VOLUME 4 ISSUE 1

The International Journal of

Science in Society

COMMON GROUND

SCIENCE-SOCIETY.COM

The International Journal of Science in Society

VOLUME 4 ISSUE 1 2012

COMMON GROUND

THE INTERNATIONAL JOURNAL OF SCIENCE IN SOCIETY
www.science-society.com

First published in 2013 in Champaign, Illinois, USA
by Common Ground Publishing LLC
www.commongroundpublishing.com

ISSN: 1836-6236

The International Journal of Science in Society is peer-reviewed, supported by rigorous processes of criterion-referenced article ranking and qualitative commentary, ensuring that only intellectual work of the greatest substance and highest significance is published.

Scope and Concerns

MODERN SCIENCE, CONVENTIONALLY UNDERSTOOD

Conventional, modern science has had a number of characteristic features, which remain resilient today, but which are now also increasingly coming under challenge. Conventional science is about the physical-natural world, relatively autonomous of the social world. It is disinterested, striving to be independent of human agendas, values and interests. Its methods are consistent, stable and replicable, allowing the objective phenomena of the natural-physical world, external to human understanding, more or less to speak for themselves. It circulates its knowledge making practices amongst initiates to a self-enclosed discipline—an exclusive institutional, methodological and discursive space accessible only to participants who have been duly apprenticed as learners and passed tests of disciplinary entry. The connections between science and the everyday lifeworld are primarily through a unilinear, transmission model, from basic to applied science and from science to technology. Evaluations of social impacts are incidental rather than an integral to systemic feedback at the core of the scientific endeavor itself.

CHANGING SCIENCE: TOWARDS GREATER SOCIAL ENGAGEMENT

The Science in Society Conference, Journal, Book Imprint and News Weblog recognize the strengths, power and historic achievements of modern science in its conventional public and professional forms and self-understandings. However, they also explore the emergence in recent times of a more socially engaged science. This is a socially reflexive science, a science which reciprocates its understandings of the natural-physical world with the social world. It is a more open and dynamic science.

Here are some key propositions about the relations of science and society in a new, reciprocal science:

Society is deeply intertwined with science. Clear-cut and definitive separations cannot be made between the social-human and the natural-physical. This is both an epistemological proposition (our knowing the natural-physical world) and an ontological one (our being of and in the natural-physical world). Our methods may deceive when they purport to represent external phenomena in an unproblematized way.

Science is intrinsically interested. At its most cogent and most productive, science is engaged, responsible and accountable to the social world. It is integrally linked to agendas, interests, values and ethical stances. These need to be declared and exposed to examination, just as much as science's propositions about the character of the natural-physical world itself. A constant and searching investigation of human interests goes to the heart of the question of the social credibility and ongoing viability of science.

Science's methods are as humanist as they are objectivist. The methods of science must test the human-social context of knowing as much as they do knowable realities in the natural-physical world. Reciprocal science provides a full account of the conditions of knowing, not only in the microdynamics of observation, induction and calculation in relation to the natural-physical but also the broader social contexts of agenda-setting, risk assessment and application.

Interested, reciprocal science is increasingly interdisciplinary. The most pressing questions of our times—sustainability, climate, health, well-being, to name just a few of the great contemporary human interests—require holistic answers. Scientists need to cross disciplinary boundaries to answer them, not only the various disciplines amongst the sciences, but also the social sciences, humanities and professions. Scientists routinely cross disciplinary boundaries, and they need to do so if they are to have a science which changes the world, albeit in small and incremental ways much of the time, and maybe also in potentially big ways.

A dynamic, socially engaged science must be an open science. It should not favor particular geographic, national or cultural centers. It should not be skewed by demographic closures which restrict access for some kinds of potential participant. It will cross many sites of knowledge making, some conventional and some new: companies, communities, schools, non-government organizations, the public sector, informally self-constituted groups. It must be decentralized in its locations and distributed in its modes of operation. It should be pluralistic, tolerant of paradigm clashes and open to new disciplinary and interdisciplinary practices. It should be collaborative in its spirit, bringing together cross-disciplinary teams marked by the complementarity of their differences. It should be as equitable and fair as it is rigorous in its modes of evaluation of intellectual quality and practical applicability.

Reciprocal science is subject-driven as well as object-oriented. Rather than establishing a primary investigator-instigated relation as has been conventionally the case in modern science, the new science should equally start with social questions. Such questions beg scientific investigation of natural-physical phenomena and their human context. This requires a change in the balance of agency between the lay public and the scientific expert, blurring the boundaries of where scientific questions are raised, how they are addressed and where they are answered.

Reciprocal science is more powerfully recursive. The knowledge system of reciprocal science is enabled in part by new technologies and social processes of scientific communication. Peer review is opened out, its criteria more explicitly stated rather than embedded in implicit professional and network-bound processes. The review process becomes more reflexive and responsive in its rating and moderation systems. Scientific writers and readers come from a wider variety of places, and evaluation of scientific worth is without prejudice to the geographical or institutional source of scientific knowledge-making. Science and scientists are exposed to a wider public, and for that become more accountable.

None of this is to say that that the newer, socially engaged science is unequivocally good. The more conventional modern science still has a role to play in many places, and is not without its peculiar merits. Although the Conference and its associated publication venues are future-oriented and agenda-setting, they do not assume a partisan position, supporting new kinds of science unequivocally against the heritage practices of science. Rather, these discussion spaces offer an open forum for debate. In moments of resolution of this debate, participants might be able to decide what of conventional disciplinary science that we want to preserve and what we might want to renovate.

Whichever model of science we chose to practice, one thing likely can be agreed. Science faces great challenges in these times. These are not only to be understood in terms of the depths and breadths of the questions it is expected to address. But science also faces a dialectic in which there seems simultaneously to be greater public trust in science today, yet also greater skepticism about its costs and benefits.

Table of Contents

The International Journal of Science in Society
Volume 4, 2012-2013, www.science-society.com, ISSN 1836-6236

COMMON GROUND

STEM Research: What the Pictures Tell Us

John Nicholson, Mississippi State University, USA
Shane T. Warren, Mississippi State University, USA
Bonnie Oppenheimer, Mississippi University for Women, USA
Mark Goodman, Mississippi State University, USA
James Codling, Mississippi State University, USA
Thomas Robinson, Mississippi State University, USA
Jee Young Chung, Southern Utah University, USA

Abstract: In our image study, we showed participants images of women associated with a job title. In one survey, each image had a STEM job title; and in a second survey, each image had a non-STEM job title. Our results indicate that college students in America maintain cultural stereotypes related to STEM careers, which we think helps explain why Caucasian and Asian males continue to dominate STEM fields, even as women are making significant career gains in other areas. We sought to obtain further insight into these stereotypical views by conducting a Draw-the-Scientist study among college students on STEM career paths and students in communication. Preservice and in-service teachers also participated. Our presentation will feature the images drawn by the participants and a sampling of the images used in our image study.

Keywords: STEM, Draw-the-Scientist, Stereotypes

Analyses of the people working in the fields of science, technology, engineering, and mathematics (STEM) show a skewed population in the United States. In the 20th century, undifferentiated Asians and Caucasian males dominated the fields, holding 60% to 80% of the jobs, depending on the specific STEM area (NSF, 2009, 9, 12, 55). Organizations such as NASA, the American Association of University Women (AAUW), and National Science Foundation (NSF) have been funding research and intervention strategies to generate greater diversity, i.e., women, Latinos, and African Americans, among populations in STEM fields. The goal was not only equity. Careers in STEM fields generally pay higher salaries than positions in the arts, humanities, or teaching. Thus, increased diversity in the STEM fields would create additional economic opportunities for traditionally lower income minority group members. Another reason for funding STEM projects was to increase the number of applicants for STEM positions. Finally, these funding organizations recognized that the STEM fields would be enriched by diversity of perspectives and research interests (HERI, 2010; Hill, Corbett, & St. Rose, 2010; Mertens & Hopson, 2006; Nagel, 2008; NSF, 2007, 2009; Selby, 1999; Seymour, 1999). A statement by the AAUW summed up the issues. "Our report will sound the alarm," said AAUW Executive Director Linda D. Hallman (Goodnight, 2008). "As a nation, we cannot afford to take baby steps toward achieving parity, especially when we're facing a shortage of professionals in the STEM fields. How can we stay competitive in the global economy when half of our population isn't fully engaged in those areas?"

The initial STEM intervention strategies led to some increase in the number of women going into STEM fields. Those interventions included funding STEM initiatives by federal and national organizations (Hill, Corbett, & St. Rose, 2010; NSF, 2007, 2009; the New York Academy of Sciences, 1999; Gullickson, A.R., & Hanssen, C.E., 2006). Intervention strategies have included professional career mentoring (Greene, J.C., DeStefano, L., Burgon, H., & Hall, J., 2006), programs in high schools (Huffman, D., Lawrenz, F. Thomas, K., & Clarkson, L., 2006; Johnson, C.C., 2012; Zhang, X., Frechtling, J., and McInerney, J., 2011), and changes in college programs (Goldberg, P., 1999). Spelman College found that encouraging Black women to take STEM

The International Journal of Science in Society
Volume 4, 2013, www.science-society.com, ISSN 1836-6236

courses lead to high levels of success (Perna, Lundy-Wagner, Drezner, Gasman, Yoon, Bose & Gray 2009). These interventions coincided with an increase in the number of women pursuing higher education. By 2010, the percentage of women attending college exceeded the percentage of men (Charts Quarterly, 2010). The number of women receiving all degrees surpassed the total number of men earning degrees (NSF, 2011). In addition, the percentage of women entering STEM careers actually equaled the percentage of men in some STEM fields (U.S. Department of Commerce, 2009). However, upon closer analysis, these increases were less impressive. Most of the percentage increase in women was a result of women becoming physicians, predominately primary care physicians, pediatricians, and doctors serving women populations (Insurance Day, 2010; Smith, 2009), and becoming veterinarians (Zhao, 2002). The percentage of women in mathematics and computer science declined (Hill, Corbett, & St. Rose, 2010, p. 9) since 1986. The percentage of women receiving bachelor's degrees in computer science climbed from 14.6% in 1966 to 35.8% in 1986, only to decline to 20.5% in 2006 (Hill, Corbett, & St. Rose, 2010, 9).

Philosophers of communication have written and argued extensively over the precise genesis and interaction among meanings, words, values, stereotypes, and culture. What is not in debate, however, is that there is a logical interplay that connects meanings, words, values, stereotypes, and culture. Saussure contends that one becomes a member of a culture through the learning of the language. It is language that connects meanings and words (Culler, 1986). Language, in the form of signs and symbols, also contains default assumptions about the meanings of the words and it implicitly contains, reveals, and reinforces the values of the culture. Stereotypes are a cognitive and linguistic resource used by members of a culture to make sense of the world. Each culture has stereotypes which connect and reveal the linkages between words, values, signs, and meanings. Thus, by exploring stereotypes, we may begin to uncover the complex interplay among those elements, and within the culture and its members.

We began our research believing that culture explained the lack of diversity in STEM fields. Here we were following the path laid out by many scholars and government reports. The cultural arguments have been that females and underrepresented minorities are taught early in life about STEM stereotypes. Professional women testifying before Congress in 1998 (A Review of HR 3007) pointed to cultural factors. Catherine Didion, executive director for the Association for Women in Science, told the committee, "Barbie dolls have been manufactured to say math class is tough. A girl who is having trouble with math is often told that her difficulties are normal, rather than being challenged to improve." Belkis Leong-Hong, president of Women in Technology, told the hearing that one-third of females report they were advised by high school counselors to not chose mathematics classes. Jones & Bangert (2006) assert that "Although issues related to gender equity have been emphasized for some time, girls only recently have been exposed to television shows such as CSI where women are portrayed in science roles that are viewed as attractive career choices." The end result of these cultural influences, argues the AAUW (2003) is that women are concentrated in what it labels "pink collar jobs."

An ACT report (2008) concludes that middle school is the crucial period in a child's preparation for college. "The level of academic achievement that students attain by eighth grade has a larger impact on their college and career readiness by the time they graduate from high school than anything that happens academically in high school," asserts the ACT report. However, females have not always been encouraged to begin STEM classes in eighth grade. According to Ambrose et al. (1997), females are being discouraged by school counselors to take science and math classes, excluding them as preteens from careers in STEM fields. "In addition to neglect and sometimes overt discouragement from instructors and counselors, young women encounter fewer female role models and have fewer opportunities for same-sex mentoring," writes Ambrose et al. "This is compounded by the fact that women in the scientific community tend to occupy the lower ranks and so may be less able to offer advice or entrees into power-sharing networks" (27). Erkut & Marx (2005) showed that these cultural factors have an impact on how eighth grade females think about the STEM fields. They found that without intervention females in the four schools used in their study consistently reported less interest in STEM subjects than boys. The research of Mertens & Hopson (2006) found that minority children and girls do not even reach higher level math classes. Of those females who might consider higher level science and mathematics, Huffman et al. (2006) and Kanai & Norman (1997) found that classroom structures and methods of teaching discourage females from taking high school mathematics and science classes.

A study conducted by the National Action Council for Minorities in Engineering Fund (Nagel, 2008) points out that the attitudes shaped in middle school and high school are perpetuated in college. Schiebinger (2008) argues that colleges have to change by making science classrooms more about learning and less about competition. Goldberg (1999) reports women find college classrooms hostile, explaining why 70% of the women majoring in science switch to non-science majors in college, compared to 61% for men. However, those changes in majors will affect career income (McCarty, 2009; Payscale, 2009). By mid-career, the difference in annual income can be as much as $100,000 annually, according to the Payscale (2009) report. Even once woman have jobs in STEM fields, many of them do not stay (LaValue-Mandy & Stewart, 2008). Part of the reason, argues Selby (1999), is that the work environment is hostile and women lack access to power. Seymour (2008) contends that social influences and work atmosphere make many women unhappy in STEM careers. Accordingly, they switch to careers that make them happy, Seymour argues.

These studies and reports led to changes in federal policy, said Gullickson & Hanssen (2006). The National Science Foundation, for example, made STEM intervention a funding priority (NSF, 2007; NSF 2009). AAUW created funding opportunities for college groups who were implementing invention strategies at their schools (Hill, Corbett, & St. Rose, 2010).

The "STEM stereotype" is that high school mathematics and science classes (ages 14-18) are the primary domains of Caucasian males and Asians. They might be called "geeks" and be socially awkward. They may be joined by unattractive and socially challenged women and minorities. Those females and minority children enrolled in higher level STEM career track classes are likely to be socially isolated by their peers. Justine Cassell (Stross, 2008), director of the Center for Technology & Social Behavior at Northwestern University, points to the "geek" factor. In her opinion, "Girls and young women don't want to be that person" who is the geek scientist. Cheryan, Siy, Vichayapai, Drury, & Kim (2011) found that many females do not believe they can be that person because they tend to underestimate their abilities in STEM classes. Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2010) argue that at every stage of development, girls and women are exposed to the message that their ingroup is worse in science and math compared with their male peers (1). In fact, when high school females were exposed to female role models, Wadley (2012) reports that the students lost interest in STEM fields and the role models had a "negative impact" on their future curriculum choices.

These cultural influences not only impact the person considering a STEM field, but also those people around them whose opinions they value. Research indicates that female elementary school (student ages 5-12) teachers are less comfortable teaching science than other topics (Lee & Luykx, 2008). High school science classes (student ages 14-18) often emphasize an organized method of experimentation and specific uses of language. The goal of class work is to discover the right answer. There often is little room in science class for discussion, argument, and varying interpretation. Carlsen (2008) describes a clash between individual learning and the disciplinary nature of science (60). Such curriculum favors a masculine approach of power hierarchies and logically arrived at right answers and disapproves of a feminine approach of cooperation and valuing all contributions. Scantlebury & Baker (2008) argue that the "masculine aspects" of science erect barriers for females (256). Additionally, women entering STEM majors or careers have historically faced hostility from men with whom they are in competition, and often there are few role models or mentors for women in academia or the workplace (Mertens, & Hopson, 2006;

Greene, DeStefano, Burgon & Hall, 2006; Schiebinger, 2008; LaValue-Mandy, & Stewart, 2008; Goldberg, 1999; Borg, 1999; Seymour, 1999; HR 3007, 1998).

We chose to focus on eighth graders in our two initial surveys. A student on the STEM career track needs to at least take pre-algebra in 7^{th} or 8^{th} grade in order to leave high school with credits in calculus, physics, and/or chemistry (ACT, 2008). Most colleges require engineering or computer science students, as well as science and mathematics majors, to complete at least a three-semester sequence of calculus. In addition, several semesters in science are required. Accordingly, a college student who wants to major in a STEM field, but who begins with college algebra and physics I, would need at least a year and possibly as many as three years of prerequisite college class work before entering a STEM major. For this reason decisions made in 7^{th} and 8^{th} grade shape future career options.

In our first two STEM studies (Cho, Goodman, Oppenheimer, Codling, Vuk, Wheeler, Robinson, Smith & Kleinmann, 2009; Oppenheimer, Cho, Goodman, Codling, & Robinson, 2008), we wanted to find out if 7^{th} and 8^{th} graders were aware of the cultural stereotypes about women in STEM fields. In a small, rural university community in the American southeast, we ran a study at a racially diverse public school and a second study at a private school of Caucasian students. Students viewed images of a variety of women taken in everyday street clothes. Each full body shot was 150 pixels wide and loaded into a SurveyMonkey.com survey. Half of the women were Caucasian and half African American. One third were under 25-years-old, one third 25-35, and one third over 35. One third of the women wore a dress size less than 8, one third wore 8 to 14, and one third described themselves as wearing a dress size greater than 14. About half of the participants in each study viewed images labeled with STEM job titles; one half viewed the same images with non-STEM job titles. They were asked to rate the women on five criteria: good at her job, well organized, creative, attractive, and intelligent.

The results of these two studies found no significance for race or sex of the participants and few significant results for four of the questions. However, the participants consistently found the women associated with STEM job titles were less attractive than the same images labeled with non-STEM job titles. See tables 1 to 3. These results indicated to us that the eighth-grade participants had not fully accepted the cultural stereotypes, but accepted the premise that women in non-STEM fields were more attractive than women in STEM fields. At the all white private school, the African-American images received significantly lower scores than the Caucasian women pictured and so we are reporting those results. The public school study asked ten questions, but the students were not able to complete the survey; accordingly, we reduced the survey to five questions per image in our following studies.

Table 1: Public School, 8^{th} grade. Mean Differences between All STEM Images and All Non-STEM Images

Question topic	STEM	non-STEM	p-value (2-tailed)
1. Good at her job	2.094	2.135	.761
2. Organized	2.385	2.468	.239
3. Efficient	2.313	2.590	.041
4. Artistic	2.717	2. 813	.308
5. Intelligence	2.279	2.149	.310
6. Sexy	4.313	4.434	.132
7. Attractive	4.333	4.427	.191
8. Creative	2.893	2.945	.541
9. Competent	2.923	2.970	.667
10. Bright	2.456	2.396	.606

Table 2: Private School, 8th Grade. Mean Difference in African-American Women's Images in Non-STEM Careers and STEM Careers.

Items		Mean	SD	*t*	Sig.
1.Good at	STEM	3.92	.83	-.54	.59
2.Organized	STEM	3.79	.73	-.30	.76
3.Intelligent	STEM	4.19	.82	.38	.70
4.Attractive	STEM	2.05	.80	-.64	.52
5.Creative	STEM	3.70	.91	.83	.40

Table 3: Private School, 8th Grade. Mean Difference in Caucasian Women Image in Non-STEM Careers and STEM Careers

Items		Mean	SD	t	Sig.
1.Good at job	Stem	4.30	.75	.30	.62
2.Organized	Stem	4.22	.69	.40	.68
3.Intelligent	Stem	4.54	.61	.36	.17
4.Attractive	Stem	2.40	.87	.38	.27
5.Creative	Stem	4.04	.83	.81	.11

We ran the same study with the same question order at a land grant university. In this study we again found that the stereotypes were not strongly held. See tables 4 and 5.

Table 4: Caucasian Images
On the 7-point scale, 1 was the lowest rating and 7 was the highest rating.

