

Designing critical pedagogy to counteract the hegemonic culture of the traditional chemistry classroom

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Stimulated by my encounter with the strange term 'hegemony' – a dominant ideology that is largely invisible to its adherents - I (first author) recently 'returned' to my experiences of being in a secondary school chemistry class. Drawing on contemporary educational research paradigms, I designed an arts-based critical auto/ethnographic methodology. The research was governed by quality standards of transferability, trustworthiness, verisimilitude, crystallisation, polyvocality, pedagogical thoughtfulness, critical reflexivity and envisioning. In this research I identified six aspects of cultural hegemony that had negatively impacted my chemistry education experiences: teacher domination, curriculum content, perfectionism, competitive assessment, traditional teaching methods and poor classroom environment. An outcome of this professional self-study research is a vision for transforming chemistry education: (i) using recycled materials to create 'green chemistry' teaching and learning activities, (ii) applying critical pedagogy as a teaching and learning perspective, (iii) embracing technology as a supplement to teaching and learning, and (iv) applying science innovation ideas as part of classroom activities. This vision can be adapted and implemented by innovative teachers wishing to enliven their chemistry classrooms with more meaningful, stimulating and socially responsible learning experiences appropriate for the 21st century.

Commencing the journey

This paper summarises a Masters research dissertation (Yusuf, 2011) that I (first author) conducted under the guidance of Peter Taylor (my co-author). My research journey commenced when I came across two unique and intriguing terms: 'hegemony' and 'critical pedagogy'. After discussions with the third author, the person behind me who contributed a lot of ideas and motivation throughout this inquiry, I took the initiative to investigate both of these notions from a range of diverse sources.

My exploration of the intriguing concept of hegemony led me to acknowledge Antonio Gramsci (1891-1937), a Marxist philosopher who first introduced the term (Bonner, 2011). Gramsci based his notion of hegemony (or 'egemonia') on the idea of *false consciousness* which describes a condition where people are blinded by the ideological domination that they endure. The invisibility of powerful ideas enables the oppressor to maintain or increase power over the oppressed (Posner, 1992). Based on this fundamental concept, Lears (1985) argued that hegemony cannot be separated from the notion of dominance. A review by Grossberg (1996) indicated that hegemony acts as "common sense" or "popular consciousness" which is designated as a product of history practised in

social groups and by individuals. Merli (2010) and Taylor (1996) shared a similar opinion that hegemonic ideology is culturally and historically possessed as beliefs, values or cultural myths that are practised in the social culture. Its dynamic feature enables it to exist as a lived experience (via popular culture, mass media, education and religion), where it might evolve and remain persistent as a social norm (Mastroianni, 2002).

As I furthered my reading, I was able to recognise that hegemonies occur in various fields, such as sports (Trujillo, 1991), anthropology (Crehan, 2002; Shore & Wright, 1997) and culture (Merry, 2003; Uzuner, 2009). I was led to understand that it might exist in education to suppress subordinate groups such as students, where they are forced to obey rules without conscious awareness or consent. I was very lucky as my comprehension of the notion was supported by the metaphor of hegemony embodied in the life of a fish given by the second author during one of his lectures:

There are two young fish swimming along and they happen to meet an older fish swimming the other way, who nods at them and says "Morning, boys. How's the water?" And the two young fish swim on for a bit, and then eventually one of them looks over at the other and says "What's water?"

Figure 1: The metaphor of hegemony in fish



As I searched further through the literature I discovered that critical awareness of the existence of cultural hegemony in classrooms has driven teachers to employ critical pedagogy. My review led me to McLaren's (1998) definition which refers to the notion as, "a way of thinking about, negotiating and transforming the relationship among classroom teaching, the production of knowledge, the institutional structures of the school, and the social and material relations of the wider community, society and the nation state" (p. 1). For me, this notion seemed to be a solution for education to liberate students from an oppressive situation by providing a means for teachers and students to think beyond their 'boxes'.

