut into 6 or 8 sections for individual student use. These boards are light and easily portable. I have used them in the classroom, hallway, cafeteria, gym, the outdoor track, football field and the local park.

I discovered whiteboarding in a 2000 article on small group cooperative learning by Dan MacIsaac[1] describing the use of these boards to increase student engagement in large enrollment college lectures. I subsequently attended an OAPT workshop by Glen Baxter who demonstrated more sophisticated applications. Successful implementation in the physics program motivated my entire department of nine teachers to adopt whiteboarding as a regular strategy in all science courses at all levels.

A safe, active-learning classroom (*community centered environment*) is one of four components recommended in *America’s Lab Report, 2006*[2]. This requires teachers relinquishing some of the apparent control of a teacher-centered curriculum, allowing students more opportunities to listen, discuss and articulate. This proceeds in steps, as students and teachers gain comfort and confidence in changing roles. It takes time to integrate whiteboards effectively into class routines, with some bumpy initial starts, but this is true of any instructional strategy. Barrie Bennett[3] (Instructional Intelligences) describes it as the inevitable ‘dip’ before the’ rise’ in learning. It is well worth the effort, as whiteboarding supports many instructional tactics; this article describes just a few.

The First Act: Small group whiteboarding

Day one: we begin the semester with a *hands-on, minds-on* review of prior learning. In Ontario, motion is taught in grade 10 and we begin this grade eleven physics course with ‘motion & forces’. Students are arranged into home-based pods of 2-3 and, after some introductions, are introduced to six stations of simple motion activities. The format is a bell-ringer and they rotate through the stations after several minutes. This permits time to read instructions, observe and make measurements, and enter information onto their 2-page worksheets. A class of 25-30 students requires two sets of six stations, with the class divided into halves.

Once finished, they return to their pods to complete the worksheets. For each of the six stations there is a focused question to answer, for example ‘How does this motion help distinguish between the terms distance and displacement?’ There is also a position-time sketch with room for a brief justification of the curve drawn. Within pods they are encouraged to discuss answers. A course textbook is provided at each pod as a reference.

Once worksheets are collected, each pod is assigned to debrief one of the six stations. They prepare a short presentation in answer to the question, display the graph and justify the graph shape. Day one ends with the groups outlining and rehearsing the presentation order. All group members must take a role in presenting.

While they prepare, I scan student worksheets for two or three level 4 (excellent) exemplars which are photocopied in sets for the next day. They are used as templates for students to form self (or peer) assessment, with remarks on the next steps needed to improve. The time invested to create clear standards and the opportunity for students to scrutinize peer work is essential in establishing buy-in to the process. If time is at a premium, students *can* self assess as homework, though there is definite merit in carrying out this process with complete class engagement.

Day two: students obtain a large whiteboard (~60 cm x ~120 cm), markers and an eraser. They display their graphical, symbolic and textual information on the large whiteboards and present to the class, station by station. Classes are large so each station has two presentations – a coin toss determines the order of presentation.

This is an effective diagnostic tool for revealing student or class misconceptions. Errors and misconceptions are noted and saved for later lessons. A difficult task for teachers is to resist the urge to jump in and explain it properly, though questions should be posed to uncover misconceptions and generate discussion. Richard Hake[4] at Indiana University has developed Socratic techniques to guide university instructors in careful questioning. A quick read of this literature will help teachers incorporate this strategy into their questioning repertoire.

It is also rich from a literacy perspective as students explain, listen, clarify and elaborate within groups while preparing, and between groups when presenting. Once presentations are complete, we line up the whiteboards around the class and rank the most effective exemplars. Classes quickly and insightfully cite features which make for effective communication pieces, furthering development of transparent standards for communication. Pods self-assess their work and suggest *next steps* to move them to level 4 (or 4+) exemplars.