Q	STEM	NON-STEM	*P*	Caucasian N = 143	Af-Am N = 41	*p*	Male	Female	*P*
1	4.76 (*SD*=.80)	4.36 (*SD*=.76)	<.001 (*t*=3.59)	4.47 (*SD*=.70)	4.95 (*SD*=.99)	.005 (*t*=2.92)	4.47 (*SD*=.70)	4.95 (*SD*=.99)	NS
2	4.49 (*SD*=.66)	4.20 (*SD*=.56)	.001 (*t*=3.23)	4.27 (*SD*=.55)	4.64 (*SD*=.82)	.010 (*t*=2.70)	4.27 (*SD*=.55)	4.64 (*SD*=.82)	NS
3	4.86 (*SD*=.68)	4.37 (*SD*=.57)	<.001 (*t*=5.43)	4.51 (SD=.59)	5.08 (SD=.75)	<.001 (*t*=4.43)	4.51 (SD=.59)	5.08 (SD=.75)	.011 (*t*=2.57)
4	3.19 (*SD*=.92)	2.92 (*SD*=.87)	.032 (*t*=2.16)	3.02 (*SD*=.81)	3.24 (*SD*=1.23)	NS	3.02 (*SD*=.81)	3.24 (*SD*=1.23)	<.001 (*t*=4.65)
5	4.16 (*SD*=.83)	4.07 (*SD*=.75)	NS	4.00 (*SD*=.69)	4.57 (*SD*=.93)	<.001 (*t*=3.71)	4.00 (*SD*=.69)	4.57 (*SD*=.93)	NS

Table 5: African-American Images
On the 7-point scale, 1 was the lowest rating and 7 was the highest rating.

Q	STEM	NON-STEM	*p*	Caucasian	African-American	*p*	Male	Female	*p*
1	4.34 (*SD*=.98)	4.29 (*SD*=.80)	NS	4.19 (*SD*=.77)	4.77 (*SD*=1.16)	.018 (*t*=2.38)	4.23 (*SD*=.86)	4.36 (*SD*=.92)	NS
2	4.21 (*SD*=.80)	4.12 (*SD*=67)	NS	4.06 (*SD*=.67)	4.55 (*SD*=.88)	.018 (*t*=2.38)	4.07 (*SD*=.71)	4.22 (*SD*=.75)	NS
3	4.44 (*SD*=.88)	4.17 (*SD*=.67)	.017 (*t*=2.40)	4.15 (SD=.68)	4.90 (SD=.88)	<.001 (*t*=5.40)	4.11 (SD=.79)	4.41 (SD=.78)	.018 (*t*=2.38)
4	3.19 (*SD*=1.03)	2.97 (*SD*=92)	NS	3.00 (*SD*=.95)	3.39 (*SD*=1.1)	.018 (*t*=2.38)	2.51 (*SD*=.97)	3.32 (*SD*=.90)	<.001 (*t*=5.40)
5	3.87 (*SD*=1.0)	3.70 (*SD*=73)	NS	3.64 (*SD*=.77)	4.32 (*SD*=1.1)	.018 (*t*=2.38)	3.79 (*SD*=.74)	3.81 (*SD*=.94)	NS

These results show that the college students rated Caucasian women better at her job, more organized, and more intelligent in the STEM fields than in the non-STEM fields at a significant level below .01. They rated African-American women more intelligent in STEM fields than in non-STEM fields. However, there was no significance for attractiveness or creativity for STEM and non-STEM regardless of the race of the women in the images. These results contradict the results expected based upon if the participants viewed the images from stereotypical perspectives.

We tested the power of the STEM stereotypes in another set of studies run at the same land grant university among non-STEM majors and at a nearby liberal arts university among STEM majors. The first set of students to participate were part of a science forum run at the liberal arts school. Many of the participants were biology majors preparing for STEM careers. We asked them to draw a picture of a scientist, a study conducted by Jones & Bangert, 2006. In this group, 34.6% of the participants drew a male scientist, 34.6% drew a female scientist, and 30.1% drew an androgynous scientist. The second set of participants was composed of communication majors at the land grant university. This group overwhelmingly drew male scientists (69.6% male, 26.1% female, 4.3% androgynous). Those participants in STEM fields had a considerable amount of personal experience with scientists when compared to the students in the communication class. See Table 6.

Table 6: Students in College Classes Were Asked To Draw Images of Scientists

	Male scientist	Female scientist	Androgynous scientist
land grant university (non-STEM majors)	16	6	1
liberal arts university (STEM majors)	9	9	8

The results of the studies reported above indicate that middle school students began to form stereotypical views about women in STEM fields. By college, personal experiences and STEM models, among other factors, seem to have a significant impact on an individual's perception of women and minorities in STEM fields (Tables 4-6). However, the stereotypes were not held as strongly as the literature led us to believe.

Based on our results and the literature on STEM, we concluded that the proper age for implementing an invention study was fifth grade. We designed and implemented a study where we ran pre-surveys and post-surveys in four public school fifth grade classrooms in the same community used for the eighth grade studies. We arranged for three mentors to teach one-hour science lessons in each class except for the control class. In one classroom, the three mentors were African-American females, in a second classroom the mentors were Caucasian females, and in the third classroom the mentors were Caucasian males. The students in the fourth classroom only took the pre-survey and post-survey. We asked participants if they liked to work math problems, if they liked to do science problems, and if they liked to work on computers. In addition, we asked them to tell us what they wanted to be when they grew up. We assigned their answers to the open ended career question to STEM, non-STEM, or both. Some students provided more than one answer.

We expected that the mentors would create attitude change. According to modeling theory (Bandura, 1978, 2001), people will repeat the behavior exhibited by people they identify with. If modeling theory worked, then girls would associate themselves with the female mentors (two classrooms) and African American students would associate themselves with African-American mentors (one classroom). Male students would associate themselves with the male mentors (one classroom). We predicted no change in the control classroom. To meet Institutional Review Board requirements, we did not identify students used in the surveys, which meant we could only track attitude change by class, by race, by gender, and by attitudes towards mathematics, science, and computers. We obtained no statistically significant results. As these tables show, our pre-survey/post-survey results indicate little change in student attitudes. Both teachers and mentors self reported that the mentors were well received by the students.

Test	Number of Caucasian children selecting STEM careers or both STEM and non-STEM.	Number of African-America children selecting STEM careers or both STEM and non-STEM
Mentored classes: pre-test n=51	11	8
Mentored classes: post-test n=47	9	9
Control class: pre-test n=19	4	2
Control class: post-test n=18	3	4

To explain the fifth grade results, we hypothesized the following explanations:

1. Piaget and sometimes Inhelder (1928, 1932, 1951, 1952, 1958, 1962) contend that people in the age range of fifth graders are concrete thinkers and will not develop into abstract thinkers until high school. It is possible that many of our fifth graders had not developed career plans nor had any sense of how to achieve careers. If true, then effective intervention strategies might be difficult to achieve because students could not conceive that science and mathematics were important to their futures.
2. We simplified the design of our surveys to be age appropriate by asking only yes/no questions. In the process, our instrument may not have been refined enough to message any attitude change that did occur.
3. The student career goals indicate that many have been influenced by mediated culture. Many wanted to be sports stars; others wanted to be entertainers. In the words of one participant, “I want to be famous.”
4. The classroom with the strongest positive attitudes towards science, mathematics, and computers in both pre-survey and post-survey was the control class. This teacher had many science materials in the classroom and had taken the students on an overnight environmental trip. She liked science and liked teaching it. Her classroom was chosen as the control by the principal because she didn’t seem to need an intervention.
5. Conversely, the other teachers expressed various levels of concern about teaching some of the content they were required to teach or they had reservations about having the mentors coming into the classroom. Potentially, these teachers conveyed to students that mathematics and science were difficult subjects and that they and the teacher might not be up to the task of learning the material.
6. Message design logic offers another explanation in light of our results. Elementary school teachers are generalized, expected to teach humanities, social sciences, physical education, science, and mathematics. Many of them may be more comfortable teaching some content than other content. According to message design logic theory (O’Keefe, 1988, 1991, 1991, 1997; O’Keefe & Lambert, 1989, 1995; O’Keefe & Shepherd, 1987; O’Keefe, Lambert & Lambert, 1993), science and mathematics requires people to

acquire a vocabulary and an understanding of methods of those fields. Elementary school teachers who do not know the vocabulary and methods of science and mathematics may not be able to prepare students for pre-algebra classes in 7th grade.

We believe that message design logic deserves closer scrutiny. According to O'Keefe, (1997) the STEM fields tend to require specialized language and understandings of methods and procedures. The goal in science and mathematics is find the right answer by using the proper procedures, which includes using the correct language (i.e., formulas). The results are to be reported using the correct language. O'Keefe argues that these approaches preference a Caucasian male patriarchy. One person, a Caucasian historically, is in charge of the procedures and methods. Everyone else on the team is to recognize his or her role in the hierarchy. As Burke points out, hierarchies inherently include heroes and villains, rights and wrongs, and a set of preferences often institutionalized through law or regulation. McPhail (1994) argues that language is a tool used in hierarchies to identify who belongs to the in group and who is the other. The "other" (Van Zoonen, 1974; Kuhn, 1982; Hall, 1985, 1992; Mulvey, 1988; Steiner, 1991; Fiske, 1991, 1987; Doane, 1988; Bergstrom, 1988; Kaplan, 1997) are those individuals not in the preferred group. Language is a method used by participants, which identifies them as belonging to the group and then their place within the group. Conversely, those who do not know the language are others. By definition, the others are those at the bottom of the hierarchies of the in group. The specialized language of science reaffirms and institutionalizes the hierarchy and places individuals within the hierarchy. Those at the top tiers of the hierarchy understand the language, and by extension the rules and regulations, better than those at the bottom.

Extending our line of logic, in science and engineering, Caucasian males are at the top of the hierarchy or they are joined by individuals willing or anxious to fit into the hierarchy. They have mastered the language and methods. Those who wish to become members of the community must demonstrate their mastery of the language, methods, and hierarchies. Those wishing to join the hierarchy typically have to go through internships, residencies, and/or Ph.D. programs to prove their worthiness.

Women and members of underrepresented minority groups often state how culturally isolated they feel as they seek admission to the hierarchy (Schiebinger, 2008; Goldberg, 1999; Borg, 1999). They believe they have to perform at higher levels than Caucasian male counterparts (National Academy of Science, National Academy of Engineering, & Institute of Medicine, 2007; Hill, C., Corbett, C., & St. Rose, 2010). They have difficulty finding mentors (A Review of HR 3007, 1998; Greene, DeStefano, Burgon & Hall, 2006). Their success is determined by their ability to learn the language and methods, and to accept the hierarchy of the Caucasian male system.

Conversely, the humanities and arts provide a different paradigm. Right answers are often in the minds of the creators. Discussion is less hierarchal and provides for more affirmation of contributing perspectives or opposing viewpoints. Accordingly, these fields are more open to underrepresented minorities and are more feminine (NSF 2009, 4-5).

Discussion

Our research indicates that people in our community in the Southeast begin to accept the STEM stereotypes by 8th grade. Those stereotypes are developed and widely accepted by the time students are in college. Data indicates that women are gaining significant ground in some specific STEM areas, such as veterinarians and family medicine. Since women remain in caregiving roles in these fields, women may be more accepted in those careers than in other STEM fields.

Significant inroads into other STEM fields have not been seen in the United States, despite some concerted efforts to create change. One factor explaining the difficulty may be culture.

Culture presents to women and underrepresented minorities that there are many more glamorous and exciting fields to enter while science and mathematics may be too difficult for them or at least require much more work than other fields. If women, or Hispanics, or African Americans do enter STEM fields, they will be expected to learn STEM language and procedures. They will be expected to join the Caucasian male hierarchy, requiring them to accept and participate in the rules and regulations of the hierarchy (Hill, Corbett, & St. Rose, 2010; NSF, 2007, 2009; U.S. Department of Commerce, Economics and Statistics Administration, 2009).

Future Study and Limitations

We need to test the points raised in our discussion. We plan to survey sets of elementary school teachers and students who are education majors to determine if they are comfortable teaching some content and less confident teaching other content. This would tell us if message design logic may help explain why some population groups select STEM careers and other groups do not. This would be valuable knowledge if successful intervention strategies are going to be developed.

Conclusions

Based upon our reading of the literature and our research, we believe that women and underrepresented minorities are no longer being excluded by policy, but more by praxis. The way of thinking rewarded in the STEM fields, the rigidity of the structure of the STEM disciplines, and the current demographics of STEM professionals combine to discourage many people of all backgrounds from seeking knowledge, training, or work in the STEM fields. Message Design Logic supports this conclusion by theorizing that people have preferred ways of thinking, and that they feel most rewarded by thinking in those ways. Only a small percentage of the general population may intuitively think in a scientific way (i.e., rigorous, methodical, and highly scripted). Accordingly, the ways STEM disciplines are taught and practiced need to change if the goal is greater diversity. Further, the current strategies of STEM interventions are unlikely to change the percentage of women and minorities in those fields if those interventions continue to rely on historical paradigms and praxis. Thus, new ideas and perspectives should be brought to STEM questions and research.

REFERENCES

A Review of HR 3007, the advancement of women in science, engineering, and technology development act. Hearing before the committee on science subcommittee on technology and subcommittee on basic research. U.S.; House of Representatives. 105th Congresss, 2nd session. March 10, 1998.

ACT. (2008). The forgotten middle: Ensuring that all students are on target for college and career readiness before high school. Available at http://www.act.org/research/policymakers/pdf/ForgottenMiddle.pdf.

Ambrose, S.A, Dunkle, K.L., Lazarus, B.B., Nair, I., & Harkus, D.A. (1997). *Journeys of Women in Science and Engineering: No Universal Constants*. Philadelphia: Temple University Press.

American Association of University Women. (2003, May 6). *Study: Women Concentrated in'Pink-Collar' Jobs*. Available at http://hr.blr.com/news.aspx?id=8444.

Annals of the New York Academy of Sciences. (1999). Vol. 869. *Women in Science and Engineering: Choices for Success*. New York: The New York Academy of Sciences.

Bandura, A. (2001). Social cognitive theory of mass communication. *Media Psychology, 3*(3), 265-299.

Bergstrom, J. (1988). Enunciation and sexual difference. In C. Penley (Ed.), *Feminism and Film Theory*, pp. 159-185. New York: Routledge.

Borg, A. (1999). What draws women to and keeps women in computing? In *Annals of the New York Academy of Sciences*, Vol. 869, pp. 102-109. Women in Science and Engineering: Choices for Success. New York: New York Academy of Sciences.

Carlsen, W.S. (2008). Language and science learning. In S.K. Abell & N. Lederman (Eds.), *Handbook of research in science education*. New York: Routledge, pp. 57-74.

Charts Quarterly. (2010). Females plan to attend college more than males. Marketing Charts. Available at http://www.marketingcharts.com/direct/females-plan-to-attend-college-more-than-males-15347/.

Cho, S., Goodman, M., Oppenheimer, B., Codling, J., & Robinson. T. (2009). Images of Women in STEM Field. *Journal of Science Communication*, 8(3). Available at: http://jcom.sissa.it/archive/08/03/Jcom0803(2009)A03.

Cho, S., Goodman, M., Oppenheimer, B., Codling, J., & Robinson, T. (2009). The Effect of Brand Image on Consumer Evaluations. International Academy of Linguistics, Behavioral and Social Sciences, Orlando, November 13-14, 2009. AGB and IALBSS Proceedings, paper 6.

Culler, J. D. (1986). *Ferdinand de Saussure*. Ithaca, NY: Cornell University Press.

Doane, M. A. (1988). Woman's stake: Filming the female body. In C. Penley (Ed.), *Feminism and Film Theory,* pp. 216-228). New York: Routledge.

Erkut, S. & Marx, F. (2005). 4 schools for WIE: Evaluation Report. Available at http://engineering.tufts.edu/stemteams/evaluation.pdf.

Fiske, J. (1987). *Television Culture*. New York: Routledge.

Fiske, J. (1991). Television: Polysemy and popularity. In R.K. Avery and D. Eason (Eds.), *Critical Perspectives on Media and Society*, pp. 346-364. New York: Guilford Press.

Goldberg, P. (1999). Creeping toward inclusivity in science. Executive Summary. In *Annals of the New York Academy of Sciences*, Vol. 869, pp. 7-15. Women in Science and Engineering: Choices for Success. New York: New York Academy of Sciences.

Goodnight, L. (2008). *AAUW to launch major STEM study with funding from National Science Foundation*, News release, AAUW, Oct 16, 2008.

Greene, J.C., DeStefano, L., Burgon, H., & Hall, J. (2006). An educative, values-engaged approach to evaluating STEM educational programs. *New Directions for Evaluation, 109* (Spring 2006), pp. 53-71.

Gullickson, A.R. & Hanssen, C.E. (2006). Local evaluation in multisite STEM programs: Relating evaluation use and program results. *New Directions for Evaluation, 109* (Spring 2006), pp. 87-108.

Hall, S. (1985). Signification, representation, ideology: Althusser and the post-structuralist debates. *Critical Studies in Mass Communication, 2*(2), 91-114.

Hall, S. (1992). Cultural studies and its theoretical legacies. In L.Grossberg, C. Nelson, & P. Treichler (Eds.), *Cultural Studies* (277-286). New York: Routledge.

Higher Education Research Institute. (2010). Degrees of success: Bachelor's degree completion rates among initial STEM majors. *Research Brief*, January.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering and mathematics*. Washington, D.C.: AAUW.

Huffman, D., Lawrenz, F., Thomas, K., & Clarkson, L. (2006). Collaborative evaluation communities in urban schools: A model of evaluation capacity building for STEM education. *New Directions for Evaluation, 109* (Spring 2006), pp. 73-85.

Inhelder, B. and J. Piaget (1958). *The Growth of Logical Thinking from Childhood to Adolescence*. New York: Basic Books.

Insurance Day (2010). Male doctors moving from general care to specialties. *Insurance Industry News*. Available at http://www.insuranceday.org/male-doctors-moving-from-general-care-to-specialties/.

Johnson, C.C., 2012. Implementation of STEM education policy: Challenges, progress, and lessons learned. *School Science and Mathematics, 112* (1), pp. 45-55.

Jones, R. & Bangert, A. (2006). The CSI effect. *Science Scope,* November, p. 38.

Kanai, K. & Norman, J. (1997). *Systemic reform evaluation: Gender differences in student attitudes toward science and mathematics*. Paper presented at the annual international conference of the Association for the Education of Teachers in Science, Cincinnati.

Kaplan, E.A. (1997). *Looking for the Other: Feminism, Film, and the Imperial Gaze*. New York: Routledge.

Kuhn, A. (1982). *Women's Pictures: Feminism and Cinema*. Boston: Routledge and Kegan Paul.

LaValue-Mandy, D. & Stewart, A.J. (2008). Avery scholarly intervention: Recruiting women faculty in science and engineering. In Schiebinger, L. (Ed.), *Gendered Innovations in Science and Engineering*, pp. 165-181. Stanford: Stanford University Press.

Lee, O. & Luykx, A. (2008). Science education and student diversity: Race/ethnicitiy, language, culture, and socioeconomic status. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of Research in Science Education*. New York: Routledge, pp. 171-279.

McCarty, R. (2009). Highest-paying college majors: Payscale. *Huffington Post*. Available at http://www.huffingtonpost.com/2009/09/08/highest-paying-college-ma_n_279522.html.

McPhail, M.L. (1994). *The Rhetoric of Racism*. New York: University Press of America.

Mertens, D.M. & Hopson, R.K. (2006, Spring). Advancing evaluation of STEM efforts through attention to diversity and culture. *New Directions for Evaluation, 109*, pp. 35-51.

Mulvey, L. (1988). Visual pleasure and narrative cinema. In C. Penley (Ed.), *Feminism and Film Theory*, pp. 57-68. New York: Routledge.

Nagel, D. Report: STEM gap widens for underrepresented minorities. *THE Journal*, May 2008. Available at http://www.thejournal.com/articles/22543/.

National Academy of Science, National Academy of Engineering, & Institute of Medicine. (2007). *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering.*

National Science Foundation. (2007, Sept. 26). *Program provides blueprint for recruiting minorities to science and engineering.* Available at http://www.nsf.gov/news/news_summ.jsp?cntn_id=110124**.**

National Science Foundation. (2009). *Women, minorities, and persons with disabilities in science and engineering.* Available at http://www.nsf.gov/statistics/wmpd/pdf/nsf09305.pdf.

National Science Foundation, Division of Science Resources Statistics. (2011). *Women, minorities, and persons with disabilities in science and engineering: 2011*. Special Report NSF 11-309. Arlington, VA. Available at http://www.nsf.gov/statistics/wmpd/.

Nagel, D. (2008, May). Report: STEM gap widens for underrepresented minorities. *THE Journal*. Available at http://www.thejournal.com/articles/22543/.

O'Keefe, B. J. (1988). The Logic of Message Design: Individual Differences in Reasoning About Communication. *Communication Monographs,* 55, 80–103.

O'Keefe, B. J. (1991). Message design logic and the management of multiple goals. In K. Tracy (Ed.), *Understanding Face-to-Face Interaction: Issues Linking Goals and Discourse*, pp. 131–50. Hillsdale, NJ: Lawrence Erlbaum.

O'Keefe, B. J. (1992). Developing and testing rational models of message design. *Human Communication Research, 18*: 637–49.

O'Keefe, B. J. (1997). Variation, adaptation, and functional explanation in the study of message design. In G. Philipsen (Ed.), *Developing Communication Theories*, pp. 85–11.Albany, NY: SUNY Press.

O'Keefe, B. J., & Lambert, B. (1989). *Effects of Message Design Logic on theCommunication of Intention*. San Francisco: Speech Communication Association.