According to Grundy (1987), embedding critical reflective thinking and critical discourse in the classroom would act as a platform to emancipate students from the dominance of the technical curriculum interest, which underpins the image of the curriculum as a product and the teacher's traditional role as deliverer of curriculum content. Thus, students are given freedom to think critically about their educational situation, which allows them to recognise the connections between their individual problems and experiences and the social context in which they live. My reading brought me to identify researchers who had investigated critical pedagogy in education, such as Paulo Freire,

Peter McLaren, Henry Giroux, Bell Hooks, Ira Shor, Shirley Steinberg, Patti Lather, Deborah Britzman and Donald Macedo (Andrade & Morrell, 2008; Kincheloe, 2004).

The connection between these two notions was now obvious to me. Cultural hegemony in the classroom needs to be acknowledged because its existence seems to occur naturally and it acts subtly as common sense in teachers' and students' lives to restrict them from being able to think critically and innovatively. The implementation of critical pedagogy is crucial in order to deconstruct hegemonic dimensions of culture. I represented my struggle to understand these powerful notions in the following poem.

My Curiosity

*As I sat in front of the computer
It made me wonder.
Exploring emergent meanings of terminologies
Slowly put me in a fury.
Hegemony and critical pedagogy
Truly make me foggy.
Antonio Gramsci originated hegemony
Paulo Freire developed critical pedagogy.
Two things that seem so different
Yet, they engage me in deep inquiry.
Developing this understanding is so interesting
As both are actually opposing.
Sooner or later I need to know them
Making a change is what I dream.*

Circumnavigated by these notions, I challenged myself to conceptualise the actual existence of hegemonic culture and critical pedagogy by exploring and unveiling my past experiences as a student and teacher in chemistry classrooms in Malaysia, my home country. I outlined three research questions to guide my inquiry:

1. How did hegemonic culture manifest in my chemistry classroom?
2. To what extent have I encountered critical pedagogy in my experience?
3. How will I use critical pedagogy to deconstruct hegemonies in my future chemistry teaching practice?

The journey setting

Three contemporary social science research paradigms laid the foundations of my study, namely, *interpretivism*, *criticalism* and *postmodernism* (Taylor, Taylor & Luitel, 2012; Taylor, 2014). Interpretivism focuses on human action and seeks to understand people's subjective worlds. Criticalism articulates a critical voice in an endeavour to make a difference in human behaviour in accordance with a critical social conscience. And, postmodernism challenges society by unsettling the established balance (Rikowski & McLaren, 2002) through its basic principle, 'be suspicious of all grand narratives'. This paradigm advocates plurality of genres and logics, and opens the door to arts-based

research methods such as poetry, story-telling, metaphor and imagery (Knowles & Cole, 2008).

Drawing on these three contemporary research paradigms, I designed an *arts-based critical autoethnographic* inquiry to explore my own feelings, thoughts and emotions as I excavated my lived educational experiences (Ellis & Bochner, 2003). This design also enabled me to understand critically the world through the eyes of other people who had shared lived experiences with me. This research design involves the integration of an autobiographic impulse and an ethnographic moment which were portrayed as a “self-narrative that critiques the situatedness of self with others in social contexts” (Spry, 2001, p.710).

Autoethnographic research designs are not new to science education. Under the supervision of the second author, arts-based critical autoethnographies have been conducted by Emilia Afonso (Afonso, 2007; Afonso & Taylor, 2009) and Alberto Cupane (Cupane, 2008; Cupane & Taylor, 2010) to excavate their cultural identities in postcolonial Mozambique and develop culturally inclusive philosophies of science teacher education (Taylor, 2008). Jason Song reflected critically and soulfully on the systemic source of his frustrations as a science teacher in China to remove the 'dark clouds' from his students' lifeworlds (Song & Taylor, 2005). Recently, Yuli Rahmawati investigated her multicultural identity as an Indonesian Moslem woman with Javanese and Bimanese parents, and transformed her philosophy of professional practice as a chemistry teacher educator in an Indonesian university (Rahmawati, 2013; Rahmawati & Taylor, 2015; Rahmawati & Taylor, in press/2017).

Research methods

Data were produced, processed and portrayed by employing two methods: writing as narrative inquiry and semi-structured interviews.

