jct Curriculum Forms
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Einstein, the Universe and Us: Science Hits the Stage
Performative Inquiry Within a Co-Evolving Curriculum

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This class has certainly been the most personally risky of all my classes at university. Even my practicum was nothing compared to ScEd 310. If you had told me a year ago that I would not only help write and create a play about science, but also direct it as well, I would have told you that you were crazy.

— Anne (Student and Director)

In Front and Behind the Curtain

Out of the slate gray of this rainy Vancouver morning comes a sinuous line of children, bodies hidden inside knee-high rubber boots and under hoods of slick kaleidoscopic raincoats. Like a stripe of ants following a collective purpose, they and their teachers move through the university building to the theater doors. Then, inside the playhouse, kinetic bodies burst from raincoats. The youngest find places in the front rows, staring at the closed curtain, their heavy boots dangling. Back and forth measures time waiting. The older children chat. "I'm really glad this is science," one whispers to another.

Behind the curtain, the ten university students and their two professors attend to last minute details, the performance imagined in science class now just moments from show time. "Is my make-up okay?" queries one of the Jesters. Einstein and Wendy rehearse their lines in a secluded corner. Einstein's rabbit ears tremble with stage fright. "Two minutes to curtain time," cautions the director. In the booth, the sound technician[1] cues the CD player. The lighting technician dims the house lights. The Monster whispers, "Break a leg."

And the play begins ...

"Physical Science for Elementary Teachers" (ScEd 310)[2] emerged over the term as creative ecology, a dynamic choreography with phenomena and our bodies *through* inquiry and performance.[3] Working within a co-evolving curriculum, we were performers seeking a language of creative action and interaction in the "sciencing" of our shared universe, both within the classroom culture and in our individual lives. For us, understanding was a rewriting of text, sharing authorship with our environment. We did not absent ourselves from the phenomenon we studied, but "enter[ed] in relation with it" (Abram, 1996, p. 117). We were members of a complex web of living relations, a performance,[4] a mutual co-evolving dance within "a world that shapes us and a world that we participate in shaping" (Davis, 1996, p. 9).

For us, learning is not about somehow getting knowledge across the chasm that Descartes believed separated mind from body, but "an ongoing bringing forth of a world through the process of living itself" (Maturana & Varela, 1987, p. 11). As participants of the living world we are never disengaged from our body or from the world which provide experience and conditions of embodied knowing. Rather the world "comes into being only in and through interpretations," as possibilities (Tarnas, 1991, p. 396).

Phenomenologically speaking, understanding begins with a recognition of the way that language can estrange us from the environment, from embodied knowing. Phenomenological understanding expresses a critical and creative imagining and reimagining of the phenomena experienced (Fels & Meyer, 1997). When we temporarily abandon scientific terminology and definition, language is no longer prescribed, and our descriptions arise with our investigation through our senses, our interactions with the phenomena. Like Abram (1996) we acknowledge that "all phenomena are animate" in performative conversation with ourselves.

> Things disclose themselves to our immediate perception as vectors, as styles of unfolding—not as finished chunks of matter given once and for all, but as dynamic ways of engaging the senses and modulating the body. ... Every phenomenon, in other words, is potentially expressive. (p. 81)

Interpreting our world as a dynamic being acknowledges that "each thing, each phenomenon, has the power to reach us and to influence us." And, in "this vital communication with the world" (Merleau-Ponty, 1962, p. 52), a creative understanding of the universe that is us "hits the stage."

From an ecological centered view, creativity is a social process, one which decenters the subjective individual and creative product. Such a perspective embraces the idea that "our lives are connected and interdependent—both with past and future generations and with the larger biotic community" (Bowers, 1995, p. 74). We are not observers but dynamic interpreters of an environment which embodies the very rhythm of our breathing.

The phenomena we deconstructed in our course were light, sound, and motion, and our instruments of exploration were our bodies (hands-on application), our voices (story and storying), and our imaginations. This curious process invariably leads to asking fundamental questions and doing systematic manipulations. *What matters? What if? So what?* That is, for the inquirers, situating the phenomenon means play(ing) with variable relations in a creative manner, the figurative mapping of an open system. And the ineffable explanation of such a dynamic task appropriately begins and ends with, "It depends ..." (which is precisely where textbooks fall short). Understanding, then, is a mindful resonance with a phenomenon in all its complexity and contingency.