O'Keefe, B. J., & Lambert, B. (1995). Managing the flow of ideas: A local management approach to message design. In B.R. Burleson (Ed.), *Communication Yearbook, 18*, pp. 54–82. Thousand Oaks, CA: SAGE.

O'Keefe, B. J., Lambert, B. L., & Lambert, C. A. (1993). *Effects of Message Design Logic on Perceived Communication Effectiveness in Supervisory Relationships.* Washington, DC: International Communication Association.

O'Keefe, B.J., Lambert, B.L., & Lambert, C.A. (1997). Conflict and communication in a research and development unit. In B.D. Sypher (Ed.), *Case Studies in Organization Communication 2: Perspectives on Contemporary Work Life*, pp. 31-51. New York: The Guilford Press.

O'Keefe, B. J., & Shepherd, G. J. (1987). The pursuit of multiple objectives in face-to-face persuasive interactions: Effects of construct differentiation on message organization. *Communication Monographs, 54*: 396–419.

Payscale (2009). Best undergrad college degrees by salary. Available at http://www.payscale.com/best-colleges/degrees.asp.

Perna, L., Lundy-Wagner, V., Drezner, N.D., Gasman, M., Yoon, S., Bose, E., & Gray, S. (2009). The contribution of HBCUS to the preparation of African American women for stem careers: A case study. *Research in Higher Education, 50*, 1-23.

Piaget, J. (1928). *The Child's Conception of the World.* London: Routledge and Kegan Paul.

Piaget, J. (1932). *The Moral Judgment of the Child.* London: Kegan Paul, Trench, Trubner and Co. (Original work published 1932.)

Piaget, J. (1951). *The Psychology of Intelligence.* London: Routledge and Kegan Paul.

Piaget, J. (1952). *The Origins of Intelligence in Children.* New York: International University Press. (Original work published 1936.)

Piaget, J., and Inhelder, B. (1962). *The Psychology of the Child*. New York: Basic Books.

Scantlebury, K. & Baker, D. (2008). Gender issues in science education research: Remembering where the difference lies. In S.K. Abell & N.G. Lederman (eds.), *Handbook of research in science education*. New York: Routledge, pp. 257-281.

Schiebinger, L. (2008). *Gendered Innovations in Science and Engineering*. Stanford: Stanford University Press.

Selby, C.C., Ed. (1999). *Women in Science and Engineering: Choices for Success.* New York: The New York Academy of Sciences.

Seymour, E. (1999). The role of socialization in shaping the career-related choices of undergraduate women in science, mathematics, and engineering majors. *Annals of the*

New York Academy of Sciences, *869*. Women in Science and Engineering: Choices for Success. Executive Summary, 118-126.

Smith, R. (2009). Women doctors will outnumber men within a decade: research. *Telegraph*. Available at http://www.telegraph.co.uk/health/healthnews/5429181/Women-doctors-will-outnumber-men-within-a-decade-research.html.

Steiner, L. (1991). Oppositional decoding as an act of resistance. In R. K. Avery and D. Eason (Ed.), *Critical Perspectives on Media and Society*, pp. 329-345. New York: Guilford Press.

U.S. Department of Commerce, Economics and Statistics Administration, (2009). Women in STEM: A gender gap to innovation. Available at http://www.esa.doc.gov/sites/default/files/reports/documents/womeninstemagaptoinnovation8311.pdf.

Van Zoonen, L. (1994). *Feminist Media Studies*. London: Sage Publications.

Wadley, J. (2012). My fair physicist? Feminine math, science role models do not motivate girls. Accessed at http://ns.umich.edu/new/releases/20355-my-fair-physicist-feminine-math-science-role-models-do-not-motivate-girls.

Zhang, X., Frechtling, J., and McInerney, J., (2011). Effect of STEM faculty engagement in the math and science partnership program. *School Science and Mathematics, 111*(6), 274-287.

Zhao, Y. (2002). Women soon to be majority of veterinarians. *The New York Times*, 9 June 2002. Available at www.anapsid.org/vets/vetdemos.html.

ABOUT THE AUTHORS

Dr. John Nicholson: John Nicholson graduated from the University of Iowa (Ph.D., 1998) and has participated in multiple interdisciplinary projects including the current STEM research presented here. His other research areas include sibling research and family nickname research.

Shane T. Warren: College of Education, Mississippi State University, USA

Dr. Bonnie Oppenheimer: Dr. Oppenheimer is a professor of mathematics at Mississippi University for Women. She has long been interested in why women do not choose the STEM fields. She helped form our research group and has led the group's efforts to pursue STEM research questions.

Dr. Mark Goodman: Professor, Department of Communication, Mississippi State University, USA

Dr. James Codling: Instructor, College of Education, Mississippi State University, USA

Thomas Robinson: Research Assistant, Social Science Research Center, Mississippi State University, USA

Dr. Jee Young Chung: Assistant Professor, Department of Communication, Southern Utah University, USA

South Korean Government's Failure to Link the Cheonan's Sinking to North Korea: Incorrect Inference and Fabrication of Scientific Data

Seung-Hun Lee, University of Virginia, USA
Jae-Jung Suh, Johns Hopkins University, USA

Abstract: South Korean (SK) navy corvette Cheonan sank on March 26, 2010 in the Yellow Sea near the sea border with North Korea. On May 20, 2010, after less than two months of investigation, the SK-appointed Joint Investigation Group (JIG) concluded that the Cheonan had been destroyed by a North Korean torpedo. The JIG presented as the conclusive evidence a set of the electron-dispersive spectroscopy (EDS) and x-ray diffraction data of the white powder samples extracted from the sunken ship, torpedo propulsion system and their own small-scale test-explosion experiment, and claimed that all of the three samples are aluminum oxide that should be produced at a high temperature environment (higher than at least 600 ^{o}C) from an explosion. Here we report our scanning electron microscopy (SEM), EDS, and x-ray experiments on an Al powder that underwent melting and quenching. Contrary to the JIG claims, our data combined with our EDS simulations clearly show that the JIG's identification of two of the white powders, from the sunken ship and torpedo fragments, is incorrect: those powders are not aluminum oxide that results from an explosion but they are aluminum sulfate hydroxide hydrate that can be produced naturally at a low temperature environment (lower than 100 ^{o}C). Furthermore, the fact that the JIG's EDS data of the third sample, from the test-explosion experiment, is identical to the EDS data of aluminum sulfate hydroxide hydrate is an anomaly. The test explosion would have produced aluminum oxide rather than aluminum sulfate hydroxide hydrate. The only scientifically possible explanation of the anomaly is that the EDS data of the test explosion was fabricated.

Keywords: Cheonan, Aluminum Oxide, Aluminum Sulfate, Hydroxide Hydrate, Torpedo Explosion, Korea

Introduction

The sinking of the South Korean (SK) corvette Cheonan on March 26, 2010 has raised novel and challenging questions regarding scientific investigation and security politics around the Korean peninsula. While the SK government–funded Joint Investigation Group (JIG) concluded that North Korea had fired a torpedo to sink the ship, its conclusion was contradicted by most of the evidences presented in its interim report released on May 20, 2010. The self–contradictions in the official report, notwithstanding, the SK government proceeded to take its conclusion, not its evidences, as the basis for taking punitive measures against North Korea on May 24. In June, the SK government took its conclusion to the UN Security Council, but the Security Council issued a presidential statement that "the Security Council condemns the attack which led to the sinking of the Cheonan," declining to identify the attacker. Although it took the JIG another four months until September 13, 2010 to publish its final report on the investigation result, the final report repeated most of the self–contradictions in the interim report without explaining, much less resolving, any of them.

In this article, we report the result of our efforts to replicate some of the scientific data in the final report. Although the JIG claims that the white powder retrieved from the Cheonan and the torpedo propulsion system is aluminum oxide that resulted from an explosion, we find its claim incorrect. We have subjected aluminum powder to melting and quenching, and performed three different kinds of experiments using SEM (scanning electron microscopy), EDS (electron dispersive spectroscopy) and x–ray diffraction measurements to identify the resulting material. Our experiments unambiguously and consistently show that the resulting material is aluminum

The International Journal of Science in Society
Volume 4, 2013, www.science-society.com, ISSN 1836-6236

oxide, but the data we have obtained from the experiments are different from those that the JIG presents as the evidence for aluminum oxide in the final report. The JIG data are instead consistent with those of aluminum sulfate hydroxide hydrate that we have obtained from the NIST-DTSA simulation. Thus we conclude that the JIG's own data, combined with ours, shows that the JIG made an incorrect inference about the identity of the white powder. Given that aluminum sulfate hydroxide hydrate results naturally from a low temperature environment, the JIG cannot hold the white powder as the material evidence that connects the Cheonan and the torpedo part to an explosion. In other words, the JIG has the body of the sunken ship and the torpedo part, but has no material evidence that links the two to an explosion, much less a same explosion. Furthermore, we show that the EDS data of the test explosion experiment was fabricated to support the wrong conclusion.

In this article we start with a discussion of the JIG's data and conclusion on the white powder. Second, we describe our experiments and results. Third, we compare our results and the JIG's to see if the JIG's claims can be confirmed. Finally, we conclude with some suggestions for future actions and a consideration of the relationship between science and politics.

The JIG's Data and Claim

On May 20, 2010, the JIG presented a set of scientific data as critical evidence for their claim that a North Korean torpedo sank the Cheonan ship. The scientific data were the electron–dispersive spectroscopy (EDS) data that the JIG claimed to have taken from the white powder samples that were found on the surface of the sunken ship and the torpedo propulsion system, as well as from a test–explosion experiment. The JIG maintains that it retrieved the torpedo propulsion system from the bottom of the sea near the accident site and that it conducted an explosion test by igniting a 5g explosive inside a water tank. In the final report released on September 13, 2010, the JIG reiterated the data and the claim.[1]

The JIG final report was marred by a number of inconsistencies. One of the most glaring inconsistencies was that between its data and conclusion. While it concluded that a torpedo of 350kg TNT equivalent exploded under water 3 to 6 meters away from the ship, most of its data contradicted the conclusion. Physical examination of the dead sailors determined the cause of their death to be drowning and did not find such wounds of ear drum or nostril ruptures as expected in a proximate underwater explosion. No fragments of the said explosives was found in the body of the ship, which also showed no signs of holes or ruptures that would have been made by torpedo fragments. The ship's surface, instruments, and equipments, including an undamaged fluorescent light bulb, betrayed no sign of the shock wave whose magnitude is estimated to be 55Mpa (megapascals) at the closest point of impact. The JIG's simulation of the bubble effect conclusively showed that the Cheonan's deformation and severance could not have resulted from the bubble effect produced by a torpedo explosion.

---

[1] Ministry of National Defense, *The Joint Investigation Report on the Attack against ROK Ship Cheonan* (Seoul: Ministry of National Defense of the Republic of Korea, 2010).

(Figure 1)

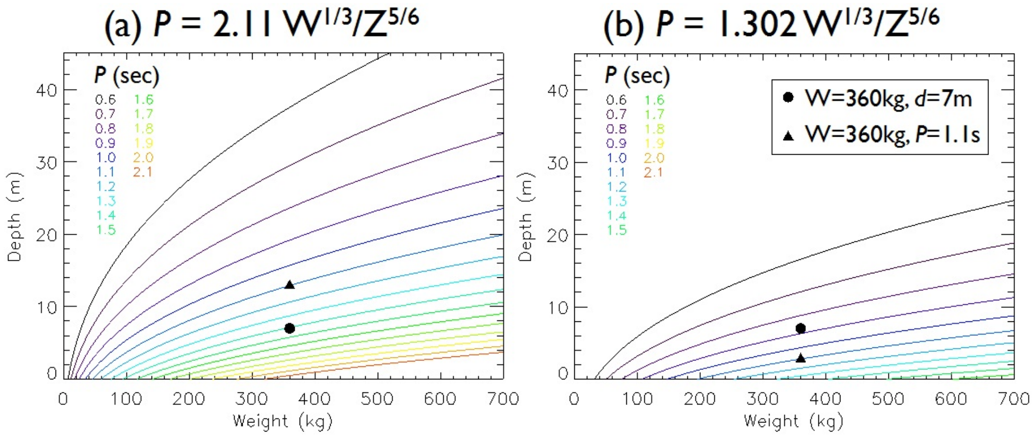


Figure 1: (a) Here we have used the formula (1) to reproduce '<Figure III–5–3> Charge size and depth of explosion according to bubble periods' shown in page 148 of the JIG's final report released in September 2010. <Figure III–5–3> and ours are identical to <Calculated Bubble Period> on page 4 of Rear Admiral Tom Eccles's PowerPoint brief titled "Loss of ROK's Cheonan" May 27, 2010.[2] However, Tom Eccles has used the coefficient 1.302 rather than 2.11 used in JIG's final report, and using his coefficient, we obtain the graph (b) on the right. The inconsistency between his formula and graph is inexplicable. The triangle and circle points are added by us and explained in the text of this article

That the report was seriously marred by this kind of inconsistency between data and interpretation can be illustrated by an examination of the JIG's analysis of the acoustic signals collected near the site of the accident. "[T]he team," which presumably refers to the JIG, noted that the signals that had two peaks separated by 1.1 seconds were "a sound unique to underwater explosions with accompanying bubble collapse" (Eccles 2010, 3). It then estimated that a 250kg TNT equivalent charge detonating at a depth of 9m would create the 1.1 seconds bubble period. The problem is that the formula it used, which is provided by Eccles (2010, 4), does not produce the same numbers: it produces a 250kg charge and a depth of 1m for 1.1 seconds. This inconsistency was later corrected in the JIG final report by replacing the original coefficient, 1.302, with a different one, 2.11, (with no explanation given as to why),

$$P = 2.11*W^{(1/3)}/Z^{5/6} \qquad (1)$$

where P is the bubble period (sec), W charge weight (kg), and Z = depth (m) + 10.1 m.[3] With the new coefficient, the formula produced the 1.1 seconds period for the 250kg charge and the 9m depth. But the JIG ran into another problem: these numbers, when plugged into its computer simulation of the bubble effect, did not create the damage pattern matching that of the Cheonan. It admitted that even a 360kg charge–the JIG offered no explanation as to why it increased the

[2] We gratefully acknowledge that we received Rear Admiral Eccles's PowerPoint from Sam Ahn, who obtained it through his Freedom of Information Act request.

[3] The formula is from <Figure III–5–3> on page 148 of the *JIG Report*. The formula, if not the coefficients, is consistent with the one in Reid's report. Warren D. Reid, *The Response of Surface Ships to Underwater Explosions* (Melbourne, Victoria, Australia: Defence Science and Technology Organisation, Department of Defence, 1996).

charge weight from 250kg to 360kg–at the 9m depth would not destroy the ship. Admitting that "an analysis on the condition that an explosive of 360kg TNT equivalent explodes at a depth of 9m revealed that the projected damage level is minimal compared to that of ROKS Cheonan," it arbitrarily changed the depth from 9m to 7m for the charge of 360kg in the simulation.[4] It still ran into three problems that it never admitted, much less resolved. First, these numbers, plugged back into the bubble period formula (Eq. (1)) would produce the period of 1.4 seconds (marked by the circle symbol in Fig. 1 (a)) or 0.87 seconds for coefficient 1.302 (the circle symbol in Fig. 1 (b)), neither of which matches the observed pulse period. Second, for the observed pulsed period of 1.1 seconds and the alleged 360kg TNT, Eq. (1) would produce the depth of 13m (marked by the triangle symbol in Fig. 1 (a)), which would significantly decrease the impact of the explosion on the Cheonan, or the depth of 2.8 m, (the triangle symbol in Fig. 1 (b)), which would put the explosive inside the ship or almost in contact with the bottom.[5] Third, the simulations, even with the JIG's most optimistic numbers (360kg TNT and the depth of 7m), did not produce outcomes that matched the Cheonan's deformation. These inconsistencies, notwithstanding, the JIG concluded that the sound signal peaks were the material evidence for the bubble effect that had sunk the Cheonan.

This pattern of fitting the data to the conclusion–not even successful at that–is not an isolated incident. It can be seen also in the JIG's handling of the white powder samples that were presented as the "critical evidence" that the Cheonan and the torpedo part had been affected by an identical explosion. In the following, we provide a more detailed analysis of the inconsistency between the JIG's data and conclusion on the "adsorbed materials."

(Figure 2)

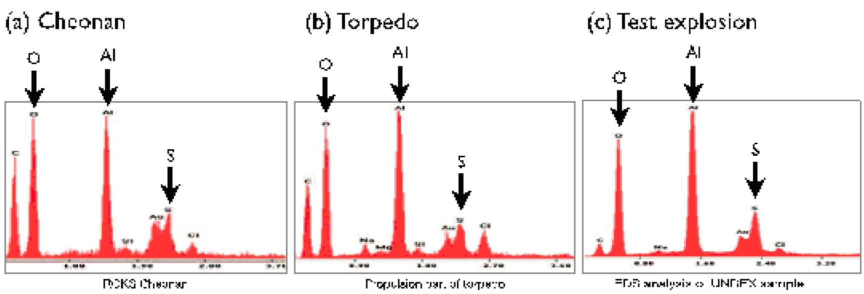


Figure 2: The JIG's EDS data obtained from three white powder samples extracted from (a) the sunken Cheonan ship, (b) the propeller of the torpedo and (c) the test explosion. The horizontal and vertical axes represent the energy in keV and the strength[6] of the signal, respectively. (a) and (b) were taken from Figure III–5–11 on page 154 of the JIG's final report and (c) from Figure appendix V–5–2 shown on page 278. The arrows and chemical elements were inserted by us for clarity

The JIG final report included several EDS data of several white powder samples taken from several different places of the sunken ship and torpedo fragments. Fig. 2 (a) and (b) show some of the EDS data. The relevant peaks are the oxygen (O) peak at ~ 520 eV, the aluminum (Al) peak at ~ 1500 eV, and the sulfur (S) peak at ~ 2300 eV. The other peaks are the carbon peak at ~ 300 eV and the gold (Au) peak at ~ 2000 eV that come from the carbon plate and the gold

[4] Ministry of National Defense, *The Joint Investigation Report on the Attack against ROK Ship Cheonan* 168.
[5] <Figure III-6-8> indicates the centerline of ship was 2.86m deep under the water (JIG 2010, 164). There are no indicators of internal or contact explosion, as the JIG acknowledges.
[6] Ibid. 154 and 278.

coating used for the EDS measurements, and the other weak peaks from salt (NaCl) and other minerals. From now on, we will focus on the three peaks of O, Al and S.

Let us first focus on the JIG's EDS data taken from the white powder samples extracted from the surfaces of the sunken ship (Fig. 2 (a)) and of the torpedo fragments (Fig. 2 (b)). Later we will show that the JIG's test–explosion EDS data (Fig. 2 (c)) is scientifically impossible and it must be fabricated. Note two main features of the data shown in Fig. 2 (a) and (b): (1) the oxygen (O) peak is as strong as the Al peak. The intensity ratio, I(O)/I(Al), varies from 0.8 to 1.2 depending on particular samples taken from the sunken ship and the torpedo fragments.[7] (2) The sulfur (S) peak is about four times weaker than the Al peak, I(S)/I(Al) ~ ¼.

With the EDS data, the JIG concluded that all of the three white powder samples were 'amorphous aluminum oxide' and were 'the explosive residue from the underwater explosive charge containing aluminum.'[8] We will now show that the JIG's EDS data clearly indicate that the two of the white powder samples extracted from the sunken ship and the torpedo fragment are not aluminum oxide but aluminum sulfate hydroxide hydrate that is naturally formed below 100^{o}C.

Our Replication of the JIG's Tests

In order to study what the Al powder contained in an explosive would turn into during an explosion, we have performed an experiment of melting and quenching of Al, which is a standard way of studying the effects of explosion on Al contained in an explosive.[9] To characterize the resulting chemical compounds, we have performed three different kinds of experiments using SEM (scanning electron microscopy), EDS (electron dispersive spectroscopy) and x–ray diffraction measurements on the following two samples: (1) an Al powder without heat treatment and (2) an Al powder that was heated at 1100 ^{o}C for 40 min and quenched in water in less than 2 sec.

A very fine powder of crystalline Al with 300 mesh, i.e., a maximum grain size of ~ 1 inch/300 ~ 85 micrometers (μm), was chosen to maximize the oxidization during the experiment. We prepared two Al samples: one sample was just taken out of the sample bottle without any heat treatment, while the other was put in a horizontal furnace, and heated up to 1100 ^{o}C that is well above the melting temperature of Al, 660 ^{o}C, and stayed at 1100 ^{o}C for ~ 40 minutes, before it was taken out quickly and put into a jar of water. The procedure of taking out and putting it into the water took less than 2 seconds. For the characterization measurements, each sample was divided into two portions: a larger amount that was used for the x–ray measurement and a smaller amount used for the SEM/EDS.