Writing as narrative inquiry

Narrative writing is a way to engage one's readers to experience vicariously situations that the writer has lived in. Writing self-narratives interweaves the researcher's self with strangers, friends or acquaintances. This method was extremely valuable for more deeply and critically understanding myself and others related to me. Chang (2008) claimed that narrative can be written in various genres, such as poetry, dialogue, memoirs, journals, personal essays and letters. Chang added that these methods are suitable for autoethnographic designs as they are written chronologically and comprehensively to represent lives of the persons involved. I used a self-narrative method to unveil my past experiences as a learner during my secondary schooling and as an in-service teacher, which served as the main data sources for this study. I also explored my in-service teaching experience to give a better view of the hegemony and critical pedagogy that I was investigating. I constructed the self-narratives using confessional and impressionistic genres (van Maanen, 1988).

Semi-structured interviews

Anderson and Arsenault (1998) defined interviewing as a process of obtaining details of personal information from an interaction between two individuals. Creswell (2008) added that interviews are suitable for participants who are not hesitant to speak. In this study, I selected three participants based on their availability and willingness to be interviewed (Cohen et al., 2008): a chemistry teacher who was a former colleague, and two of my former chemistry students. Guided by ethical procedures as proposed by Creswell (2008), I conducted semi-structured interviews with my participants to obtain accounts of their experiences related to the issues being investigated. An audio recorder and note pad were used to assist me to record the conversations.

Quality standards

The validity of qualitative research is determined based largely on the intensive entanglement and in-depth responses of participants (Agar as cited in Cohen et al., 2008). Therefore, the feasibility and plausibility of the evidence and the arguments of a study are judged by the readers themselves (Polkinghorne, 2007). In this study, I applied eight quality standards which I express as questions:

- *transferability* do the rich details of the study enable readers to apply the findings to their own varied contexts?
- *trustworthiness* does the quality of this study come from explicit sources and are the data represented with fidelity?
- *verisimilitude* would the experiences portrayed in the study seem real to my readers?
- *crystallisation* are perspectives represented that are different, contradictory or at variance?
- *polyvocality* were various genres used to represent my voice and the voices of my participants?
- *pedagogical thoughtfulness* does the study serve to engage other teachers in reflecting on their pedagogical perspectives?
- *critical reflexivity* did I demonstrate an ability to reflect critically on my experiences in order to make a difference to my own life? and
- *envisioning* does the study demonstrate a vision of an ideal chemistry classroom relatively free from the hegemony of the technical interest?

Scenes of the past

The hegemonic culture of my chemistry classroom

In the narrative of my experience as a secondary school student I identified six aspects of cultural hegemony: teacher domination, curriculum content, perfectionism, competitive assessment, traditional teaching methods, and poor classroom environment. I also identified a hegemonic aspect that had shaped the culture of my in-service experience as a chemistry teacher. These aspects were identified through in-depth self-reflection and

memory recall and/or were triggered by interview conversations. The following narrative extracts taken from my Masters dissertation (Yusuf, 2011) exemplify each aspect of hegemony that shaped the prevailing culture of my chemistry classrooms.

Teacher domination

At first, I was full of anticipation. Judging by the teacher's personality, I felt that she would teach us in an interesting way. After we had introduced ourselves the teacher briefly explains about the topics in chemistry that we are going to learn throughout the year. Later on, she starts the first lesson on that day by writing notes on the blackboard and asks us to copy down what she has written. After we have finished copying the notes, she explains about the topic. The teacher does not ask for our feedback on whether or not we understand the lesson she has just 'taught'. (Yusuf, 2011, p. 49)

The first aspect of cultural hegemony was teacher domination. This represents the situation where my secondary chemistry teacher maximised her authority to control the lesson. As I reflected on this experience, I realised that my friends and I were disenfranchised without our conscious awareness by the teacher's power. As a consequence, our voices never had any weight in classroom decision-making.

Curriculum content

Reaching the end of the year, we had rarely experienced doing practical work. Only twice did I have opportunities to do experiments but that was only to fulfil the curriculum's practical assessment. We simply followed the experimental methods using the laboratory manual. As a result, we could not see any relationship between the theories and the practical work. Thus, I got such frustrating results for my final year chemistry assessment. Besides, when we did experiments, my teacher did not emphasize the precautions that should be taken in dealing with the chemicals. There was no waste bottle provided inside the laboratory. Instead, we just threw the waste liquid into the sink while the solid waste was thrown into the dustbin. (Yusuf, 2011, p. 51)

The second aspect of hegemony was science curriculum content, as described by Osborne, Duschl and Fairbrother (2002). This situation occurred as my chemistry teachers seemed too eager to deliver the content of the chemistry textbook, while neglecting the importance of carrying out practical work. Our teachers overlooked the importance of nurturing practical scientific values among the students.