We performed scientific principles of motion by swimming in the university pool, ice skating in the nearby hockey rink, and doing simple gymnastics in the gym. But mostly we generated curious questions. What if the blade on an ice skate is made longer? What matters for an object to float? So what if a large pole helps me balance on a tightrope? Science comes to be about making connections. Such events are foreplay for qualitative interpretation. They push us into thinking about the world and into wondering why we hadn't wondered before. Aha! The moment of inertia unfolds the romance of science.

I felt like I just put on these science glasses and everywhere I looked things were science.

— Christine

Curtain Rises

LIGHT, SOUND, MOVING AROUND: WHAT ARE MONSTERS MADE OF?

Written and Performed by:
Students in ScEd 310: "Physical Science for Elementary Teachers"

Characters

Wendy:	the young heroine who is tired of reading about science in textbooks
Einstein:	Wendy's sidekick, a pink "stuffed" bunny who takes part in Wendy's adventure
Jesters:	two jocund helpers who talk in rhyme and occasionally stop the play to interact with the audience
Monster:	a villainous shadow creature that appears in Wendy's room
Bob:	an audacious character who works with the jesters (he sometimes wears a dress)
Piano Player:	a mysterious musician in a gray fedora

The play came to be the physical integration of what the students had learned, imagined, generated, and storied during the course. They romped science out of the closet through a surrealistic door and created a monster. Physics or phantasy? It was mutual surrender. Drama was woven in modes of science and vice versa.

Einstein: M = l + s + m
Wendy: So? What does that mean?
Einstein: It means that Monster equals light plus sound plus movement ...
Monster: Light, sound, movin' around. A nice scientific theory, but that's not all monsters are made of ... [Bold, scary laugh]

The students came to the elective science course in search of expertise, to find a space of competence and confidence that could be imported into their future classrooms. What they discovered were not answers but possibilities; not the science textbook but experience; not memorization or recipes but imagination and exploration. This science was applied on the skating rink, the gym floor, the swimming pool ... and, yes, as Finale in the theater.

Einstein: HELP! There's a giant bunny after me! Don't panic! Stay calm! There must be a scientific explanation for this? ... Ah, yes! When an object intercepts the light falling on a surface, then the size of the shadow will be dependent upon the distance that the object is away from the light source! Whew! [Einstein turns around and sees his own giant shadow and again screams.] It's still there! Wendy! Come over here! Quick!

The Expert wears an assortment of masks making a number of guest appearances throughout the course—as gymnast, sound artist, lighting technician, astronomer. The gymnast teaches us about balance. We move. The sound artist, disclaiming scientific knowledge, introduces us to sound through her understanding of soundscape. We listen. The lighting expert shows us ways to light the stage. We dance in light and shadow. The astronomer turns the building outside our window upside down with a pair of lenses. We refocus. Unmasked, the Expert becomes us, our explorations implicated within and outside the class to the play in its writing and production.

What is beneath the mask of science? John Dewey (1956) warns that science teaching makes the mistake of regarding science as the experience of the scientists, the "final" mapping of their journey. Science curricula present the completed map but fail to invite the imagining or the experiencing that scientific inquiry demands. Textbooks report scientists' findings, presented formulae and capsule explanations. But the questions that these explanations answer do not arise directly from the students' domains of experience or fantasy.

How then can students learn the praxis of science, without "rolling up their sleeves" and engaging with/in phenomena?

The science was pervasive in this course. In problem solving the lighting, there was not one area of light that we did not actively discuss during our preparation for the play. I now know intimately how to make large and small shadows and create any color shadow on demand. And don't even get me started on spot lighting ... there is nothing we can't do now.
— Anne

Light. It's an obsession—for the artist and the scientist alike. Color. Energy. Even its absence fills the imagination.

Prop-person scribbles on his script ...

> Gruntwork: Backlight the stage to create the shadow of Piano Man. Make sure shadow same size as bunny; best stand on chair hold spot at waist level then off chair hold spot at feet of Piano Man.