For the x–ray measurements, the samples were placed on glass plates, while for the EDS measurements they were placed on carbon tapes that were attached to small carbon circular plates. One thing to remember is that x–ray penetrates into the sample about a few hundred μm while EDS penetrates only about several μm. Thus EDS probes the atomic composition of the surface of the sample while x–ray probes the chemical material composition of the sample in bulk. Fig. 3 (a)–(c) show the SEM images and EDS data obtained from the untreated sample. The SEM image shows that the untreated Al samples have typical grain sizes of ~ 10 μm to ~ 100 μm. Fig. 3 (b) is a close–up of one large grain on which the EDS data was taken as a function of energy (see Fig. 3 (c)). The EDS data clearly exhibits the Al peak centered at around 1.5 keV. There are no other peaks, except the signal of the carbon plate on which the sample was placed.

---

[7] Ibid. 261–82.
[8] Ibid. 153.
[9] R. Friedman and A. Macek, "Ignition and Combustion of Aluminium Particles in Hot Ambient Gases," *Combustion and Flame* 6 (1962), A. G. Merzhanov, Yu M. Grigorjev, and Yu A. Gal'chenko, "Aluminium Ignition," *Combustion and Flame* 29 (1977), T. G. Theofanous *et al*., "Ignition of Aluminum Droplets Behind Shock Waves in Water," *Physics of Fluids* 6, no. 11 (1994).

We have also looked at other grains, and obtained similar EDS data. Fig. 4 (a) shows the x–ray diffraction data obtained from the untreated sample. Sharp peaks were found in the x–ray data, which are called Bragg peaks and are well accounted for by a polycrystalline Al sample. This confirms that the untreated Al sample was of high quality without any oxidization.

On the other hand, Fig. 3 (d)–(f) show the SEM images and EDS data of the heat–treated and quenched sample. The SEM images (Fig. 3 (d) and (e)) are much shinier than those of the untreated sample (Fig. 3 (a) and (b)). This tells that the metallic Al grains are oxidized on the surface into the insulating Al_2O_3 from which the incident electrons are reflected rather than penetrating into the sample. Thus, the shiny SEM images indicate that oxidization occurred during the heating and quenching as expected. The EDS data shown in Fig. 3 (f) exhibit oxygen peak centered at ~ 0.52keV in addition to the Al peak at ~ 1.5keV, which confirms that the surface of the Al grains are oxidized. One thing to be noted is that the relative strength of the Al and O EDS signals, I(O)/I(Al) = 0.25 for the treated sample, which will be discussed in detail later.

(Figure 3)

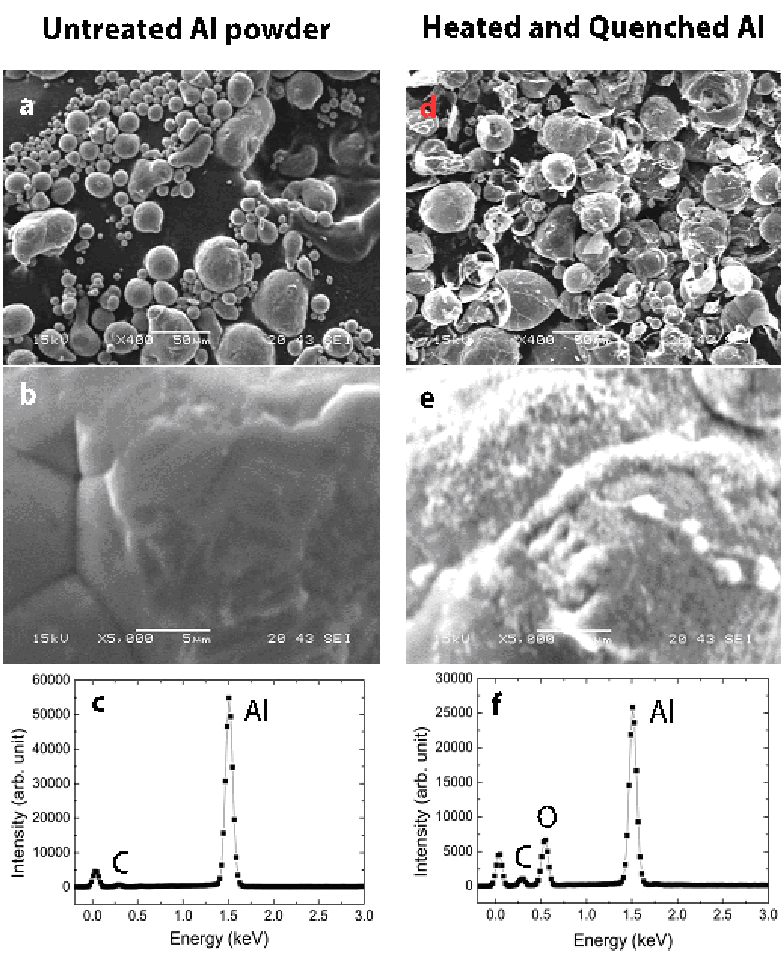


Figure 3: SEM and EDS data of (a)–(c) the untreated Al sample and (d)–(f) the melted and rapidly quenched Al sample. (a), (b), (d) and (e) are the SEM images. (c) and (f) are the EDS data

To determine how much Al has been oxidized during the heat treatment and which form, crystalline or amorphous, the oxidized Al and the un–oxidized Al were turned into, we performed x–ray diffraction measurements. Fig. 4 (b) shows the result. Unlike the x–ray data of the untreated sample (Fig. 4 (a)), the x–ray data of the heat–treated sample exhibit two sets of well–defined sharp Bragg peaks from crystalline Al and crystalline Al_2O_3. This x–ray data unambiguously tell us that during the heat and quenching process the Al sample was oxidized only partially and the resulting Al and the oxidized Al_2O_3 become crystalline rather than amorphous. Our refinement of the data determined that the surface of the Al grains were oxidized during the heat treatment and the fraction of the oxidization is ~ 40 %.

(Figure 4)

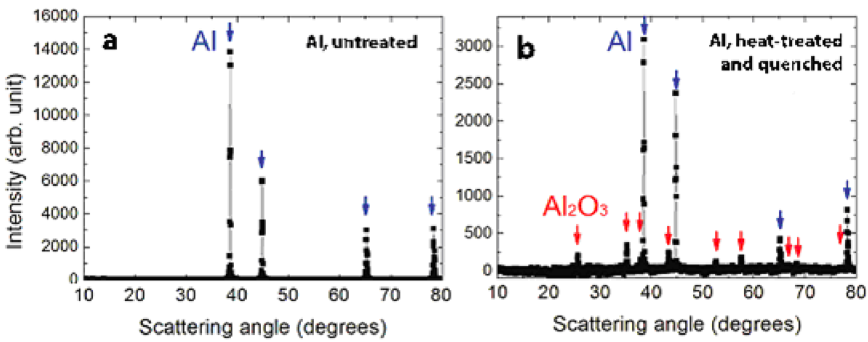


Figure 4: X–ray Data of (a) the untreated Al sample and (b) the melted and rapidly quenched Al sample

Comparing the JIG's Data and Ours

Now let us compare our data and the JIG's data. First, it is very strange that our treated sample's EDS data are very different from the EDS data of the JIG's test explosion experiment. It is well–documented in scientific studies that during explosion Al_2O_3 forms, and thus the JIG's EDS data should have I(O)/I(Al) ~ 0.25 as in our data (see Fig. 3 (f)) rather than their very high value of I(O)/I(Al) ranging from 0.8 to 1.2.[10] Furthermore, the JIG's EDS data shows the existence of a considerable amount of sulfur (S) that is unexpected for their test explosion experiment. Second, the JIG's test explosion EDS data are identical to their EDS data obtained from the sunken ship and torpedo propulsion system (see Fig. 2 (a)–(c)).

In order to understand the discrepancy between our and the JIG's EDS data, we used a standard EDS simulation software, NIST DTSA II, to find out what kind of EDS data would be expected for Al–related compounds.[11] Fig. 5 (a) shows the simulated EDS data for Al_2O_3 that is expected to form during explosion. The I(O)/I(Al) ratio is ~ 0.25 that is consistent with our EDS data, I(O)/I(Al) ~ 0.25 (Fig. 3 (f)). Fig. 5 (b) shows that if the sample is aluminum sulfate hydroxide ($Al_4(OH)_{10}(SO_4).x(H_2O)$), the I(O)/I(Al) becomes ~ 0.8 (x = 0) or 1.2 (x = 4), and also the sulfur peak will appear, which is consistent with the JIG's EDS data. This indicates that the samples that the JIG took from the sunken ship and torpedo fragments were aluminum sulfate hydroxide that is naturally formed below 100°C, rather than aluminum oxide.[12] In order words,

[10] Theofanous *et al*., "Ignition of Aluminum Droplets Behind Shock Waves in Water."
[11] The NIST DTSA II software is free and it can be downloaded from the website http://www.cstl.nist.gov/div837/837.02/epq/dtsa2/index.html.
[12] T. Delfosse, F. Elsass, and B. Delvaux, "Direct Evidence of Basic Aluminium Sulphate Minerals in an S–Impacted Andosol," *European Journal of Soil Science* 56, no. 3 (2005), J. Kim, S. Kim, and K. Tazaki, "Mineralogical

the JIG's claim that the white powder samples taken from the sunken ship and torpedo fragments were a critical evidence for an explosion is flatly wrong: the white powder samples were naturally formed at low temperatures below 100°C. Indeed, this was confirmed by two geologists, Dr. Panseok Yang at Manitoba University in Canada and Dr. Gi–Young Jeong at Andong National University in South Korea. Back in the summer of 2010, upon several requests from members of the National Parliament's Special Committee on the Cheonan, the JIG released some of the powder samples from the sunken ship and the torpedo part, and the two geologists performed independent research to find out the identity of the samples. After two months long research, they reached the same conclusion: the samples were aluminum sulfate hydroxide.[13]

(Figure 5)

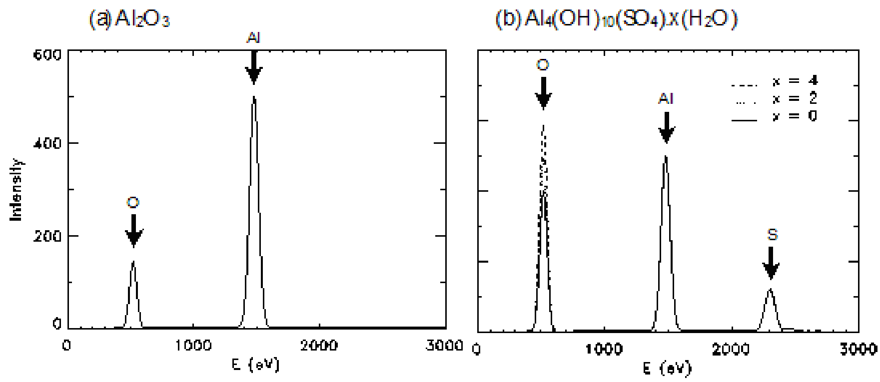


Figure 5: EDS data that were simulated using the NIST DTSA II software, (a) for aluminum oxide (Al_2O_3) and (b) aluminum sulfate hydroxide ($Al_4(OH)_{10}(SO_4).x(H_2O)$).

Now, let us discuss why we believe that the JIG's test explosion EDS data (Fig. 2 (c)) must be fabricated. During the test explosion of a real explosive, Al_2O_3 should have been produced. Thus, the data should have been similar to the simulated data for Al_2O_3 shown in Fig. 5 (a) and the data of our Al–melting experiment (Fig. 3 (f)). It is scientifically impossible for the test–explosion EDS data to be the data shown in Fig. 2 (c) unless a grave mistake had been made in the experiment or the data had been intentionally made to fit the JIG's conclusion. For almost two years since the publication of the final report, the JIG has stood by its data and conclusion. We thus exclude the possibility of an unintentional mistake, and arrive at only one possible explanation: the JIG's test explosion EDS data (Fig. 2 (c)) must have been fabricated. Given the pattern that we discuss earlier in the article that the JIG makes a number of efforts to fit the data to its conclusion, we conclude that it fit the data to its claim that the white powder samples from the sunken ship and torpedo fragment are products of an explosion. Interestingly, the JIG has thus far refused to release the white powder samples from their test–explosion experiments.

Characterization of Microbial Ferrihydrite and Schwertmannite, and Non–Biogenic Al–Sulfate Precipitates from Acid Mine Drainage in the Donghae Mine Area, Korea," *Environmental Geology* 42, no. 1 (2002).

[13] Ŏyŏng Ha, Pohyŏp Kim, and Ujong Ryu, "Ch'ŏnanham Hŭpch'akmulŭn 'Alumiyumhwangsanyŏmsuhwamul', P'okpaljaega Anida [Cheonan's Adsorbed Material Is 'Aluminium Sulphate Hydrate,' Not Explosion Byproduct'," *Han'gyŏre21*, November 19 2010.

Conclusion

We have shown in this article beyond doubt that the Joint Investigation Group incorrectly identifies the white powder from the Cheonan and the torpedo part as aluminum oxide. Its own data and our experiments, as well as two independent tests by scientists in Korea and Canada respectively, show the powder to be aluminum sulfate hydroxide hydrate, which existing studies report results naturally from a low temperature environment. Given that the powder is the only material evidence that the JIG presents to connect the Cheonan and the torpedo to a common explosion, the JIG has to acknowledge that it has failed to prove beyond reasonable doubt that there is a causal relationship between the ship's destruction and the torpedo's explosion. On the basis of the material evidence alone, the JIG must acknowledge that the torpedo part did not cause the ship's destruction.

Given the political importance of our finding, we humbly propose that the South Korean government reopen an investigation of the cause of the Cheonan's sinking and that the investigation be carried out by a group of experts independent of the Ministry of National Defense and the government as a whole. This can be done if the 19^{th} National Parliament passes a special law requiring an inspection or if the new President, elected in December 2012, directs a new investigation. Given that the accident involved the Ministry of National Defense, and by extension the executive body, the Parliamentary route will better ensure an objective and neutral investigation.

Science offers a useful and powerful tool with which to identify the cause of an accident. At the same time, it can be a tool that obfuscates reality or makes it difficult to understand it. Even worse, it may be misused to lend the aura of objective truth to a claim that is based on ambiguous evidence. However, our study confirms that replication is the standard of scientific knowledge that can thwart an attempt to abuse science for a non–scientific motive. The more politically sensitive one's claim is, the more important it is to scientifically replicate the claim and verify it.

REFERENCES

Delfosse, T., F. Elsass, and B. Delvaux. "Direct Evidence of Basic Aluminium Sulphate Minerals in an S–Impacted Andosol." *European Journal of Soil Science* 56, no. 3 (2005): 281–86.

Eccles, Tom. "Loss of ROK's Cheonan: US Support to the Republic of Korea Joint Investigative Group 12 April through 24 May 2010," powerpoint brief, May 27, 2010.

Friedman, R., and A. Macek. "Ignition and Combustion of Aluminium Particles in Hot Ambient Gases." *Combustion and Flame* 6 (1962): 9–19.

Ha, Ŏyŏng, Pohyŏp Kim, and Ujong Ryu. "Ch'ŏnanham Hŭpch'akmulŭn 'Alumiyumhwangsanyŏmsuhwamul', P'okpaljaega Anida [Cheonan's Adsorbed Material Is 'Aluminium Sulphate Hydrate,' Not Explosion Byproduct'." *Han'gyŏre21*, November 19 2010.

Kim, J., S. Kim, and K. Tazaki. "Mineralogical Characterization of Microbial Ferrihydrite and Schwertmannite, and Non–Biogenic Al–Sulfate Precipitates from Acid Mine Drainage in the Donghae Mine Area, Korea." *Environmental Geology* 42, no. 1 (2002): 19–31.

Merzhanov, A. G., Yu M. Grigorjev, and Yu A. Gal'chenko. "Aluminium Ignition." *Combustion and Flame* 29 (1977): 1–14.

Ministry of National Defense. *The Joint Investigation Report on the Attack against ROK Ship Cheonan*. Seoul: Ministry of National Defense of the Republic of Korea, 2010.

Reid, Warren D. *The Response of Surface Ships to Underwater Explosions*. Melbourne, Victoria, Australia: Defence Science and Technology Organisation, Department of Defence, 1996.

Theofanous, T. G., X. Chen, P. Di Piazza, M. Epstein, and H. K. Fauske. "Ignition of Aluminum Droplets Behind Shock Waves in Water." *Physics of Fluids* 6, no. 11 (1994): 3513–15.

ABOUT THE AUTHORS

Prof. Seung-Hun Lee: University of Virginia, USA

Prof. Jae-Jun Suh: Johns Hopkins University, USA

The Alternative Conceptions Held by High School Students in Mechanics

Stephan Paraffin Mchunu, University of Zululand, South Africa
Sitwala Imenda, University of Zululand, South Africa

Abstract: The main purpose of this study was to identify alternative conceptions held by high school learners concerning mechanics, as one of the major topics in South Africa's NCS. The research sample comprised 140 grade 12 students from four high schools. A researcher-designed test was used to collect the required data. Although quantitative data were collected, the main thrust of data analysis for this paper was on the qualitative data generated. The results showed that the students mainly held eight alternative conceptions related to mechanics. These were that (a) the velocity and acceleration of a projectile increase as the projectile goes up; (b) the weight, or mass, of an object has an effect on the magnitude of the force it exerts; (c) force is needed to keep an object moving at all times, (d) only active agents exert force; (e) objects that are not moving do not exert force; (f) action-reaction forces occur at different times.; (g) at the highest point, the acceleration of a projectile is zero; and (h) motion implies active force. These findings are discussed, and recommendations made.

Keywords: Alternative Conceptions, High School Students, Physics, Mechanics, South Africa

Introduction

The view that learners do not come to class with empty minds because they develop beliefs about things that happen in their surroundings from the very earliest days of their lives has been echoed by many authors (e.g. Wandersee, Mintzes and Novak 1994; Talanquer 2006; Ochsendorf and Pyke 2007; Coetzee 2009). This view is supported by cognitive scientists who contend that physics students come to class with a set of beliefs which they are typically unwilling to discard, even in the face of evidence to the contrary (Oliver 1992). Thus, learners come to the physical science class with already strongly held ideas, which may differ from the theories the educator may wish to develop in them. These strongly held ideas are referred to by several names – such as home knowledge, misconceptions, pre-conceptions, students' naïve ideas, students' primitive ideas, common-sense conceptions, alternative conceptions, and so on. This paper prefers the term 'alternative conceptions'.

It has also been reported that alternative conceptions, once formed, influence learners' observations and the sense they make of future learning – and tend to be resistant to change, making a considerable number of learners hold on to certain intuitive notions despite the science teaching they receive in school (Driver 1983; Richardson 1990; Tsai 2003; Clement 2006).

The importance of paying attention to the alternative conceptions that learners bring to the classroom lies in the contention that these could sometimes hinder learning. In this vein, Oliver (1988) points out that new learning depends on previous learning in a number of ways in that (a) correct new learning depends on previous correct learning; (b) incorrect new learning is often the result of previous incorrect learning, and in the same way; (c) incorrect new learning is mostly the result of previous correct learning; (d) every alternative conception has a legitimate origin in the previous correct learning – each alternative conception was correct for some earlier task, as performed in some earlier domain of the curriculum; and (e) the source of alternative conceptions is mostly an overgeneralization of previous knowledge (that was correct in an earlier domain), to an extended domain (where it was not valid).

Many alternative conceptions learners have are hidden in the mistakes they make. Learners do not make mistakes because they are stupid – their mistakes are rational and meaningful efforts to cope with science. Alternative conceptions have their own origins in a number of sources. Schoon (1995) reports that many alternative conceptions originate in the classroom. Advancing

The International Journal of Science in Society
Volume 4, 2013, www.science-society.com, ISSN 1836-6236

this point further, Coetzee (2009) reports that, despite textbooks being the main sources of students' knowledge in many classrooms, they are a major contributor to the existence of alternative conceptions. However, Coetzee hastens to point out that the common origin of alternative conceptions could be any previous experience or observation by the learner, not necessarily arising out of formal training, but any life experience.

With regard to mechanics, Steinberg, Brown and Clement, (1990:1) state that "research has shown that serious misconceptions frequently survive high school and university instruction in mechanics". One most common alternative conception is one which dates back for ages – the idea that sustaining motion requires a continued force. Prior to Newton's time, everyone assumed that a force was needed to keep an object moving. For example, if one slides a book across a table, it soon stops. To keep it moving, one needs to continue to push it on. Indeed, it is nearly obvious that this observation, although correct, does not apply to objects that have zero resultant force acting on them (Bueche 1986:57). Learners need to view physics as a system of thinking about the world rather than information that can be dumped into their brain without evaluating its consistency with their belief systems (Giancoli 2000).

There are also some alternative conceptions related to Newton's third law of motion. The word force is used to describe the interaction between two objects. By way of definition, force is a push or pull upon an object resulting from the object's interaction with another object (Giancoli 2000). When two objects interact, they exert forces on each other. Newton's third law states that these forces are equal in magnitude and opposite in direction. If object A exerts a force on object B, object B exerts a force on A that is equal in magnitude but opposite in direction.