Perfectionism

Today, 33 of us were asked to do exercises in groups for one class period of 40 minutes. During the second period, we started to discuss the answers. During the discussion each group needed to present their answers in front of the class. However, during the discussion my chemistry teacher started to scold us when we made any mistakes. For example, we wrongly drew the atomic structure of Lithium (the atomic number is 3) with an electron in the outermost space. Whoever mistakenly drew the number of electrons was required to stand up in front of the class and draw five more atomic structures. At the time I thought that the punishment would enhance our memory in drawing atomic

structures. But the teacher's approach of admonishment was not accepted by some of my friends. On the other hand, she never praised us if we gave a correct answer or produced excellent work. We accepted our teachers' behaviour so as not to be rude. (Yusuf, 2011, p. 51)

The third aspect was the hegemony of perfectionism, as I called it. This describes the situation of my teacher demanding perfect learning outcomes from her students; she scolded students who failed to answer her questions correctly. She rarely praised students even when they had done good work. This caused us to feel afraid and pressured every time the chemistry class was held. My narrative highlights the teacher's attitude of being very admonishing even for a simple mistake. Because of the teacher's behaviour, my friends and I felt discouraged to learn chemistry. From my point of view, making mistakes is part of the process of learning. As we make mistakes we tend to revise the problem and try to solve it. Thus, we would learn more! This is supported by Rye (2009) who claimed that mistakes provide a learning experience by pointing out what we need to look at more carefully.

Competitive assessment

After finishing Form 4, I still have another year to complete my secondary school study. However, I have to face the same chemistry teacher again this year. So to improve my academic situation I change my study routine. I start to ask more from my friends who get better scores in chemistry. However, some of them are unable to explain their understanding, and others are reluctant to share their understanding. I have to put in my own effort because I need to sit an important national assessment this year. I do not meet my chemistry teacher personally any more because I am frustrated with her attitude. Instead I search for additional classes during the school break, including joining a tuition centre. I try my best during the monthly tests but I only get an average result compared to my friends. My performance in chemistry doesn't improve much right up until it is time to sit the most important assessment for the school leaving certificate. The result of the assessment disappoints me. As a consequence, I bury chemistry as a no-no for my future endeavours. (Yusuf, 2011, p. 54)

It was common in my chemistry classroom for students to compete with each other during the test or examination. The tension of competitiveness was so obvious that it caused students to become individualistic in order to escape from being scolded. This is congruent with what has been claimed by Hudson (2005) as the hegemony of assessment.

Traditional teaching method

Day by day ... my chemistry classes create a similar situation. I am struggling to understand what has been taught after each class has finished. I just cannot get the point. I ask my friends about their understanding of the subject, but they also experience the same condition as me, having blurred and ambiguous moments. Whoever understands the lessons seems to do so because they have a good memory, but without depth of understanding. Some can cope with the lessons very well without deep understanding of the concepts. This is because they are good at memorizing. I realize this as I ask one of my classmates:

- Liza: Muaz, do you know how many electrons an inner orbital should occupy in an element and why does it happen?
- Muaz: Yes, I do. This is because the teacher said, "Only two electrons should occupy the inner orbital". But, I don't know what the reason is, though!

Sometimes, when I meet my teacher personally she seems really unwelcoming as she is busy doing administration tasks. The way she behaves puts me off going back to meet her again. The whole year just passes without me realizing it. I could describe my situation as like watching television where the teacher is the only person who is active and she acts like the transmitter of knowledge, whereas we, her students, are her captive audience and passive receivers. (Yusuf, 2011, p. 49)

Traditional teacher-centred teaching method was the fifth hegemonic aspect that I identified in my chemistry classroom. Applying memorisation technique and rote learning caused us to be passive learners. Moreover, lack of facilitation of our conceptual development meant that we did not learn how to apply the knowledge to solve problems.