... applying his knowledge of light and shadow to create the effect required by the director.

Script Notes from lighting technician:

> Lighting Problem #2 - Creating the monster - from class activities we knew that the size of the shadow depended on how close the objects, actors, were to the light source and the screen. A flashlight was not bright enough to light up a whole person's shadow so we decided to use a hand-held spot. However, Wendy could not carry a spot with a cord throughout the play so we positioned one at the edge of the stage for this scene. This led to modifying the script slightly.

Like the brilliant wizard who fabricates a fearsome visage striking awe in the hearts of Dorothy and her traveling companions, the science students created an imaginary world, replete with unexpected adventure in the lands of light, sound, and motion. Science. Theater. Separated only by a curtain.

Scripting Science

Wendy: You know, Einstein, I really hate this science homework. All we do is read from fat text books and memorize definitions like the angle of refraction and angle of reflection. And we memorize formulas that just don't make sense! It's all scientific bafflegab to me. Why don't they just use normal language?

Perhaps Wendy really is saying, "Why doesn't the science textbook speak my language?" Language explores and shares experience. If it does not welcome or resonate with the students' experience—their knowing—they remain reluctant and detached observers rather than participants. Joan Solomon (1993), science educator, aptly describes learning science as the arrival on a foreign shore and the struggle with conversation in an unknown language. Science as a second language turns into memorizing words and definitions. It's survival.

But a definition is not the experience. Science learning is exploring the landscape of our experience through performative inquiry.[5] If we stop listening for an echo, what sounds will we hear? What language will co-evolve through the experience of doing, performing, sharing, and talking? A discourse of investigation emerges.

Wendy: Shhhhhh. [tiptoes over to Einstein and whispers in his ear] Einstein, I don't think we can stop an echo.
Einstein: That is correct Wendy. You see, there's a scientific explanation for that. ...

Dear Einstein. He studies. The science he knows is words, vicariously experienced through Wendy's science textbooks. But he never leaves her room. Ain't nothin' like the real thing, Bunny. Like Recess. Playground pendulums, inclined slides, spinning wheels, rotating carousels. (Wheels can keep a little girl moving over the bumpiest of times.) These are elaborate equipment for discovering motion. And experience has the momentum of a thousand words.

Scientific terminology was not abandoned in our science class; but we came to the language of science post investigation and inquiry. Only after we used the vernacular, common metaphors—"real life" connectors to describe what we experienced—did we engage the language of scientists. Then, in reading formal explanations, we recognized within the "scientific bafflespeak" our experience and understanding. And in the recognition, we realized the poetry within. ...

A definition: Sound is like a musical earthworm ... because it is a longitudinal wave that moves through a medium. A disturbance that triggers a vibration (repeated action). The landscape of movement. A voicing of presence and absence. Silence the absence of.

Clever Wendy. She seeks not answers but possibilities. Wendy knows. She moves within spheres of phenomena. Her monster is not hiding under the bed, but in the blackboard jungle, between the pages, within the words of lectures. Textbook opened to p. 328.

Our laboratory debutante sits rehearsing definitions like lines in a play. Lines. To memorize. To reproduce. Easier to echo someone else's words, imagination. To reproduce the known rather than realizing the unknown. The suicidal act of imitation, Emerson (1841) argued, can never be genius and disallows the "inmost" to become the "outmost." Teaching science without reliance on a textbook is students improvising lines, writing a script, enacting the space between the lines, storytelling an experience.

What if? We create our own monster called Science.
What matters? Language, Exploration, Inquiry, Imagination.
So what? A mapping of our universe through our words, our experience, our being present in action and interaction.

Curtain Call

The curtain closes to a long applause. The actors and technical crew bow to several curtain calls. As the house lights come up, the university students ask the audience if they have any questions. A hundred small hands fly into the air. *Who is the monster? How was the monster made?* A flurry of questions about the monster ensues, questions that we do not answer, only invite. *What do you think?* But soon with the direction of their teachers, the children stand and don their raincoats. Many file by the stage and ask the actors to autograph their programs. The theater doors again open and the school children leave the way they came, but filled with questions and reflections.