Thus, the forces always occur in pairs. It is common to refer to one force in the pair as an action and another as a reaction. However, according to Tipler (1997: 89) this terminology is unfortunate because it sounds like one force 'reacts' to the other, which is not the case in that "both forces occur simultaneously. Either can be called the action and the other the reaction."

In support of Tipler's view, Brown and Clement (1987) also state that "it makes no difference which force you call the action and which one the reaction, because they occur at exactly the same time." The action does not 'cause' the reaction; action and reaction coexist – such that there cannot be one without the other. Brown and Clement (1987) further maintain that in a way these forces are like debt and credit. One is impossible without the other; they are equally large but of opposite signs, and they happen to two different objects. Giancoli (2000) also contends that to avoid confusion, it is important to remember that the action force and the reaction force are acting on different objects. Equally importantly, it is also important to dispel the often misinterpreted meaning that the two forces cancel each other out because they are of equal strength and act in opposite directions.

Two other important concepts in mechanics are mass and weight. Learners tend to confuse mass with weight, and vice versa. As Griffith (2007: 64) points out, weight is a familiar term often used interchangeably with mass in everyday language. Learners take these concepts as used in day-to-day, layman's language and extend this to their understanding of mechanics – thereby leading to alternative conceptions. Physicists make a distinction between mass and weight that is important to Newton's theory. Bueche (1986: 61) points out that mass is defined in terms of a one kilogram standard; other masses are defined in comparison to this standard. Thus, mass is a scalar quantity, that is, it only has magnitude, and its Systeme International (SI) unit is kilogram (kg).

Tipler (1997: 85) defines mass as an intrinsic property of an object that measures its resistance to acceleration. That is, the measure of an object's inertia. In the same way, Giancoli (1991) also defines mass as the measure of the inertia of a body, that is, the more mass a body has, the harder it is to change its state of motion. It is harder to start it moving from rest, or to stop it when it is moving, or to change its motion sideways out of a straight-line path.

On the other hand, the weight of an object is the force with which gravity pulls on it. Muncaster (1993: 13) defines weight of a body as the force acting on its mass due to the gravitational attraction of the earth. Weight is a vector quantity, that is, it has both magnitude and direction. The SI unit of weight is newton (N) plus direction. Thus, whereas the mass of a body is the same everywhere, the weight of a body on the surface of the earth depends on where it is, that is, its location, and would have considerably different values at other places in the Universe.

The above snapshot presentation of literature review on alternative conceptions, generally and more specifically concerning mechanics, indicates that there is a major concern regarding learners' meaningful engagement with the physics concepts. In this respect, Brown and Clement (1987) maintain that alternative conceptions are widespread and are resistant to change – and that learners come to the science classroom with a number of alternative conceptual frameworks which inhibit the learning and understanding of certain concepts. Indeed, in South Africa, the analysis of the performance of Grade 12 physical science learners in 2010, for instance, revealed that the basics of mechanics "were not attended to during the teaching and learning" (Department of Education 2010:1). This suggested that the way teaching and learning took place in classes contributed to the increase of the conceptual difficulties in the learners' mind and hence less alleviation of the alternative conceptions. It was, therefore, recommended that more educator workshops be organized on topics like *work, energy and projectile motion*.

The Aims of the Study

It has long been realized that students possess their own notions about things that happen in their lives and environments as they grow up (Talanquer 2006). As Kyle, Family and Shymansky (1989: 1) observe:

> From the moment of birth infants begin to generate views about their new environment … and, long before children begin the process of formal education, they attempt to make sense of the natural world. Thus, children begin to construct sets of ideas, expectations, and explanations about natural phenomena to make meaning of their everyday experiences.

However, the ideas and explanations that children generate form a complex framework for their own thinking about the world, but frequently differ from the views of scientists (Kyle, *et al* 1989; Wandersee, *et al* 1994; Talanquer 2006). Ochsendorf and Pyke (2007: 7) make a similar remark as follows:

> The role of prior knowledge in the learning process has been well researched and the results of many studies are generally in agreement … that prior knowledge has a strong positive relationship with improved learning outcomes. That is, when students come to learning situations with more prior knowledge about a topic, they are likely to learn more than other students who possess less prior knowledge.

Certainly, in situations where students' prior knowledge falls within the same conceptual paradigm as the espoused, scientific knowledge, what Ochsendorf and Pyke state would be the case. However, where the students' prior knowledge falls outside the dominant scientific domain, learning difficulties are bound to occur as the students experience dissonance between explanations in their lived-worlds and those espoused by the formal education system. It is in these cases, in particular, that educators need to pay special attention to the notions about the world that students bring to the classroom. It is the discrepancy between the concepts constructed by children, on one hand, and those held by the community of scientists, on another, which educators seek to address. Thus, the aim of this study was to investigate the most prevalent alternative conceptions held by high school learners – such alternative conceptions as may interfere with intended learning. The identification of alternative conceptions was seen as a first important and necessary step towards future research that would focus on developing curricular interventions that would address such alternative conceptions and allow for a better learning experience and success for the learners.

Research Objective

Pursuant to the above aim, this study set out to identify and document the most prevalent alternative conceptions relating to mechanics amongst Grade 12 physical science learners in the Empangeni school district, KwaZulu Natal, South Africa.

Research Methods

The research methods are presented below under several sub-headings, as indicated.

Research Sample

This study focused on grade 12 learners' alternative conceptions in mechanics. Empangeni Education District grade 12 physical science learners constituted the target population of this study. Therefore, all grade 12 physical science learners in Empangeni Education District formed a natural grouping in respect of this research topic. There are four (4) education circuits in the Empangeni Education District – that is, Lower Umfolozi, Mthunzini, Nkandla and Eshowe. For the purpose of this study, all grade 12 physical science learners in the Lower Umfolozi Education Circuit constituted the accessible population, since Empangeni Education District is too wide. The accessible population was deemed to be identical to the target population in that all types/categories of schools that are found in the target population are also found in the accessible population. The accessible population was chosen because it was near enough to the first researcher and possessed the same major and critical characteristics of the target population.

This study involved a total of 140 grade 12 physical science learners drawn from four high schools in the Lower Umfolozi Circuit of the Empangeni Education District. These high schools were coded as A, B, C and D. There were 35 grade 12 physical science learners selected per school constituting one intact class. Non-probability, convenience sampling was used to select participating schools. According to Leedy and Ormrod (2005:206), convenience sampling "takes people or other units that are readily available" for selection. Leedy and Ormrod(2005:206) further state that "in this type of sampling some members of the population have little or no chance of being sampled". The selected schools were geographically convenient to reach by the first author who carried out the field research. Thus, no claim is made in this study that the selected schools were representative of the wider, high school population in the province.

Instrumentation

This study made use of a researcher-designed test: the Test in Basic Mechanics (TBM) to collect the required information. The TBM comprised two sections, and was used to obtain biographical information and determine the familiarity of learners about mechanics (projectile motion, forces, Newton's laws, work and energy). The test comprised both structured and open-ended items. The questions were based on targeted alternative conceptions identified from the literature review, those identified from the pilot study, as well as alternative conceptions which had emerged from learners' responses and problematic notions, from the researchers' experiences as physical science educators. Accordingly, there was a deliberate attempt to focus not only on the learners' knowledge of mechanics concepts and principles but, even more importantly, on the underlying conceptual understanding. The second section of the TBM consisted of multiple choice questions – each of which was followed by an open-ended question where the answer had to be motivated. Furthermore, the learners were asked to rate themselves before motivating each answer. The ratings were categorized as "just a blind guess", "not very sure", "fairly sure" and "I'm sure, I'm right".

Validity and Reliability

Debates among researchers about qualitative research perspectives revolve around issues of data gathering and analysis techniques, as well as validity and reliability. With regard to validity, the TBM was validated by one science education expert and two physics lecturers– all three from the University of Zululand, as well as one physical science subject advisor from the Empangeni Education District. The instrument was also cross-validated by two physical science educators (both Heads of Science Departments) from two schools that were not selected for participation in the study. The linguistic complexity of the text was also investigated to make sure it was not beyond the understanding of the grade 12 learners. In addition, the test, as a whole, was then proof-read by two colleagues before the pilot study was undertaken. This process was done in order to establish content and face validity, as well as to clear out misunderstandings or misleading and ambiguous texts. The feedback received from these experts was used to fine-tune the instrument. Many alternative responses were reformulated and rephrased to enhance clarity and remove ambiguity. The test was finalized after analysis of the pilot study, in readiness for the main study.

Reliability is much more difficult to establish where research data are predominantly qualitative in nature. Indeed, there is even a view that the construct of "reliability" itself is both irrelevant and misleading to qualitative research (Stenbacka 2001; Golafshani 2003), and that, rather, the notion of trustworthiness is the crucial one. On their part, Lincoln and Guba (1985:316) argue that "since there can be no validity without reliability, a demonstration of the former (validity) is sufficient to establish the latter (reliability)". Patton (2002) contends that with regard to the researcher's ability and skill in undertaking qualitative research that reliability becomes a consequence of the validity in a study. In this regard, Healy and Perry (2000) assert that "the quality of a study in each paradigm should be judged by its own paradigm's terms". In concurrence with this view, Lincoln and Guba (as cited by Golafshani 2003:601) posit that "the terms Reliability and Validity are essential criteria for quantitative paradigms, in qualitative paradigms terms Credibility, Neutrality or Conformability, Consistency or Dependability and Applicability or Transferability are to be essential criteria for quality".

To be more specific, qualitative research, construes the notion of "dependability", as applied to quantitative research, to correspond to "reliability" in quantitative research (Lincoln & Guba 1985). Indeed, imposing the requirements of the quantitative research paradigm on qualitative research is tantamount to applying soccer game rules on a boxing match. The two operate on conceptually different paradigmatic assumptions, and are undertaken to serve different purposes and achieve different ends. Unlike quantitative research, which is often based on a logical positivist philosophy (often-times espousing one particular worldview), qualitative research assumes that there are multiple realities which are socially constructed through individual and collective definitions of particular situations (McMillan and Schumacher 1993). As Denzin and Lincoln (1994:3) aver, the main aim of qualitative research is not to search out data or evidence to prove or disprove hypotheses formulated before the study commenced - as is the case with the dominant positivist paradigm on which most quantitative research rests. Rather, generalizations are developed as singular particulars are pieced together – thereby leading to the bottom-up (rather than top-down) development of knowledge and theory (Bogdan and Biklen 1992). Consequently, construction of meaning and knowledge by both the researcher and other participants is overly central to the qualitative research paradigm – centering on the research epistemologies of phenomenology, hermeneutics and phenomenography (Popkewitz 1984; Gallagher 1992; Vandenberg 1992).

The TBM was meant to gather mainly qualitative data in the form of motivations advanced by the participating learners, as a way of determining and detecting the presence of alternative conceptions. The motivations were then considered to be a reliable measure of the learners' understanding – more than assumptions drawn simply on the basis of the learners' choices from multiple choice test items. Learners' motivations were categorized to reveal possible alternative conceptions when they presented evidence of having such alternative conceptions. In this regard, only responses which directly addressed a certain alternative conceptual theme were categorized. In the same way, uncertainties were categorized as 'not applicable', which included wrong statements and statements which could not be used for the purpose of the study.

Data Analysis

The main emphasis in this study was to collect qualitative data that represented the original thoughts of the respondents. As such, the analysis of the students' responses did not focus on the knowledge, *per se*, but the underlying conceptions behind the respondents' answers. The main interest of the researchers was to try and understand how the experiences of the respondents, within the context of their lived worlds, had shaped their understanding of various concepts related to mechanics. So, in this regard, the researchers searched for patterns of meanings from the statements and explanation given by the students. From there, descriptions and interpretations of the students' experiences were constructed and categorized. These categories emerged progressively from the data as the analysis proceeded.

Results and Discussion

The results are presented and discussed below under various sub-headings.

Demographics

The research sample consisted of more girls than boys. In total there were 140 learners who participated in the study, comprising 56 males (40%) and 84 females (60%). It is interesting to see that many female learners are interested in physical science. The majority of learners (66%) in the research sample were older than 17 years. Relatively fewer learners (7%) were 16 years of age – implying that these learners started schooling at an early age for them to have been in Grade 12 by the age of 16. The official age for starting school (i.e. grade 1) in South Africa is seven years of age.

All (140) respondents (100%) indicated that their Home Language (HL) was IsiZulu and their First Additional Language (FAL) was English. The language of instruction across all subjects was also English. Therefore, the language barrier was a possible factor with regard to the comprehension and understanding of instruction and science concepts in physical science.

Most Prevalent Alternative Conceptions

The research objective of this study was to identify and document the most prevalent alternative conceptions held by grade 12 physical science learners about mechanics. The alternative conceptions, as identified from the quantitative and qualitative analysis of the TBM were categorized. Overall, eight categories of alternative conceptions were identified. Each category was assigned a symbol (AC1 to AC8), in no specific order of significance. Abbreviation AC stands for 'alternative conception'.

After the analysis was completed, it was not possible to tell which alternative conceptions came from which students – and whether or not there were patterns in the types of alternative conceptions given respondents presented. When the questions were constructed, it was not possible to foresee which alternative conceptions would originate from a question. Some alternative conceptions occurred in more than one question; and some of the options of the multiple choice questions indicated alternative conceptions, while others were identified from the motivations.

The following eight sub-sections briefly present the most prevalent alternative conceptions about mechanics which this study revealed.

AC1: The Velocity and Acceleration of Projectiles

Alternative Conception: The velocity and acceleration of a projectile increase as it goes up.

The following quotes from learners illustrate the presence of this alternative conception:

> "The velocity increases as the stone goes up".
> "I think acceleration increases as the stone goes up".
> "While the stone is accelerating upwards, the velocity is increasing".
> "As the stone moves vertically upwards, the velocity decreases while the acceleration increases".

According to Giancoli (2000, 55) "projectile motion refers to the motion of an object that is projected into the air at an angle". In this regard, a projectile is an object (e.g. stone, ball or bullet) that is given an initial velocity by dropping, shooting, throwing or projecting (launching) it, and where the only other force acting on it is due to the force of gravity. Projectiles in motion have zero velocity at their greatest height. Projectiles take the same time to reach their greatest height from the point of upward launch as the time they take to fall back to the point of launch. In many cases the effect of air resistance is ignored. Again, in many cases the process by which the object is thrown or projected is not the issue of concern. Only the motion of a projectile after it has been projected and moving freely through the air under the action of gravity alone is considered. Thus, the acceleration of the object is that gravity, g, which acts downward with magnitude $g = 9.8\ m.s^{-2}$ (Giancoli 2000). Gravitational acceleration is the constant acceleration that a free falling object experiences due to gravitational attraction of the earth in the absence of air resistance, whether the object is moving upwards or downwards.

The velocity of the object decreases as it goes upward due to the action of gravity. In the same vein, the velocity of the object increases as it falls freely to the ground or to the thrower's hand. The acceleration due to gravity is constant and always acts downward. Bueche (1986, 46) posits that "like all accelerations, the acceleration due to gravity is a vector. It is directed downward toward the earth". In this way, falling objects speed up and rising objects slow down (Bueche 1986).

Given the above, therefore, conventional science does not support the view that the velocity and acceleration of projectiles increase as an object goes upwards.

AC2: Weight/Mass of an Object

Alternative Conception: The weight, or mass, of an object has an effect on the magnitude of the force it exerts.

This alternative conception was also derived from a number of explanations and motivations given by the learners in response to one of the questions.

> "Because the monument is larger than the mosquito."
> "I think it is because the mosquito has a smaller weight than the monument."
> "I think it is because the mosquito is too small to exert a force."
> "A mosquito exerts force on the monument which is less than the force exerted by the tower."

"I am fairly confident because the monument has got a bigger mass as compared to the mosquito and hence the monument exerts a larger force to the mosquito although they both apply a force on each other".
"The monument exerts a larger force from the earth and it is pushing up the mosquito."
"The mosquito has a small force."
"Because the monument is bigger than the mosquito."

This alternative conception relates to Newton's Third Law of motion. Kirkpatrick and Francis (2010) use the example of a ball with a weight of 10 Newton falling freely towards earth. The ball exerts an upward force on the earth of 10 Newton while the earth exerts a downward force on the ball of 10 Newton. These forces are equal in magnitude but opposite in directions. Kirkpatrick and Francis (2010, 50) thus state that "common sense may tell you that earth must exert a larger force because it is so much larger, this is not true." They further posit that "no matter what the origin of the forces, Newton's third law tells us that the forces must be equal in size and opposite in direction" (Kirkpatrick & Francis, 2010, 51). This illustration explains that the mass or weight of an object has no effect on action-reaction force pair.

AC3: Force Concept

Alternative Conception: Force is needed to keep an object moving at all times.
The following quotes from learners explain and support this alternative conception:

"A force is always needed to keep an object moving."
"An object can only move when there is a force applied."

This alternative conception existed long ago. In this regard, Tillery (2009, 32) observes that "the Greek philosopher Aristotle incorrectly thought that an object moving across earth's surface requires a continuously applied force to continue moving ... it took about two thousand years before people began to correctly understand motion". Force causes motion and force is needed to keep objects in motion but not always. Newton's First Law states that an object will continue to move with constant velocity in a straight line. This can only happen in the absence of the unbalanced force. When the velocity is constant there is no acceleration and hence zero net force or resultant force. Therefore, an object can still move even if the net or resultant force is zero.

AC4: Objects in Motion

Alternative Conception: Only active agents exert force.
This alternative conception resulted from two questions showing (a) a stubborn goat pushing against the wall and (b) a mosquito landing on top of a monument.
The following quotations from learners illustrate the reasoning behind the above alternative conception:
(1) Stubborn goat pushing against the wall.
"The goat has a larger force than the wall because the wall is not moving."

(2) Mosquito landing on top of the monument.
"Because it is the mosquito that is moving, the monument is just stand still."
"Because the mosquito is a moving object and the monument exerts an earth force."

Terry and Jones (1986, 1) report that "pupils' alternative frameworks and misconceptions about force and motion have been widely reported." According to Newton's third law, the stubborn goat pushing against the wall does not mean that the wall is not exerting force against the goat, although the wall is not moving. Similarly, the mosquito landing and exerting a force on the monument does not mean that the monument is not exerting a force on the mosquito – again, notwithstanding that the monument is not moving.

AC5: Static Objects

Alternative Conception: Objects that are not moving do not exert force.

In addition to the explanations given above, this alternative conception was further based on responses from a question showing a book resting on a table. Both the book and the table are not moving but it does not mean that there are no forces exerted. Griffith (2007) states that the book exerts a downward force on the table, and the table exerts an upward force on the book. The two forces are equal but opposite in directions. However, some of the learners in this study did not see it this way. The following are quotations from learners which illustrate this alternative conception:

> "Book on the table exerts no force on the table since it is not moving."
> "Because both of them are not moving, they both have no weight so they are not exerting any force."
> "The book is not moving on the table so no force is exerted."
> "Neither the table nor the book exerts a force since they are both at rest."
> "Neither of the table/book exerts a force on each other because the book is at rest it cannot exert a force."

Brown and Clement (1987) report the common alternative conception that static objects are unable to exert a force. In their study, learners also maintained that a table did not exert a force upward on a book resting on it. Thus, the results of this study concur with this earlier result. In explaining this alternative conception, Giancoli (2000, 83) avers that "we tend to associate forces with active bodies such as humans, animals, engines, or a moving object like a hammer". All these examples suggest that a force is caused by animate objects or moving objects. Even a force itself, when exerted may cause no noticeable effect. In this way, Giancoli (2000) further posits that "it is often difficult to see how an inanimate object at rest, such as a wall or a desk, can exert a force". To facilitate understanding of this phenomenon, Giancoli (2000, 83) explains that "every material, no matter how hard, is elastic, at least to some degree … And just as a stretched rubber band exerts a force, so does a stretched (or compressed) wall or desk". Therefore, a seemingly innate and static object does exert a force.

AC6: Newton's Third Law of Motion

Alternative Conception: Action-reaction forces occur at different times.

The following quotations from learners illustrate this alternative conception:

> "Because Newton's Third Law agrees that both forces are exerted at different times on different objects."
> "If object A exerts a force on object B, they will both be exerted at different times."
> "If object A exerts a force on object B, they will both be exerted at different times".

Newton's third law states that when pairs of objects interact they exert forces on each other. These forces are equal in size but point in opposite directions. Thus, according to this law, a force pair will (a) be the same size but in opposite directions; (b) work along the same line; (c) exert a force on two objects; (d) be of the same force type; and (e) be exerted at the same time.

In this regard, Newton is credited as having said "whatever draws or presses another is as much drawn or pressed by that other" (Brown and Clement 1987, 28), and "if you press a stone with your finger, the finger is also pressed by the stone" (Kirkpatrick and Francis 2010, 50).