Poor environment

As the lesson is held in an uncomfortable, dark and boring laboratory, I feel it is difficult to absorb what the teacher delivers. She does not seem to care much about how her students' learning skills should be developed. I had expected that my chemistry lessons would be interesting, as they were in the previous years of learning science, or exciting such as in my English and History classes. However, my perception is distorted.

One day, I fall asleep during the lesson with my pen drawing a long line on my notebook.

BANGGGG.....!!! (suddenly, the very loud sound of a long wooden ruler hitting the laboratory table)

"How long do you want to sketch the line sis...!!!?", says my teacher with a sarcastic voice.

Oh my gosh! I have fallen asleep. How shamed I am that such a thing has happened.

Deep in my heart I hope and try to enjoy myself and get rid of the dull and boring feelings of the lessons. But, as I try to fight the dull situation the more I feel disgusted. (Yusuf, 2011, p. 51)

The sixth hegemonic aspect was a poor classroom environment (Fleischer, 2009). As the chemistry lessons were frequently held in dull and boring classrooms, this atmosphere diverted our attention from the lesson and subsequently led us to reduce our interest in being in the classroom.

Aspects of critical pedagogy I have encountered

Using the same strategy to obtain information about aspects of hegemonic culture from my past experience, I identified four aspects of critical pedagogy, namely, transformative teachers, students encouraged to have a critical voice, using new forms of knowledge, and emphasising ethics as central to education.

Transformative teachers

The first aspect of critical pedagogy that I identified was transformative teachers. This phenomenon was obvious in my English and History classes where the teachers enacted fascinating teaching and learning approaches in order to help us understand deeply what we were learning. In the English class, we learned English through songs and games, whilst during History class we learned simple techniques for memorising facts and events using key words and themes. One of the engaging activities was group work in which one person would come up with a theme and the other students would guess the answer and make mind maps. During this recollection, I was thinking how exciting it would have been if this pedagogy had been employed by my secondary school chemistry teacher. This aspect was also highlighted during reflections on my pre-university study at a matriculation college where I recall the lecturer using concept mapping and brainstorming activities. I remembered how, at that college, chemistry laboratory work was frequently conducted with a focus on supporting our theoretical understanding. That learning experience transformed my perception of chemistry from a dull and boring subject to one of the most interesting subjects.

Critical voice

The second aspect of critical pedagogy that occurred in my life was related to students being encouraged to have a critical voice. During English and History classes at secondary school, we frequently had dialogue sessions in which everybody had the opportunity to get involved, to speak up and give our opinions. As I continued my study in the matriculation college, my lecturers always encouraged us to voice our opinions and reflect on certain issues. It was from these learning experiences that my self-esteem started to build up.

New forms of knowledge

During my pre-service training, I had the determination to teach in a way that was very different from the way my chemistry secondary school teacher used to teach us. I wanted to develop an engaging classroom culture using teaching techniques that would intrigue my chemistry students. I created new forms of knowledge representation such as a mnemonic technique and poems to deliver chemistry content.

Teaching ethically

In the matriculation college my lecturers displayed their humanistic personalities by treating us well and encouraging us to be successful in our studies. We were taught to love nature through embracing *green chemistry*. These two examples are congruent with Giroux's (as cited by Huckin, 2002) advocacy of ethics as central to education.

A transformative vision



Figure 2: By implementing my vision in my teaching practice I hope to elevate students' interest, self-confidence and achievement in chemistry education.

During this research I became critically aware of how my immersion in the hegemonic culture of my secondary schooling had disempowered and demoralised me. This realisation triggered my commitment to counteract its powerful grip on my own teaching practice, and stimulated me to explore classroom teaching and learning activities aligned with principles of critical pedagogy. My aim is to transform the conventional chemistry curriculum towards a more dynamic and exciting classroom culture. To achieve this I propose a four-fold vision of transformative chemistry teaching and learning.

Green chemistry

The first part of my vision involves creating green chemistry teaching and learning activities. Twelve principles of green chemistry have been established by John Warner and Paul Anastas: prevention, atom economy, less hazardous chemical syntheses, designing safer chemicals, safer chemicals and auxiliaries, design for energy efficiency, use of renewable feed-stocks, reduce derivatives, catalysis, design for degradation, real-time analysis for pollution prevention, and inherently safer chemistry for accident prevention (Jimenez-Gonzalez & Constable, 2011). These principles serve as a conceptual framework for establishing green chemistry teaching and learning activities, involving use of recycled and organic materials. Consistent with these principles are several classroom activities: the fountain of phases, moving water and organic glue.