Assessment of whiteboards poses potential problems. An overemphasis on summative assessment can focus students on results and derail the primary process of concept attainment and refinement. It is recommended the focus should be on communication and cooperative groupwork skills. Content can – and should – be tested with traditional quizzes, tests and applications. Rubrics for whiteboards are discussed on websites such as **http://modeling.la.asu.edu/** as recommended by D. MacIsaac.

Act Two: Individual whiteboarding

Day three: there are arguably 5-6 key equations for the study of kinematics. Each pod is provided a set of equations on colored stock paper, which are cut up to encourage kinesthetic manipulation. After an introduction and warm-up exercises, each student obtains a small whiteboard (~30 cm x 40 cm), eraser and marker. I then select a single equation, such as $a = \Delta v/\Delta t$ and challenge them to rearrange the equation to solve for Δv. They work individually, hold up their answer when complete and scan the room for differing responses. If answers vary, they are instructed to engage and defend their response. Typically the correct solution is quickly obtained. We cycle through equations as the rearrangements increase in complexity.

I do not provide correct answers but do inform them if the class consensus is incorrect. When a teaching moment occurs, I leap in with my own whiteboard. Occasionally I ask a student to walk the class through a clever mathematical manipulation they have utilized. This use of small whiteboards was a low cost variation of the JiTT (Just-in-Time Teaching)[5] approach blended with a simple adaptation of the Peer Instruction[6] process by Eric Mazur at Harvard.

The next step involves students authoring word problems as described in the opening of this article. Creating and solving word problems develops literacy skills while promoting stronger connections of symbols to concepts. Whole number usage encourages mental arithmetic, honing number sense in a student-centered, active learning paradigm.

Day four: today is our first homework check. Students are placed in tutorial sections of five or six and immediately number off. "Number ones can pick up a large whiteboard for each group, plus a marker and eraser." I instruct. "The tutorial leader today is... number five. Come and pick up an assessment sheet. First thing to do is a homework check." The tutorial leaders scan the homework for each member, including themselves, formatively assessing for effort or completion on a scale of 1 to 4.

"Ok, tutorial leaders, the question today is on page 53, number 12. Go for it." Dutifully, tutorial leaders locate the question and read it quietly to the group. The group listens intently while the tutorial leader works through the solution, identifying the known values, the method of analysis, and the steps to solution. All steps must be accompanied by a monologue of the thinking and strategy.

"How many significant figures?" Brenda asks. "Two," Tonia answers, "Maybe three." "It's two," adds Habar, "Look at the smallest number, not the biggest." Agreement is reached. The groups conduct a quick consensus on the performance of the tutorial leader. Assessment sheets are collected and the class continues.

Final Act: the plot is revealed

"Mr. Doucette, when are you gonna teach us something?" Ben asks, near the end of class.

"Yeah – you don't do anything." Someone else pipes in. They are not being rude or mischievous, it had just occurred to them I had done very little conventional teaching.

"I guess I haven't been doing much teaching!" I say. They laugh in agreement. "Then I guess you haven't done any learning, either."

"Are you kidding – we've done everything in the last few days. The time just flies by. But when are you going to teach?"

"Well, have you been learning?"
"Yeah...sure!"

"Then what does that make me if I stand around, direct and coordinate, while you toil like worker bees? If I am not a teacher – in the usual sense – then what would I be? Who else makes you work like crazy while they stand around and critique your performance?"

"My parents!" Keshia offered. "No – a COACH!", a voice calls out. "Ahh" the class realizes in a collective sigh, the subterfuge revealed. The bell rings and they rise as a group. As they shuffle out they are smiling. Alexandra, a taciturn student dressed in head to toe black, gives me a brief nod while leaving. That is progress indeed.

"Hey, Mr. D., you're a pretty smart dude." Anton says, in passing.

I think I'm a pretty lucky dude, too. I love my job.

Postscript: Whiteboards were purchased at Home Depot for about $8 (Canadian) for a large whiteboard. These can be cut down to produce ~8 small whiteboards. Not all Home Depot stores carry the whiteboards. Recently small whiteboards have been appearing at dollar stores, complete with markers.

Further References

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