According to Brown and Clement (1987, 28):

> This statement suggests that forces always arise as a result of mutual actions ('interactions') between objects. If object A pushes or pulls on object B, then at the same time object B pushes or pulls with precisely equal force on A. These paired pulls and pushes are always equal in magnitude, opposite in directions, and on two different objects.

Brown and Clement (1987) further posit that Newton's third law is about action-reaction pair. It makes no difference which force you call the action and which the reaction, because they occur at exactly the same time. Thus, "because the two forces are equivalent, it doesn't matter which one is called the action and which the reaction" (Kirkpatrick and Francis 2010, 50). The action does not 'cause' the reaction. Action and reaction coexist – one cannot have one without the other. Most important, the two forces are not acting on the same object.

AC7: Acceleration of Projectiles

Alternative Conception: At the highest point, the acceleration of a projectile is zero.

The following two quotations epitomise the responses advanced by the responses to support the above alternative conception:

> "The acceleration of the stone decreases and becomes zero at the highest turning point."
> "The acceleration increases during free fall of the stone."

For projectile motion, Giancoli (2000) states that the acceleration of an object acts downward with magnitude $g = 9.8\ m.s^{-2}$. As stated under AC1 with regard to this notion, Giancoli (2000) posits that gravitational acceleration is the constant acceleration that a free falling object experiences due to gravitational attraction of the earth, in the absence of air resistance, whether the object is moving upwards or downwards. Cutnell and Johnson (2010) emphasize that it is the velocity of the projectile that becomes zero at the highest point. They further maintain that "the acceleration vector is not zero at the top of the motional path just because the velocity vector is zero there" (Cutnell and Johnson 2010, 46). By way of definition, "acceleration is the rate at which the velocity is changing, and the velocity is changing at the top even though at one instant it is zero" (Cutnell and Johnson 2010, 46). It is also an alternative conception to say that the acceleration of a projectile is zero at the highest point (Giancoli 2000).

AC8: Active Force

Alternative Conception: Motion implies active force.

This alternative conception is based on responses to the two questions involving (a) a book resting on a table, and (b) a mosquito landing on a monument. The following quotations from learners illustrate this alternative conception:

Book Resting on the Table

No Motion, No Force

> "Because both of them are not moving, they both have no weight so they are not exerting any force".
> "The book is not moving on the table so no force is exerted."

Mosquito Landing on a Monument

Mosquito Exerts Larger Force

> "Because it is the mosquito that is moving, the monument is just stand still."
> "Because the mosquito is a moving object and the monument exerts an earth force."
> "Mosquito has power to force."
> "Because the mosquito is the one standing on top of the monument there is pushing force."

Hestenes, Wells and Swackhamer (1992) report that students hold an alternative conception about the force concept, particularly active force producing motion. Hestenes et al (1992) state that active force is an alternative conception that corresponds most closely to Newton's second law of motion. The above example of a stubborn goat pushing against a wall is a good illustration of this point. There is an active force exerted by the goat but the wall does not move. The goat is an active agent. However, it does appear that "active forces have their limits, that is, a limited capacity to produce motion" (Hestenes et al 1992). This means that a force may cause no noticeable effect when exerted on an object.

Summary

As a way of summarizing the above results and discussion, Table 1 presents the eight most prevalent alternative conceptions identified in this study. The frequencies in the last column are presented to give the reader a sense of the degree of prevalence of these alternative conceptions in the research sample.

Table 1: Most Prevalent Alternative Conceptions (n=140)

Category	*Alternative Conception*	*Frequency*
AC1	**THEME: The Velocity and Acceleration of Projectiles** The velocity and acceleration of a projectile increase as it goes upwards.	47
AC2	**THEME: Weight/Mass of an Object** The weight, or mass, of an object has an effect on the magnitude of the force it exerts.	44
AC3	**THEME: Force Concept** Force is needed to keep an object moving at all times.	47
AC4	**THEME: Objects in Motion** Only active agents exert forces	47
AC5	**THEME: Static Objects** Objects that are not moving do not exert forces.	55
AC6	**THEME: Newton's Third Law** Action-reaction forces occur at different times.	54
AC7	**THEME: Acceleration of Projectiles** At the highest point, the acceleration of the projectile is zero	51
AC8	**THEME: Active Force** Motion implies active force	50

It is quite clear from this table that these alternative conceptions are prevalent among grade 12 physical science learners. This leaves the teachers with the challenge of arranging and presenting these learners with those learning experiences which will make them willingly abandon the alternative conceptions in favor of scientific explanations of the phenomena. The tasks of overcoming alternative conceptions involves becoming aware of the misconceptions, considering alternative conceptions or explanations, making a personal evaluation of the two competing ideas and adopting a new conception that is more plausible than the previously held misconception. This system involves self-reflection (to ponder on one's own belief systems), critical thinking (to analyze the reasonableness of two competing ideas), and evaluation (Oliver 1992).

Schoon (1995:2) contends that "understanding how alternative conceptions are formed can make it easier for classroom teachers to help their students uncover their own alternative conceptions". One effective way of overcoming alternative conceptions is to use computer simulations as an alternative instructional tool (Jimoyiannis and Komis 2001, 1). It is argued that this helps students to confront their cognitive constraints and develop functional understanding of physics. Indeed, Ozmen, Demircioglu and Demircioglu (2009) report of findings which suggest that conceptual change texts, combined with computer animations, can be effective instructional tools to improve students' conceptual understanding of science concepts. This could be accompanied by the alleviation of alternative conceptions, and other learning difficulties. There is also a view that teachers and teacher educators need to change their mind-sets in favor of placing a greater emphasis on the understanding of basic but critical conceptions of science, even if the syllabus is not exhausted (Schoon and Boone 1998).

Clement (2006) designed lessons to deal with students' alternative conceptions in three areas of mechanics: static normal forces, frictional forces, and Newton's third law for moving objects. From the results of the study, Clement (2006) suggests that researchers and curriculum developers focus on identifying students' useful prior knowledge, as much as they concentrate on students' alternative conceptions. As Schoon and Boone (1998:2) opine, "some alternative conceptions may represent greater barriers to learning than others".

From a constructivist perspective, alternative conceptions are crucially important to learning and teaching, because they form part of a learner's conceptual structure that will interact with new concepts and influence new learning, mostly in a negative way, because alternative conceptions tend to generate errors. Furthermore, from a constructivist perspective the teacher cannot transmit ready-made and intact knowledge to the learner. Errors and alternative conceptions are seen as the natural result of learners' efforts to construct their own knowledge, and these alternative conceptions are intelligent constructions based on correct or incomplete (but not wrong) previous knowledge. Alternative conceptions, therefore, cannot be avoided. As such, errors arising out of alternative conceptions, should not be treated as terrible things to be uprooted, since this may confuse the learner and shake his/her confidence in his/her previous knowledge. Instead, errors should be seen as part of the process of learning. Physical science educators should therefore create a classroom atmosphere that is tolerant of errors and alternative conceptions and exploit them as opportunities to enhance learning. In this regard, the direct teaching (telling) approach may only be of limited benefit. Rather, teachers should help learners to connect new knowledge to previous learning. Thus, discussions, inter-learner and teacher-learner communications, reflections, and negotiation of meaning could all be essential features of a successful package of approaches to resolving learners' alternative conceptions.

Collaborative teaching and learning can also be used to enable meaningful learning and conceptualization of new concepts. In particular, collaborative learning also makes learners more active and self-reliant. Indeed, "the active, collaborative, reflective re-examination of ideas in a social context is one of the most important remedies for combating the illusion of misunderstanding and persistence of misconceptions" (Schulman 1999). In the same vein, Coetzee (2009, 88) posits that "collaboration is a powerful stimulus for the reflection which is fundamental to change beliefs, values and understanding".

Conclusion

In conclusion, it may be said that this study achieved its objective. The identification of the eight alternative conceptions, in mechanics, revealed by this study can go a long way in assisting high school teachers to better prepare their students for this topic.

REFERENCES

Brown, David E. and John Clement. 1987. "Misconceptions concerning Newton's law of action and reaction." *The Proceedings of the second international seminar on misconceptions and educational strategies in science and mathematics.* Ithaca, New York: Cornell University.

Bogdan, Robert C. and Biklen, Sari K. 1998.*Qualitative research in education: An introduction to theory and methods* (3rd ed.). Needham Heights, MA: Allyn & Bacon.

Bueche, Frederick J. *Introduction to Physics for Scientists and Engineers: International Student Edition.* New York: McGraw-Hill Book Company, 1986.

Clement, John. 2006. "Thought experiments and imagery in expert protocols." In L. Magnani (ed.), *Model-based reasoning in science and engineering* (pp. 151-166). London: College Publications.

Coetzee, Annaretha. 2008. "*Overcoming alternative conceptions concerning interference and diffraction of waves.*" Ed.D thesis, Department of Mathematics, Science and Technology Education, Faculty of Humanities, Tshwane University of Technology.

Cutnell, John D and Kenneth Johnson W. 2010. *Introduction to Physics* (8th ed., International Student Version), John Wiley & Sons, Inc.

Denzin, Norman K. and Lincoln, Yvonna S. 2000. *Handbook of qualitative research 2nd ed.*). Thousand Oaks, California: Sage.

Department of Education. 2010. *KZN Provincial Report 2010*: *Analysis of learner performance. Subject: Physical Sciences. Paper 1: Grade* 12 National Senior Certificate Results Analysis. Examiners' Report on Physical Sciences Learner Performance, Pietermaritzburg, South Africa.

Driver, Rosalind. 1983. *The pupil as scientist*. Milton Keynes: Open University Press.

Giancoli, D.C. 2000. *Physics. For Scientist and Engineers* (3rded.). Upper Saddle River: Prentice–Hall International Editions, U.S.A.

Golafshani, Nahid. 2003. Understanding reliability and validity in quantitative research. *The Qualitative Report8*(4): 597-606, Retrieved March 21, 2013 from http://www.nova.edu/ssss/QR/QR8-4/golafshani.pdf

Griffith, Thomas W. 2007. *The Physics of everyday phenomena*. A Conceptual Introduction to Physics (fifth ed.). Pacific University. New York: McGraw-Hill Company.

Healy, Marilyn and Perry, Chad.2000. Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm. *Qualitative Market Research*3(3): *118-126.*

Hestenes, David., Wells, Malcolm., and Swackhamer, Gregg. 1992. Force Concept Inventory, *The Physics Teacher* 30:*141-158.*

Jimoyiannis, Athanassios., Tassos Mikropoulos., and Konstantinos, Ravanis. 2000. Students' performance towards computer simulations on kinematics. *Themes in Education,* 1(4): 357-372.

Jimoyiannis, Athanassios., and VassilisKomis. 2001. Computer simulations in physics teaching and learning: a case study on students' understanding of trajectory motion. *Computer & Education* 36(2): 183-204.

Kirkpatrick, Larry D., and Gregory Francis E. 2010. *Physics: A Conceptual World View. International Edition* (7th ed.). Brooks/Cole: Cengage Learning Mary Finch Publisher, USA.

Kyle, Jr., William C., Family, Desmond, L.E., and Shymansky, James. 1989. "Research matters – to the science teacher, No. 8902: Enhancing learning through conceptual change teaching." http://www.narst.org./publications/research/concept.cfm Accessed on January 7, 2008.

Leedy, Paul D., and Ormrod, Jeanne. E. 2005.*Practical research planning and design*(8th ed.). New Jersey: Merrill Prentice Hall.

Lincoln, Yvonna S., and Guba, Egon G. 1985. *Naturalistic inquiry*. Beverly Hills, CA: Sage.

McMillan, James H. and Schumacher, Sally. 1993.*Research in education* (3rd ed.). A conceptual introduction; Narper Collins College. New York. U.S.A.

Muncaster, Roger. 1993. *A Level Physics* (4th ed.). Cheltenham: Nelson Thornes Ltd., UK.

Ochsendorf, Richard., and Pyke, Curtis. 2007. Assessment Practices in Curriculum materials research: Do Students learn from the pretest? Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, Illinois 10-14.

Oliver, Ron. 1998. "Partnerships in teaching and learning: An emerging role for technology." *Proceedings of EdTech'98: The Biennial Conference of the Australian Society for Educational Technology.* Perth: ASET.

Özmen, Haluk., Hülya, Demircioğlu and Gokhan, Demircioğlu. 2009. "The effects of conceptual change texts accompanied with animations on overcoming 11th grade students' alternative conceptions of chemical bonding." *Computers and Education* 52(3): 681-695.

Patton, Michael Q. 2002. *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Popkewitz, Thomas. 1984. *Paradigms and ideology in educational research.* Barcombe: Falmer Press.

Richardson, Virginia. 1990. "Significant and Worthwhile Change in Teaching Practice." *Educational Researcher* 19(7): 10-18.

Schoon, Kenneth J. 1995. "The origin and extent of alternative conceptions in the earth and space sciences: A survey of pre-service elementary teachers." *Journal of Elementary Science Education* 7(2): *27-46, DOI: 10, 1007/BF03173734.*

Schoon, Kenneth J., and William J. Boone. 1998. "Self-efficacy and alternative conceptions of science of preservice elementary teachers." *Science Education* 82(5): 553-568.

Schulman, Lee S. 1999. "Taking Learning Seriously."*Change Magazine* 31: 10 – 17.

Steinberg, Melvin S., David E. Brown and John Clement. 1990. "Genius is not immune to persistent misconceptions: conceptual difficulties impeding Isaac Newton and contemporary physics students." *International Journal of Science education* 12(3): 265 – 273.

Stenbacka, Caroline. 2001. Qualitative research requires quality concepts of its own. *Management Decision* 39(7):*551-555.*

Talanquer, Vicente. 2006. "Common-Sense Chemistry: A Model for Understanding Students' Alternative Conceptions." *Journal of Chemical Education* 83(5): 811- 816**.**

Tipler, Paul A. 1997. *Physics for Scientists and Engineers (4th ed.).* New Jersey: Cherry Hill.

Tsai, Chin-chung. 2003. "Using a conflict map as an instructional tool to change student alternative conceptions in simple series electric-circuits." *International Journal of Science Education* 25(3): 307-327.

Vandenberg, Donald. 1992. Metaphysics, dialectical materialism, Maline Creene, And Education. *Phenomenology and Pedagogy*10: 107-124.

Wandersee, James H., Joel J. Mintzes., and Joseph D. Novak. 1994. "Research on alternative conceptions in science." In Gabel, D., (Ed.) *Handbook of Research in Science Teaching and Learning.* New York: Simon and Schuster Macmillan: 177-210.

REFERENCES

Brown, David E. and John Clement. 1987. "Misconceptions concerning Newton's law of action and reaction." *The Proceedings of the second international seminar on misconceptions and educational strategies in science and mathematics.* Ithaca, New York: Cornell University.

Bogdan, Robert C. and Biklen, Sari K. 1998. *Qualitative research in education: An introduction to theory and methods* (3rd ed.). Needham Heights, MA: Allyn & Bacon.

Bueche, Frederick J. *Introduction to Physics for Scientists and Engineers: International Student Edition.* New York: McGraw-Hill Book Company, 1986.

Clement, John. 2006. "Thought experiments and imagery in expert protocols." In L. Magnani (ed.), *Model-based reasoning in science and engineering* (pp. 151-166). London: College Publications.

Coetzee, Annaretha. 2008. "*Overcoming alternative conceptions concerning interference and diffraction of waves.*" Ed.D thesis, Department of Mathematics, Science and Technology Education, Faculty of Humanities, Tshwane University of Technology.

Cutnell, John D and Kenneth Johnson W. 2010. *Introduction to Physics* (8th ed., International Student Version), John Wiley & Sons, Inc.

Denzin, Norman K. and Lincoln, Yvonna S. 2000. *Handbook of qualitative research 2nd ed.*). Thousand Oaks, California: Sage.

Department of Education. 2010. *KZN Provincial Report 2010*: *Analysis of learner performance. Subject: Physical Sciences. Paper 1: Grade* 12 National Senior Certificate Results Analysis. Examiners' Report on Physical Sciences Learner Performance, Pietermaritzburg, South Africa.

Driver, Rosalind. 1983. *The pupil as scientist*. Milton Keynes: Open University Press.

Giancoli, D.C. 2000. *Physics. For Scientist and Engineers* (3rd ed.). Upper Saddle River: Prentice–Hall International Editions, U.S.A.

Golafshani, Nahid. 2003. Understanding reliability and validity in quantitative research. *The Qualitative Report 8*(4): 597-606, Retrieved March 21, 2013 from http://www.nova.edu /ssss/QR/QR8-4/golafshani.pdf

Griffith, Thomas W. 2007. *The Physics of everyday phenomena*. A Conceptual Introduction to Physics (fifth ed.). Pacific University. New York: McGraw-Hill Company.

Healy, Marilyn and Perry, Chad. 2000. Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm. *Qualitative Market Research* 3(3): *118-126.*

Hestenes, David., Wells, Malcolm., and Swackhamer, Gregg. 1992. Force Concept Inventory, *The Physics Teacher* 30:*141-158.*

Jimoyiannis Athanassios, Tassos Mikropoulos, and Konstantinos Ravanis. 2000. Students' performance towards computer simulations on kinematics. *Themes in Education,* 1(4): 357-372.

Jimoyiannis, Athanassios., and Vassilis Komis. 2001. Computer simulations in physics teaching and learning: a case study on students' understanding of trajectory motion. *Computer & Education* 36(2): 183-204.

Kirkpatrick, Larry D., and Gregory Francis E. 2010. *Physics: A Conceptual World View. International Edition* (7th ed.). Brooks/Cole: Cengage Learning Mary Finch Publisher, USA.

Kyle, Jr., William C., Family, Desmond, L.E., and Shymansky, James. 1989. "Research matters – to the science teacher, No. 8902: Enhancing learning through conceptual change teaching." http://www.narst.org./publications/research/concept.cfm Accessed on January 7, 2008.

Leedy, Paul D., and Ormrod, Jeanne.E. 2005. *Practical research planning and design* (8th ed.). New Jersey: Merrill Prentice Hall.

Lincoln, Yvonna S., and Guba, Egon G. 1985. *Naturalistic inquiry*. Beverly Hills, CA: Sage.

McMillan, James H. and Schumacher, Sally. 1993. *Research in education* (3rd ed.). A conceptual introduction; Narper Collins College. New York. U.S.A.

Muncaster, Roger. 1993. *A Level Physics* (4th ed.). Cheltenham: Nelson Thornes Ltd., UK.

Ochsendorf, Richard., and Pyke, Curtis. 2007. Assessment Practices in Curriculum materials research: Do Students learn from the pretest? Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, Illinois 10-14.

Oliver, Ron. 1998. "Partnerships in teaching and learning: An emerging role for technology." *Proceedings of EdTech'98: The Biennial Conference of the Australian Society for Educational Technology.* Perth: ASET.

Özmen, Haluk., Hülya Demircioğlu and Gokhan Demircioğlu. 2009. "The effects of conceptual change texts accompanied with animations on overcoming 11th grade students' alternative conceptions of chemical bonding." *Computers and Education* 52(3): 681-695.

Patton, Michael Q. 2002. *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Popkewitz, Thomas. 1984. *Paradigms and ideology in educational research.* Barcombe: Falmer Press.

Richardson, Virginia. 1990. "Significant and Worthwhile Change in Teaching Practice." *Educational Researcher* 19(7): 10-18.

Schoon, Kenneth J. 1995. "The origin and extent of alternative conceptions in the earth and space sciences: A survey of pre-service elementary teachers." *Journal of Elementary Science Education* 7(2): *27-46, DOI: 10, 1007/BF03173734.*

Schoon, Kenneth J., and William J. Boone. 1998. "Self-efficacy and alternative conceptions of science of preservice elementary teachers." *Science Education* 82(5)*:* 553-568.

Schulman, Lee S. 1999. "Taking Learning Seriously." *Change Magazine* 31: 10 – 17.

Steinberg, Melvin S., David E. Brown and John Clement. 1990. "Genius is not immune to persistent misconceptions: conceptual difficulties impeding Isaac Newton and contemporary physics students." *International Journal of Science education* 12(3): 265 – 273.

Stenbacka, Caroline. 2001. Qualitative research requires quality concepts of its own. *Management Decision* 39(7): *551-555.*

Talanquer, Vicente. 2006. "Common-Sense Chemistry: A Model for Understanding Students' Alternative Conceptions." *Journal of Chemical Education* 83(5): 811- 816**.**

Tipler, Paul A. 1997. *Physics for Scientists and Engineers (4th ed.).* New Jersey: Cherry Hill.

Tsai, Chin-chung. 2003. "Using a conflict map as an instructional tool to change student alternative conceptions in simple series electric-circuits." *International Journal of Science Education* 25(3): 307-327.

Vandenberg, Donald. 1992. Metaphysics, dialectical materialism, Maline Creene, And Education. *Phenomenology and Pedagogy* 10: 107-124.