The *fountain of phases* was first proposed by Puan Naziyah Khalid (a lecturer during my Bachelor degree studies) to represent the changing states of matter from solid to liquid and from liquid to gas. The model enhances students' understanding of the connection between the arrangement of molecules, forces of attraction, volume and shape, and kinetic energy of movement (Toon, Leng, & Tin, 2009). Instead of using standard chemicals and laboratory apparatus, kitchen utensils and ice cubes are used. In this activity, ice cubes (solid state) are placed at the highest position. After a period of time, the ice cubes melt (liquid state) and flow down to be collected in an aluminium container. The pool of water in the container is heated to produce vapour (gas state). This step-by-step change of phase activity helps students to better understand the relationship between the observable properties and the abstract particle model concepts.

Moving water is a classroom activity for understanding the movement of particles between cold and hot water. Cold and hot water, which are dyed with blue and red colouring respectively, are placed in separate styrofoam cups with a pin-size hole at the bottom of each cup. Students are directed to observe the different dripping rates of each solution. Later, they discuss the connection between the rate of dripping water and the size and movement of the molecular particles. This activity requires students to interact with each other in order to find the best rationale (Caravita & Hallden, 1994; Chapman & Singelton, 2002).

In the topic, “chemistry in industry”, students are challenged to make *organic glue*. They learn how to make glue using common organic substances such as tapioca starch instead of inorganic substances. To begin the project, students are organised in groups and are directed to investigate the standard process of making glue. They are encouraged to research the history of the topic, organise a visit to an industrial chemistry plant, and build an exhibit to present their findings. Knowing about the use of renewable resources in making glue, such as using tapioca starch, encourages students to appreciate the natural world and their own lived environment.

Critical pedagogy

The second part of my vision involves activating students’ critical subjectivities by giving them choice and voice to share authority with the teacher. Two learning activities - concept mapping and concept cartoons - are proposed to carry out this vision.

Constructing *concept maps* enables students to access their prior knowledge, and alerts teachers about possible misconceptions as result of incorrect links or concepts represented in the maps (Akinsanya & Williams, 2004; Goodrum, 2004). Concept maps can be applied before or after specific lessons. For this activity, students are required to recognise the disparate ideas they yield as recommended in the interactive model developed by Faire and Cosgrove (1988). Concept maps act as the ‘external mirror’ of students’ thinking (McAleese, 1998, p. 260). Learning to construct concept maps engages students in thinking critically, which leads to more meaningful learning. Designing their own concepts maps enhances creative thinking, in-depth understanding about a particular topic, and initiates high-level thinking (Akinsanya & Williams, 2004; Hassard & Dias, 2009).

Concept cartoons feature a cartoon-style drawing with several characters arguing about a scientific phenomenon. Typically three to four characters discuss alternative statements. However, only one character’s response is aligned with the correct scientific concept. To illustrate, a character starts by giving an alternative conception and the others add to the argument with alternative ideas (Keogh & Naylor, 1999). All the statements are presented verbatim in quotation marks or speech bubbles (Rowe, 2003). Joyce (2006) argued that this activity motivates students to engage in discussion, including those who normally refuse to do so. The discussion involves choosing and justifying which character has proposed the best answer (Doubler, Asbell-Clarke, Carraher & Tobin, 2011). Students are motivated to offer their own ideas with the understanding that everybody can give an opinion without fear of being labelled wrong. This enables the teacher to readily access

students' ideas and to detect misconceptions, while students can check and rethink their own ideas based on the ideas of their peers. The concept cartoons approach helps make students critically aware of their own ideas, and encourages them to think carefully about their own opinions and give considered reasons for their answers.