The syllabus for the physical science course outlined scientific themes, a portfolio assignment, and the call for some sort of performance. Every class started with specific events, planned effects, laboratory materials, but became improvisation of differences, the unexpected, the unknown suddenly becoming the known. The students themselves gave the course its luster. Most of them had left science back in secondary school. This re-visitation was a last-ditch effort to apprehend science. The course was a risky invitation for students and their two professors to leave the written script, the textbooks at the door, and to walk over the threshold into the unknown territory of possibility, application. Paths were laid as we explored. So was the curriculum. But not in stone. In transgressions.

It was amazing how well everything came together...when I first heard about the idea (the play) in January, I certainly had some doubts.

— Doug (Student)

What happened when we brought performative inquiry into a science course? We celebrated our voices, our bodies, our imaginations. We voiced ourselves and our experiences. We imagined the world of a six-foot tall bunny, and a girl who through exploration seeks the monster—learning that science is not just formulae but amazing landscapes of light, sound, and motion. As we moved towards the performance date it became impossible to know what shaped our experience and the co-emerging script with its many authors. The science or the play. We were both scientists at play and players in science (knowing, doing, being, creating),[6] finding expression on stage. The play resonated the learning realized in our shared journey located within a landscape that is scientific exploration.

Imagining and re-imagining realized through performative inquiry invites an intense conversation and play between the inquirers and the phenomenon investigated. *What if? What matters? So what?* These three questions explode the language and experience of the science classroom into a pro-active interaction with phenomena resulting in fissures that allow a creative reading of the text that is science. Our quest with our students in seeking an understanding of science was a co-emergent recognition of the possibilities inherent, a reading sought by dramatist Barba (1995), "Not walls of cement, but ... the melodies of your temperature" (p. 162).

Understanding requires the moment of relevance that experience brings forth

The creative ecology—our experience—breathes a tangled web of moments, ideas, happenings, explorations, understandings. A curriculum that can be labeled neither drama nor science—nor yet a hybrid of the two—co-evolves within the interaction of ourselves and our living world(s). The mind-body dichotomies that shape our traditional curricular understandings are interruptions in the fluid unfolding that is life. We, curriculum theorists and educators, compartmentalized and labeled, scientist and dramatist, create a monster where only light, sound, and motion play ... and we reimagine possibilities that are us.

Notes

1. The technicians were three of the students. They were in charge of light, sound, and props during the performance. At times, during the writing of the script, all ten students worked on light, sound, or motion teams to design special effects and choreography.
2. "Physical Science for Elementary Teachers" (ScEd 310) is an elective course within our teacher education program. It focuses on the teaching and learning of physical science. Ten student teachers "became" the course and wrote the play. Fourteen teachers from an elementary school also participated in the course as part of an attempt to bring together beginning and practicing teachers (their classroom students were part of the audience).

   The ten science students: Wendy Mok, Mike Gould, Joan Todd, Christine Gerencser, Doug Palm, Dion Vescarelli, Valerie Lees, Ann Martin, Travis Louie and Rob Michalopoulos.
3. We do not mean to imply that inquiry and performance are separate—that is, that inquiry of the mind and performance of the body are disconnected. Rather, we think of performance as an enactment of inquiry: a creative, interpretive, and critical exploration.
4. Our use of the word "performance" speaks of a dynamic creative action and interaction through which learning is realized. See Fels & Stothers (1996). An etymological reading of "performance" takes us to a shared space with complexity theorists, where new worlds co-evolve "on the edge of chaos" and new understandings are possible.
5. "Performative inquiry" is a learning-research vehicle that embraces and recognizes the unexpected, the interruption, the "Aha!" moment in which absence becomes present through performance (See Fels in this issue.) Performative inquiry within the science classroom is the interaction between performance, inquiry, and experience, the "knowing, doing, being" (Davis, Sumara, and Kieren, 1996), which leads the student(s) to "interstanding" (Taylor and Saarinen, 1994) within co-evolving, co-emerging possible worlds.
6. "Knowing, doing, being" comes from Davis, Sumara, and Kieren, 1996. The addition of "creating" comes from Fels, 1995.

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