Wandersee, James H., Joel J. Mintzes., and Joseph D. Novak. 1994. "Research onalternative conceptions in science." In Gabel, D., (Ed.) *Handbook of Research in Science Teaching and Learning.* New York: Simon and Schuster Macmillan: 177-210.

ABOUT THE AUTHORS

Dr. Stephan P. Mchunu: Dr. Mchunu has just completed his doctoral degree in science education from the University of Zululand, investigating grade 12 learners' alternative conceptions and learning difficulties in mechanics in a number of schools in KwaZulu Natal, South Africa. Dr. Mchunu has many years of experience teaching physical science at the high school level. He worked with Prof. Sitwala Imenda as his promoter on this project.

Prof. Sitwala N. Imenda: Prof. Imenda is a professor of science education, and has worked at a number of universities in the Southern African region. He graduated from the University of Zambia, SUNY – Albany and the University of British Columbia, Vancouver, Canada.

Positive Psychology as a Scientific Movement

Jonathan Simmons, University of Alberta, Canada

Abstract: Psychology has always been vulnerable to fads, producing its share of psychological movements and therapeutic cults that blur the borderline between science and non-science. It is important for sociologists and other scholars who study the social life of scientists and intellectuals to engage with the content of ideas and to take conflicts about scientific legitimacy seriously. This research examines a debate regarding scientific legitimacy in a qualitative case study informed by Frickel and Gross's general theory of scientific/intellectual movements. The focus will be positive psychology's emergence at the end of the last decade and its failure to persuade the wider psychology community of its necessity due to its use of aggressive framing strategies. Understanding how positive psychology works to establish itself as value-free, objective science, while desiring to be perceived as relevant to the public contributes to discussions about framing and boundaries in science.

Keywords: Science, Knowledge, Controversy

Introduction

In his forward to the Oxford Handbook of Positive Psychology, psychologist Christopher Peterson argues "[p]ositive psychology is psychology—psychology is science—and science requires checking theories against evidence.... Positive psychology will rise or fall on the science on which it is based" (Snyder and Lopez 2009, xxiii). Early on in positive psychology's development, psychologists wondered if it would end up being yet another fad, and as it matured as a movement, strong reactions about its credibility moved beyond academic journals and other pseudo-private arenas, attracting the attention of columnists and essayists like Barbara Ehrenreich (2010), who see positive psychology as the shade under which self-help entrepreneurs can rest because they no longer need to rely on gods and mysticism for their emphasis on the relationship between positive thoughts and positive results; they can "fall back on that touchstone phrase of rational, secular discourse—'studies show ...'" (148).

Positive psychology's founder, Martin Seligman, initially defined positive psychology in 1998 as a new field concerned with positive experiences such as well-being, optimism, and flow. In his most recent book, Flourish: A Visionary New Understanding of Happiness and Well-Being, Seligman (2011) describes positive psychology as a scientific and professional movement with a new goal to build the enabling conditions of a life worth living. Critics' concerns about positive psychology follows from its emphasis on social change, its role in guiding organizational policy, and its relevance to research and public policy initiatives tied to happiness discourses. Understanding how positive psychology works to establish itself as value-free, objective science, while desiring to be perceived as relevant to the public, is important for policy-makers, but it also makes contributions to social movement literature concerning framing and boundaries in science. In this paper I conceptualize positive psychology as a "scientific/intellectual movement" (SIM), drawing from Frickel and Gross's (2005) general theory which defines SIMs as "collective efforts to pursue research programs or projects for thought in the face of resistance from others in the scientific or intellectual community" (206). I focus on how proponents of positive psychology engage in boundary-work to demonstrate their movement's legitimacy and the challenges they face because of their framing strategies. I argue that positive psychology's leaders and proponents have failed to persuade the wider psychology community of the necessity of a positive psychology movement due to their use of aggressive framing strategies.

The International Journal of Science in Society
Volume 4, 2013, www.science-society.com, ISSN 1836-6236

COMMON GROUND

Positive Psychology as a Scientific Movement

Like the dominant contentious politics approaches used in social movement scholarship (McAdam, Tarrow, and Tilly 2001), studies of scientific movements have been preoccupied with organized collective action and resource mobilization. While movements may be described as ideologically structured action, it is important not to bury the role that scientists play in nurturing movement identity. Frickel and Gross's general theory provides avenues for examining the importance of collective identity to movements and the complex motivations that scientists have for competing for meaning in emerging fields.

SIMs are similar to social movements, but they have six distinct features, the first of which is that they are implemented within a particular realm, the intellectual community or academia, where unlike other kinds of social movements, knowledge production is the primary goal. Second, SIMs must challenge the dominant approaches of a given field, even if movement ideas later become normative. Initially at least, they should be contentious, which leads to the third element: SIMs are political, but not in the activist sense that we associate with political process theories of social change. Frickel and Gross (2005) instead refer to the "distribution, maintenance, or transfer of power" (207) in fields with limited and unequally distributed resources. The political nature of a SIM is constituted through organized collective action, unlike, say, more individualistic lifestyle movements (Haenfler, Johnson, and Jones 2012). This fourth element is important because it forces researchers to look beyond the influence of an individual leader. Frickel and Gross (2005) do not dismiss the actions of charismatic founders, but leaders' choices must be connected to the social dynamics of the movement. The fifth element contends that like political process movements, SIMs are episodic, in that they either transform into a more stable institutionalized form or they disappear. Finally, SIMs can vary in aim and scope, i.e., they may emphasize the importance of previously neglected methods, introduce new theories, or even blur the boundary between science and non-science (208).

Along with the six elements that define a SIM, Frickel and Gross discuss four propositions regarding the opportunities for SIM emergence. The first proposition is that a movement's emergence is largely driven by established scholars who are dissatisfied with the prevailing practices of their field. Seligman is one such scholar. He is the thirteenth most frequently cited psychologist in introductory psychology textbooks (Haggbloom et al. 2002) and he built a successful career out of studying depression following his early work with learned helplessness.[1] As Seligman began to consider alternatives to repairing mental illness and the possibilities of prevention, which he metaphorically describes as psychological immunization, he became increasingly dissatisfied with mainstream psychology's focus on pathology.

The second, third and fourth propositions address what is necessary for a successful SIM, such as opportunity structures, access to resources, micromobilization contexts, and the importance of framing to inspire and guide collective action. It is not possible to say whether positive psychology has been successful as a movement because it is ongoing and remains in tension with mainstream psychology. Even though SIMs exist for finite periods, episodes can last as long as two decades, if not longer (Frickel and Gross 2005, 208). Since positive psychology has neither succeeded nor failed, I will focus on how it has been received by psychologists outside the movement.

SIMs depend on opportunity structures and access to resources, including access to employment, strategies for securing intellectual prestige, and mobilizing structures. Seligman (2011) reveals that when he was president-elect of the APA in 1997 he received a mysterious e-mail requesting a meeting, the only clue being the author's initials "PT." After developing a relationship with two-lawyers representing an anonymous organization, Seligman was handed a

[1] Learned helplessness occurs when an animal comes to believe that their actions will have no power to change the conditions in a given situation.

cheque for $1.5 million dollars to pursue his positive psychology research. The mysterious foundation funding his work later took the name Atlantic Philanthropies, tasked by the billionaire Charles Feeney to do good works. Perhaps caffeinated by this early donation, Seligman secured $30 million U.S. dollars by 2003 from nonprofit organizations, and positive psychology eventually became self-supporting. Now, almost 15 years later, positive psychology has amassed many of the trappings of a mature science. The International Positive Psychology Association (IPPA) facilitates communication and collaboration among researchers and practitioners around the world who are interested in positive psychology, boasting 3,000 members from over 70 countries. Membership benefits include free quarterly calls with leading positive psychologists, reduced registration for World Congress, and access to two journals: Applied Psychology: International Review and Psychology: Health and Well-Being. Positive psychology is also credited with numerous books, journal special issues, conferences, meetings, centers, courses, and interventions. It has its own journal, the Journal of Positive psychology, and proponents of positive psychology have a variety of avenues for community building: undergraduate positive psychology courses remain extremely popular, there are several Ph.D. and M.A. concentrations in positive psychology, and numerous conferences for early scholars to engage in sustained contact with one another (Linley et al. 2007).

Frickel and Gross (2005) extend these micromobilization contexts into the realm of collective identity. Social movements, according to the authors, are “generated from, and ultimately sustained by, ideas” (221). The success of a SIM depends a great deal on inspiring collective action through boundary-work and framing. Frames are “sets of ideas purposefully articulated to lend specific meaning and urgency to actors' individual and social experiences” (221) which operate along four related dimensions: (1) intellectual identity or self-concept and associated social categories; (2) the movement’s defining ideas; 3) the construction of historical narratives often for the purpose of developing a cohesive ideology; and 4) the movement’s positioning with respect to competitor movements (Abbott 1999). All four of these dimensions involve rhetorical moves to support a SIM’s legitimacy through persuasion, differentiation, and opposition.

Seligman’s Firewall: Positive and Negative Psychology in Context

Seligman was concerned from the beginning about how to present his new movement, both to insiders and outsiders, while remaining cognizant of the fact that some elements would necessarily have to be excluded. Rather than a frame, he preferred the metaphor of a firewall, identifying positive thinking literature as distinct from positive psychology and expressing his antipathy towards self-help gurus (Seligman, 1998). Along with resisting claims that positive psychology is nothing more than a shallow happiology with an optimistic bias, positive psychology’s proponents have also used Seligman’s firewall to promote a separatist message, contrasting positive psychology with mainstream (negative) psychology and past psychological research which covered similar ground.

In early publications, positive psychology is presented as both a Manhattan Project for the social sciences (Seligman, 1998) and a mere supplement to other research, the goal of which is to provide a balance to psychology within an explicitly scientific framework. Seligman and Csikszentmihalyi (2001, 89-90) argue "We are, unblushingly, scientists first. The work we seek to support and encourage must be nothing less than replicable, cumulative, and objective" and "If empirical research fails to confirm the usefulness of the positions we advance, we hope to have the resilience to admit defeat and bow out with good grace.” This is not, at first glance, a revolutionary message, but Seligman (1999, s165) establishes an enduring divide, claiming that mainstream psychology’s attention to negative emotions is dangerous for a science, limiting and biasing psychology's theories. Furthermore, psychology's negative focus has contributed to a culture of blame and victimology which may breed anger and violence and contribute to a pessimistic view of human nature. These early statements are part of a historical narrative that acts as a rallying cry for change, undermining mainstream psychology, while presenting positive psychology as calming salve for an open wound.

Positive Psychology's Separatist Message

Seligman is not the first psychologist to separate the field of psychology into positive and negative approaches. Maslow (1954) did the same over fifty years ago:

> The science of psychology has been far more successful on the negative than on the positive side. It has revealed to us much about man's shortcomings, his illness, his sins, but little about his potentialities, his virtues, his achievable aspirations, or his full psychological height. It is as if psychology has voluntarily restricted itself to only half its rightful jurisdiction, and that, the darker, meaner half (354).

It is no coincidence that Maslow is the source of the phrase "positive psychology," which is drawn from a chapter heading in his book Motivation and Personality. Admitting the relationship, Seligman nonetheless makes a distinction:

> What distinguishes positive psychology from the humanistic psychology of the 1960s and 1970s and from the positive thinking movement is its reliance on empirical research to understand people and the lives they lead. Humanists were often skeptical about the scientific method and what it could yield and yet were unable to offer an alternative other than the insight that people were good (Peterson and Seligman 2004, 4).

Rather than limiting the scope of his new network to positive psychology, Seligman hoped to forge a positive social science with interdisciplinary collaborations based on his familiarity with both successful and failed scientific movements. He did not create new boundaries to promote his new science, instead reshaping already existing boundaries. Humanistic psychology operated in opposition to the orthodox conception of science at the time, which Maslow saw as mechanistic and ahuman. He wanted a discipline that could rediscover human needs and aspirations, emphasizing a positive view of human nature with an individualistic perspective regarding personal happiness and growth as opposed to more communitarian aspirations.

Like positive psychology, humanistic psychology attached itself to a longstanding scientific and philosophical tradition. Humanistic psychology also marketed itself as a change in focus or orientation. Admittedly, humanistic psychology rebelled against the quantitative methods now embraced by positive psychologists, but the responses of critics are comparable: humanistic psychology and positive psychology have both been accused of making naive assumptions about human nature and for failing to address conceptual ambiguities. Critics point to the difficulty in operationalizing their terms and ideas, leading to concerns about testability. Movement reactions to these criticisms are also similar: Carl Rogers, like Seligman, considered real science to be objective, exact, and rigorous, and he valorized the experimental method when faced with objections from his contemporaries (Elkins 2009; Kristjánsson 2010; Martin 2007).

In keeping with the contemporary expectations of mainstream psychology, Seligman intended for positive psychology to be more empirical, less political, and less narcissistic than previous attempts to study the same subject matter. For movement proponents, science means being descriptive rather than prescriptive, i.e., avoiding normative content. This coupling of value-neutrality with science for the public good is a "historically resonant" discourse (Kinchy and Kleinman 2003), in that it is taken-for-granted and serves as a patterned strategy for achieving legitimacy. Positive psychology's legitimacy hinges on maintaining a balance between these two discourses, but this effort is complicated by Seligman's firewall and his movement's dominant separatist message (Held 2004). Even when proponents effectively frame a SIM in concert with historically resonant discourses, maintaining legitimacy may be destabilized by how proponents differentiate their SIM from competing intellectual positions (Frickel and Gross 2005, 224).

Not long after positive psychology's emergence, the late Richard Lazarus (2003) argued that the movement was in "danger of being just another one of the many fads that come and go" in psychology, and "which usually disappear in time, sometimes to return again in another form because the issues addressed are important but unresolved" (93). Lazarus is particularly concerned about positive psychology's marketing to fellow psychologists, which suggests that researchers should abandon their negative research and focus instead on "positive human qualities" (105). Even if this is not the intention of movement participants, he contends that collapsing "several discrete emotions into two broad categories and labeling them as positive and negative is unwise and regressive" (99). Positive psychology's leaders downplay the juxtaposition between positive and negative psychology:

> Lazarus's juxtaposition is his own, and it is unfortunate; positive psychologists intend no disrespect to the many academics and practitioners who have spent the bulk of their careers investigating negative states (Seligman is one of them and is proud of the accomplishments of this field; contrary to Lazarus's invention, we have written no 'diatribes' against 'negative' psychology) (Seligman and Pawelski 2003, 159).

As we have seen, this juxtaposition remains an important part of the positive psychology movement's discursive practices. Despite Seligman's claim that positive psychologists have not criticized the dominant practices of his field, he nonetheless wonders why psychology has been so focused on the negative, offering one possible explanation:

> Beginning with World War II and continuing through the cold war, American society became increasingly concerned with defense and damage. This is reflected in our media, children's books and in the topics studied by our social sciences. Local evening news shows exemplify this negative focus. Lead programs typically concern violence, arson, robberies, accidents and other atrocities. Stories of human kindness, courage and virtue are typically relegated to the end of the newscast, buried among dull items labeled 'human interest stories' (Gillham and Seligman 1999, s164).

Frickel and Gross (2005) argue that recruitment to a SIM is dependent on the "capacity of movement participants to depict themselves as caught up in some grand sweep of intellectual history" (223), but there are many different ways to construct historical narratives. Proponents of positive psychology do not just see themselves as being in a stream of scientific progress. Their movement is also polemical, which is consistent with the notion that the political aspects of a SIM tend towards exaggeration and promotion rather than cautious scientific or intellectual activity. In attempting to establish legitimacy, proponents make statements that are used to strategically develop and sustain the movement's identity.

Intellectual Identity and Psychology's Forgotten Promise

Proponents of positive psychology believe that critics misunderstand the movement, going so far as to describe a "widespread cultural and scientific myth" that mischaracterizes positive psychology as being divisive (Hart and Sasso 2011, 91). They have consequently attempted to massage their movement's relationship to mainstream psychology and competitor movements in such a way as to not seem threatening. Peterson and Park (2003) draw a line between the ideological movement and the science produced under the umbrella term positive psychology:

> Perhaps the infrastructure—a steering committee, conferences, training institutes, special issues of journals, edited volumes, handbooks, a teaching task force, awards, seed grants, electronic mailing lists, and Web pages—strikes some as too elaborate and deliberate at this early stage in the field's development. Regardless, positive psychology should not be confused with its infrastructure (145).

Despite Peterson's plea for mainstream psychologists to focus on the science produced under the umbrella positive psychology, it is tempting to view positive psychology's boundary-work as nothing more than a tool for strategic mobilization. Csikszentmihalyi dismisses this emphasis on strategy as a conspiratorial account of positive psychology's success, describing its emergence as the rather unexpected result of an untapped demand for its ideas (Csikszentmihalyi 2003, 114), though he does express some reservations:

> I would have preferred developing theory and research for a few more years before entering the public arena to defend positive psychology against the charges of Johnny-come-lateism that entrenched interests were sure to bring up against it. I know full well that new ideas can be killed just as soon by uncritical acceptance as by opposition (114).

Accounts of scientific and intellectual life have a tendency to view the formation of SIMs as being based on a power struggle for prestige. Collins (1975), for example, writes that a realistic image of science "would be an open plain with men scattered throughout it, shouting 'Listen to be! Listen to me!'" (480). Intellectuals, then, are preoccupied with internal discussions within small closed networks. When intellectuals look outside of these networks they are predisposed to look towards other small groups within the attention space. Serious talk between intellectuals is a concrete activity in which the sacred object "truth" arises. While the truth value of an idea may strengthen one side, the key element of intellectual life is competition involving domination through cultural capital and emotional energy.

Frickel and Gross differ from Collins, in that they do not see the quest for prestige and status to ever be the primary motivation for the creation of a SIM: "We agree with Bourdieu and Collins that opportunities for strategic gain may sometimes subconsciously give rise to intellectual dissatisfaction, but we do not see much theoretical or empirical warrant for the claim that SIM-catalyzing dissatisfaction arises only or primarily in response to opportunities" (211). Positive psychology's two sides, the "talk about the movement and talk about the subject matter of the movement's doctrine" (Katzko 2002: 674), are bound up with one another in a cultural space that serves as fertile ground for debates about intellectual motivation; however, motivation is rarely simple, and struggles over a SIM's legitimacy are intertwined with moral and political considerations (Frickel and Gross 2005; Fuchs 1992; Latour 1987; Shapin and Schaffer 1985).

While contentious historical narratives can serve as powerful tools of legitimation, it is important to recognize that boundary-work is not always or even mostly strategic (Knorr-Cetina 1981, 73), a fact which is often overlooked in talk about scientific practice. A more nuanced approach is available to sociologists. Intellectual identity, and inevitably motivation, consists of social categories that provide patterns intellectuals seek to cohere with, in that they are motivated to engage in research that feels consistent with their sense of the kind of intellectual they are (Frickel and Gross 2005, 222). Proponents of positive psychology take a variety of approaches to criticisms of their movement, but one consistent theme throughout their responses is positive psychology's promise and perspective. They identify themselves with a forgotten promise and of an era when psychology was concerned with more than just a single-topic such as mental illness.

Seligman differentiates his movement by emphasizing rebellion and synthesis. He wants to unite "scattered and disparate lines of theory and research about what makes life most worth living" (Seligman et al. 2005, 410), and positive psychology is meant as a supplement rather than a replacement for other research, the goal of which is to provide a balance to psychology within an explicitly scientific framework. Seligman's self-presentational strategies are inexorably linked with his scientific concerns, which arose from what he refers to as the analytic-synthetic failure, positioning himself as a courageous rebel in "one faculty battle after another" (Morgeson et al. 1999, 108) trying to convince his colleagues that synthesis is a valid form of scientific activity. He describes himself as working at the border of the light and the penumbra of what is known, presumably why he identifies himself in opposition with the public, Congress, and the New England Journal of Medicine. He believes that the normative expectations of his field are too invested in reductionism, leaving him at a disadvantage in his department at the University of Pennsylvania, which he categorizes as "one of the three or four scientifically traditional, rigorous—constipated—of any department" he has come across (Morgeson et al. 1999, 107). He also tellingly refers to himself as the "left wing" of his department, reinforcing the necessity of challenging conservative tendencies within science to make advances.

Seligman's self-concept resonates with movement insiders, who also emphasize that they are housed in traditional psychology departments, and stifled by an intellectual culture that is resistant to change. Peterson and Park (2003), for example, accept that positive psychology does not have a monopoly on past or present research dealing with human goodness and excellence and that positive psychology is just an "umbrella term for what have been isolated lines of theory and research and to make the self-conscious argument that the good life deserves its own field of inquiry within psychology" (p. 144). However, they do see the academic skepticism of positive psychology (as opposed to the public embrace) as being informed by assumptions that human nature is flawed. In this respect, positive psychology should not be viewed as an ideological movement or a "secular religion" (p. 145), but instead as a unique scientific movement with the goals of "description and explanation as opposed to prescription" (p. 145). This focus on what constitutes good science links positive psychology to the intellectual self-concepts shared by movement proponents, but also with broader values and world-views (Frickel and Gross 2005, 222).