Technology as a supplement

The third part of my vision is to embrace technology to enrich student learning. In the topic, "The Periodic Table of Elements" in the Form 4 (Grade 10) Chemistry Syllabus, a readily available graphic podcast can be used to teach students about the history of the periodic table of elements. Instead of using the tedious traditional chalk-and-talk situation, they watch a podcast in which scientists present an historical narrative of the development of the periodic table. In this way, students are encouraged to learn about other chemical characteristics of the periodic table, such as chemical and physical properties of elements in the same group, how to predict the position of an element, and how to identify and compare elements from different groups. By knowing the history of the periodic table students can appreciate and celebrate the contributions of the scientists who have contributed to the ongoing development of the current highly sophisticated model.

Science innovation ideas

Practising science innovation ideas as part of classroom activities is the fourth part of my vision. These ideas are embodied in two activities: black box and sight and light.

In the *black box* activity, eight cardboard boxes with different internal structures are sealed with tape. Opening the boxes is not allowed. The students are divided into pairs and one box is given to each pair to imagine its internal structure. Each pair twists, turns, and shakes their box to determine the internal structure and materials. The students draw on their imagination and record the possible internal structure of each box. After the observations, each team presents to the whole class their theory of the internal structure of their box and lists the characteristics on the whiteboard. After the discussion, the teams open the boxes to discover their actual internal structure. The black box activity encourages students to think creatively and imaginatively (Chien & Godshall, 2005). Even though the activity does not demonstrate real-life science research, it does provide a good opportunity for students to experience the scientific method of investigation.

The *sight and light* activity is based on the historic theory of vision of Ibn al-Haytham, a famous 11th Century Muslim researcher, that light emanates from sources such as the sun, candles and mirrors and is reflected to the eye to produce sight. As a class activity students test whether light is transmitted equally in all directions. The experiment is performed using a candle, a tube, nails, a plastic plate, and a large sheet of paper. In small groups, students design their investigation. The activity is conducted in a darkened classroom. In a typical student-designed activity, the candle is placed inside the tube in which a series of nail holes has been made. A circular sheet of paper is placed around the outside of the tube to serve as a screen. After lighting the candle students observe whether light is distributed equally in all directions through the nail holes. In another student-designed activity several nails are erected to encircle the candle and the distribution of light is

observed by looking at the shadows of the nails. This is an open-ended investigation that promotes creative experimental design.

The destination is still further

I admit that moving away from the powerful hegemonic aspects of the traditional teacher-centred classroom culture that I have identified and moving towards the application of critical pedagogy is not necessarily an easy task. Nevertheless, it will never be my excuse to give up attempting to make the transformation, even if the result is akin to a tiny grain of sand, because most importantly the effect should be long lasting. I would like to relate my eagerness to making this change to the story of a little girl's experience with saving starfish (which I adapted from various versions that have been derived from the original essay by Loren Eiseley, see *The starfish story*, n.d.)



Figure 3: The starfish story that represents my passion to make a difference!

One day, a man is jogging on a beach when he sees a little girl coming the other way who appears to be dancing. As he draws nearer he can see the girl is not dancing but is gently picking up starfish from the beach and throwing them back into the sea.

"Why are you throwing starfish into the sea?" he asks.

"Because they have been washed ashore, the day is getting hot and if I do not throw them back they will die", replies the girl.

The man looks around him and sees that the beach goes on for miles and that there are many thousands of starfish along its length.

"But there are too many", he protests to the girl, "You can't possibly make a difference".

The girl smiles, picks up another starfish and gently tosses it beyond the waves, back into the sea.

"I made a difference to that one!" she says.

It is my hope that the aspects of cultural hegemony and the promise of critical pedagogy that I have identified in this research will assist other teachers to become critically aware of the existence of false consciousness that has been oppressing chemistry teaching and learning for a very long time, especially in my country. As an alternative to the disempowering hegemonic culture of the traditional, teacher-centred chemistry classroom learning environment, I have proposed a four-fold transformative vision that embeds in classroom teaching and learning higher-order thinking skills of reflective, critical and creative thinking. My goal is to enable students to become self-motivated learners who are more fully aware of and engaged in the knowledge they are co-learning. I am committed to implementing this vision in my chemistry classroom to help break the grip of the traditional hegemonic teaching-learning culture. Davis (1998) and Settelmaier (2003) have

acknowledged that such a transformative approach could enhance students' awareness of their future discourse as citizens as well as improve their knowledge integration.

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