The effectiveness of a frame is based on more than how well it resonates with potential recruits, i.e., the "distribution of intellectual self-concepts is a function of other social processes both endogenous and exogenous to the intellectual field" (Frickel and Gross 2005, 213). The more in harmony self-concepts are with other, broader, social forces, the more likely they are to be seen as legitimate to potential recruits; however, the linking intellectual self-concepts to macro level changes can also cause problems for SIMs.

Discussion and Conclusions

This article set out to examine positive psychology as a scientific movement, focusing on its framing activities and the resulting debates about its scientific legitimacy. This research makes contributions to the sociology of ideas and scientific movement research by looking at how psychology's ambiguous scientific boundaries transform the role of boundary-work into a stylistic resource for ideologists. Positive psychology's framing, while successful in terms of recruiting, has failed to resonate with members of the wider psychology community. Its proponents are faced with a struggle to develop and acquire symbolic profit[2] in lieu of their movement's attachment to past positive psychologies and its treading of a "narrow line between the requirements of scientific or expert jargon, and popular discourse" (Yen 2010, 70). This is not to say that the popular face of positive psychology undermines its scientific research, but as Coyne and Tennen (2010) argue, it has been hampered as a movement by its sloganeering, separatist impulses, and close association with "self-help materials, personal coaching, and training programs to the lay public, industry, and the military" (36).

[2] A form of symbolic recognition such as wealth and authority.

Matthews and Zeidner (2003) see much of the work being done within positive psychology as important for the discipline of psychology as a whole, but they identify elements associated with what they see as a zeitgeist in American culture that emphasizes personal growth. They draw parallels between positive psychology and emotional intelligence, whose founder, Daniel Goleman, touched on many of the same topics as Seligman, and many of the criticisms of emotional intelligence anticipate criticisms of positive psychology, including “conceptual incoherence, neglect of measurement issues, and a tendency to make grandiose claims without supporting evidence” (138).

I have shown that the movement takes priority in arguments about positive psychology’s credibility because a scientific movement is held together by more than the knowledge it carries. The social glue acts as a selector, sacrificing more truthful representations of the external referents in favor of those that “facilitate the maintenance and continuity" of the movement (Kim 2009, 46). The resulting spectacle “resembles less a forum for discussion than it does that other great Roman institution” (Katzko 2002, 268) with the archetype of the scientist–explorer being replaced by the scientist–warrior who seeks to define and defend territory, emphasizing group formation over scientific pursuits and leading in some cases to social organizations that resemble religious orders or political parties in their ability to encourage devotion, even when the ship is sinking.

REFERENCES

Abbott, A. 1999. *Department and Discipline: Chicago Sociology at One Hundred*. Chicago, IL: University of Chicago Press.

Collins, R. 1975. *Conflict Sociology: Toward an Explanatory Science*. New York: Academic Press.

Coyne, J., and H. Tennen. 2010. "Positive psychology in cancer care: a story line resistant to evidence." *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine* 39(1):35-42.

Csikszentmihalyi, M. 2003. "Legs or wings? A reply to R. S. Lazarus." *Psychological Inquiry* 14(2):113-115.

Ehrenreich, B. 2010. *Bright-Sided: How Positive Thinking is Undermining America*. New York: Picador.

Elkins, D. 2009. "Why humanistic psychology lost its power and influence in American psychology." *Journal of Humanistic Psychology*. 49:267–291.

Frickel, S., and N. Gross. 2005. A general theory of scientific/intellectual movements. *American Sociological Review*. 70(2):204-232.

Fuchs, S. 1992. *The Professional Quest for Truth: A Social Theory of Science and Knowledge*. Albany: SUNY Press.

Gillham, J., and M. Seligman. 1999. "Footsteps on the road to a positive psychology." *Behavior Research and Therapy*. 37(Suppl 1):S163-73.

Haenfler, R., B. Johnson and E. Jones. 2012. "Lifestyle movements: Exploring the intersection of lifestyle and social movement." Social Movement Studies. 11(1):1-20.

Haggbloom, S., and Warnick, Renee and Warnick, Jason E. and Jones, Vinessa K and Yarbrough, Gary L. and Russell, Tenea M. and Borecky, Chris M. and McGahhey, Reagan and Powell, John L. and Beavers, Jamie and Monte, Emmanuelle. 2002. "The 100 most eminent psychologists of the 20th century." *Review of General Psychology*. 6(2):139-152.

Hart, K., and T. Sasso. 2011. "Mapping the contours of contemporary positive psychology." *Canadian Psychology*. 52:82-92.

Held, B. 2004. "The negative side of positive psychology." *Journal of Humanistic Psychology*. 44(1):9-46.

Katzko, M. 2002. "The rhetoric of psychological research and the problem of unification in psychology." *The American Psychologist*. 57(4):262-270.

Kim, K. 2009. "What would a Bourdieuan sociology of scientific truth look like?" *Social Science Information*. 48(57):57-79.

Kinchy, A., and D. Kleinman. 2003. "Organizing credibility: Discursive and organizational orthodoxy on the borders of ecology and politics." *Social Studies of Science*. 33:869-896.

Knorr-Cetina, K. 1981. *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science*. Oxford: Pergamon Press.

Kristjansson, K. 2010. "Positive psychology, happiness, and virtue: The troublesome conceptual issues." *Review of General Psychology*. 14(4).

Latour, B. 1987. *Science in Action: How to Follow Scientists and Engineers through Society*. Cambridge, Mass: Harvard University Press.

Lazarus, R. 2003. "Does the positive psychology movement have legs?" *Psychological Inquiry*. 14(2):93-109.

Lyubomirsky, S., and A. Abbe. 2003. "Positive psychology's legs." *Psychological Inquiry*. 14(2):132-136.

Martin, M. 2007. "Happiness and virtue in positive psychology." *Journal of the Theory of Social Behaviour*. 37(1).

Maslow, A. 1954. *Motivation and Personality*. New York: Harper.
Matthews, G., and M. Zeidner. 2003. "Negative appraisals of positive psychology: A mixed-valence endorsement of Lazarus." *Psychological Inquiry*. 14(2):137-143.
McAdam, D., S. Tarrow, and C. Tilly. 2001. *Dynamics of Contention*. New York: Cambridge University Press.
Morgeson, F., M. Seligman, R. Sternberg, S. Taylor, and C. Manning. 1999. "Lessons learned from a life in psychological science: Implications for young scientists." *American Psychologist*. 54:106-116.
Peale, N. 1996. *The Power of Positive Thinking*. New York: Ballantine Books.
Peterson, C., and N. Park. 2003. "Positive psychology as the evenhanded positive psychologist views it." *Psychological Inquiry*. 14(2):143-147.
Peterson, C., and M. Seligman. 2004. *Character Strengths and Virtues: A Handbook and Classification*. Oxford: Oxford University Press.
Seligman, M. 1998. Positive psychology network concept paper. Accessed March 4, 2012 from http://www.psych.upenn.edu/seligman/aparep98.htm.
—. 2002. *Authentic Happiness*. Boston, MA: Nicholas Brealey Publishing Limited.
—. 2011. *Flourish: A New Understanding of Life's Greatest Goals and What it Takes to Reach Them*. New York: Free Press.
Seligman, M., and M. Csikszentmihalyi. 2000. "Positive psychology: An introduction." *American Psychologist* 55(1):5-14.
—. 2001. "Positive psychology: An introduction: Reply." *American Psychologist* 56(1):89-90.
Seligman, M., and J. Pawelski. 2003. "Positive psychology: FAQs." *Psychological Inquiry*. 14:159-163.
Seligman, M., T. Steen, N. Park, and C. Peterson. 2005. "Positive psychology progress: Empirical validation of interventions." *American Psychologist*. 60:410-421.
Shapin, S., and S. Schaffer. 1985. *Leviathan and the Air Pump: Hobbes, Boyle and the Experimental Life*. Princeton: Princeton University Press.
Snyder, C., and S. Lopez. 2009. *Oxford Handbook of Positive Psychology*. New York: Oxford University Press.
Yen, J. 2010. "Authorizing happiness: Rhetorical demarcation of science and society in historical narratives of positive psychology." *Journal of Theoretical and Philosophical Psychology*. 30(2):67-78.

ABOUT THE AUTHOR

Jonathan Simmons: Jonathan Simmons is a Sociology PhD student at the University of Alberta. His doctoral research involves an investigation of the value-system embraced by members of the skeptical movement and how appeals to science constitute lifestyle actions. Some of his other interests include lifestyle movements, the sociology of religion and secular studies, and the advancement of the public understanding of science and technology.

Fractured Culture: Educare as a Healing Approach to Indigenous Trauma

Tanietta Delauney, Southern Cross University, Australia

Abstract: In Australia, governments of various persuasions spend many millions of dollars 'tackling' drug and alcohol abuse, high incarceration rates, violence, and other social problems in Indigenous communities. Research shows that trauma and addiction go hand in hand, and Intergenerational Trauma, a complex form of Post Traumatic Stress Disorder, is expressed as violence and drug and alcohol abuse, with poor health, and high rates of injury, death, and imprisonment. Educare, education as healing, is an Indigenous pedagogical approach that uses culturally sensitive protocols and utilises 'cultural medicine'. A major strength of this approach is the use of Indigenous cultural tools. Weaknesses include the limited number of trained Indigenous practitioners. The importance of this program relies on cultural safety, Educaring and Dadirri as spiritual and holistic healing methods. Research suggests that many social problems are associated with disconnection from traditional cultural and spiritual ways of being. Indigenous peoples have a role to play in developing and implementing culturally safe healing practices. The Indigenous program creates the relational milieu needed for genuine safety and is a recognized psychosocial variable in epidemiological patterns of disease. Healing via educaring is culturally safe and is a genuine Indigenous pedagogical platform used for engaging with culture.

Keywords: Indigenous Trauma, Pedagogies

Indigenous trauma can be addressed by using Indigenous tools, methods and ceremonies. I describe some Indigenous methods, including the program I designed to help mend the fractured relationship between family members. I discuss *the healing fractured relationships program* (HFR) I have facilitated between an Indigenous mother and her daughter, with the use of cultural safety, *Dadirri* and *Educaring* methods. The program uses a trauma informed approach and Indigenous pedagogy to explore individual and collective stories of Intergenerational transference of trauma. Intergenerational trauma is trauma passed down by family members and through generations (Atkinson 2002). Educare has its roots in Latin, and means: to lead out from, and when used in programs such as this, it offers the notion that people have the potential to know his/herself and are capable to make the changes through an educational approach (Atkinson 2002). Dadirri is an Aboriginal word for *inner deep listening,* and it is our connection to the spiritual within the self via an awareness and stillness (Atkinson 2002). Cultural safety is an experience, which offers no assault on a person's way of being, and asks that people contribute and be responsible for the atmosphere, which is free from judgement (Bin-Sallik 2003, 24). Others wishing to use this reconnection ceremony could shape the program to suit what is familiar to their cultural norms. The support of the facilitator as a collaborative witness is crucial to providing encouragement and safety.

In Australia, governments of various persuasions spend many millions of dollars 'tackling' drug and alcohol abuse, high incarceration rates, and other social problems in Indigenous communities. However, abuse of alcohol and use of violence is not as prevalent where language and culture have been maintained (Roe 2010, 248; Chandler and Lalonde 2008). Addiction to drugs can help people to numb their pain through a form of 'self-medication', and drugs are also used to help *release* the pain often via the vehicle of violence; but when the drug wears off the underlying problem is exposed repeatedly (Dayton 2000, 18). Trauma and addiction go hand in hand, and Intergenerational trauma is a complex form of Post Traumatic Stress Disorder (PTSD), which is an official diagnosis in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) and is characterized by a specific set of symptoms caused by chronic activation of the stress response (Porth and Matfin 2009, 209). Intergenerational trauma is often expressed as violence, excessive drug and alcohol abuse, and even poor health, and high rates of injury, death

The International Journal of Science in Society
Volume 4, 2013, www.science-society.com, ISSN 1836-6236

COMMON GROUND

and imprisonment (Atkinson C 2007). In Australia in 2006-2007, 71% of people were in prison for alcohol related and violent offences (Wild and Anderson 2007, 16). Indigenous people are over-represented in prisons with a national average of 27 times more than non-Indigenous people, with a ratio of 26.3 in WA to 16.6 in SA; 12.3 in Victoria; 12.3 in QLD; 11.0 in NSW; 10.2 in NT, and 3.7 in Tasmania (Hollinsworth 2007, 171). Considering Indigenous people make up around 4% of the population, this is not just a matter over-policing, but Aboriginality and their Otherness have become criminalised (Hollinsworth 2007, 171). A crucial point to understanding the connection of addiction and a breakdown of spirituality among Indigenous peoples is that drugs can offer a sense of community that may otherwise be fractured (Atkinson 2002, 228).

Many of the problems with violence and addictions are associated with the disconnection from cultural and traditional ways of being (Atkinson and Atkinson 2007, 38; Chandler and Lalonde 2008; Morgan and Drew 2010, 260; Roe 2010, 248; Dudgeon and Ugle 2010, 187; Szalavitz and Perry 2010). National reports such as *The Bringing Them Home Report* (1997), *The Ways Forward Report* (1995) and *The Royal Commission in Aboriginal Deaths in Custody* (1991), all identify the effects of Intergenerational trauma as a main contributor to syndromes such as family violence, addictions and family breakdown (Atkinson 2007, 1). Trauma affects a person's ability to cope, and produces feelings of being overwhelmed (Atkinson 2002, 146). Complex trauma is experienced as numbness alternating with hypervigilance, with heightened feelings of inadequacy, fear, anger and isolation (Perry and Szalavitz 2010, 69). Trauma is a reaction by the body and can be explained as a breakdown of the nervous system and in the past has been known as shell shock among war veterans (Levine 2010, 33) and because of the ongoing and compounded traumatic events for Indigenous people, called Intergenerational trauma. The nervous system is the survival structure that elicits *fight or flight* (Autonomic Nervous System), an unconscious response to what the body experiences as life threatening, which becomes 'stuck' on fight, flight or freeze when over whelmed by a traumatic event (Levine 2010, p. 97). Approaches for the Indigenous HFR program are underpinned by confirming the traditional holistic ties between physical-mental-spiritual-emotional connections to wellbeing; while using groundbreaking neuro-scientific concepts to support the healing process (Atkinson 2012, 5; McEwan et al 2009, 1; Day et al 2008, 116; Doidge 2007, 225).

Trauma responses for many Indigenous people are the effects from extensive social exclusion and cruelty during and following colonization; and often transferred intergenerationally (Atkinson 2002, 147; Hollinsworth 2007, 97). Many Indigenous families were massacred and others forced to separate from parents from the 1800's up until 1970's just for being of Aboriginal decent (Hollinsworth 2007, 97). Cultural genocide included being forbidden to speak language or practice spiritual and community based rituals; as well as being pushed off homelands and as a consequence starvation most often occurred (Morgan and Drew 2010, 256; Atkinson 2007, 1). Atkinson and Atkinson (2007, 36) believe that there is currently an epidemic of a complex form of PTSD among Indigenous Australians (Intergenerational trauma). This is demonstrated in the extremely alarming health statistics and high incarceration rates due to the compounded violations of human rights from the insidious ongoing nature of colonization (Atkinson and Atkinson 2007, 36). Key characteristics from Indigenous specific programs have informed the structure of the HFR program and have led to the use of culturally safe tools (Atkinson 2002, 14; Chandler and Lalonde 2008; Roe 2010, 248; Morgan and Drew 2010, 260). At the forefront of the program is utilizing a trauma informed lens with a strong emphasis on education in relation to the socio-historic and the biological effects of trauma, while highlighting the plasticity of the brain's ability to change (Atkinson and Atkinson 2007, 36; Doidge 2007, 62; Atkinson 2012, 1).

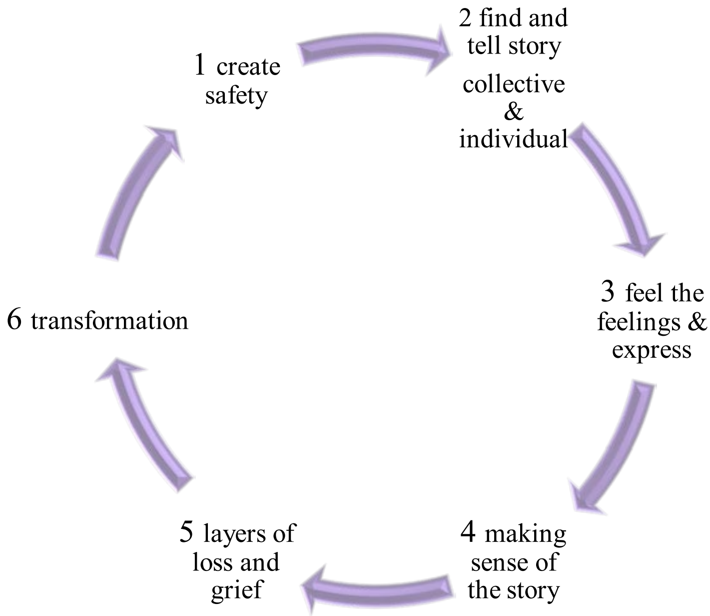
The Federal Government allocates money to address these problems and to ensure training programs for staff include cultural awareness. Yet much literature continues to use demeaning terms in reference to Indigenous peoples (Townsend-Cross 2013; Bin-Sallik 2003, 25).

Universities still run courses that are not inclusive of Aborigines or Torres Strait Islander peoples, including courses in Australian history and education that actually exclude Indigenous Australians (Townsend-Cross 2013; Bin-Sallik 2003, 25). Furthermore many Sociology courses continue to deny the legitimacy of Indigenous peoples' family models of relatedness and structures (Townsend-Cross 2013; Bin-Sallik 2003, 25; Atkinson 2002). The biomedical model dissects health into compartments that usually ignore emotional or spiritual wellbeing, which can be a huge problem when approaching Indigenous health, and contributes to the lack of cultural safety within most health practices (Atkinson and Graham 2002, 3). The 1986 Ottawa Health Charter emphasises the interconnectedness of all things in a person's life (Atkinson and Graham 2002, 3). The Charter has a particular focus on the everyday settings of where we work, play and learn (Atkinson and Graham 2002, 3). It is important to understand that this connection with their entire environment and the universe, experienced as spirituality, has helped Indigenous Australians survive the brutality and intergenerational effects of colonization (Atkinson 2002, 88; Kneebone 1991, 90).

Professor Judy Atkinson (2002) developed a practical program for traumatised Indigenous communities, *We Al Li,* which has incorporated and adapted traditional practices such as: cultural safety; healing circles; lifting the trauma blankets; histo-genograms; *Dadirri*; loss and trauma maps; *educaring*/trauma-informed approaches; and traditional anger management techniques. Healing circles are considered to be genuine Indigenous pedagogical platforms used for learning and ceremony (Young 2007, 82; Atkinson 2002, 240). Healing circles are structures that promote equality and they break down classic hierarchical styles of healing. For example, the therapist-client classical structure can make a client feel there is a power imbalance, and render the client feeling 'less than' the therapist and also not in control of their capacity to initiate their own healing journey. The circle structure therefore, embraces the notion that everyone together has a wealth of knowledge and this can make all participants feel valued. The circle model promotes the concept that the 'teacher and taught' create the learning (Atkinson 2002, 24). Atkinson (2002) offers tertiary educational programs at Australian universities that educate people on the many faces of trauma: collective-social trauma, historic-cultural trauma, complex-generational trauma and childhood and developmental trauma. Chandler and Lalonde (2008) have aimed at explaining the differences between communities where youth suicide amongst Aborigines is high and those communities where youth suicide is barely known. Chandler and Lalonde (2008, 2) highlight that where autonomy is strong and language and knowledge systems are nurtured, suicide rates are lowest. Cultural continuity and connection to spirituality are genuine healing components to any Indigenous-focused program.

Dadirri is used to reconnect the self and others to spirituality, and is a way of re-discovering meaning in life by learning through listening with an intention to act, and a responsibility learned from listening (Ungunmerr, 2003). *Educaring* is a term coined by Atkinson (2012, 3), which suggests more than *just* education, and offers a reciprocal achievement in listening and learning together in an environment of safety. *Educare*, education-as-healing is an Indigenous pedagogical approach that uses culturally sensitive protocols and utilises 'cultural medicine' with the implementation of cultural tools. The *Prun* is an Indigenous ceremony that allows participants to engage with the 'very real' emotion of anger and explore it in the safety of ceremony (Atkinson 2007b, 15). Historically Indigenous people used conflict management as law for wellbeing with a deep understanding of the negative effects of suppressed strong feelings (Atkinson 2007b, 15). Structured ceremonies to address conflict were a regular part of everyday life for wellbeing (Atkinson 2007b, 15). Anger is a natural aspect to being human, and it is how we express our anger that determines whether it is a healthy or unhealthy behaviour (Atkinson 2007b, 27).

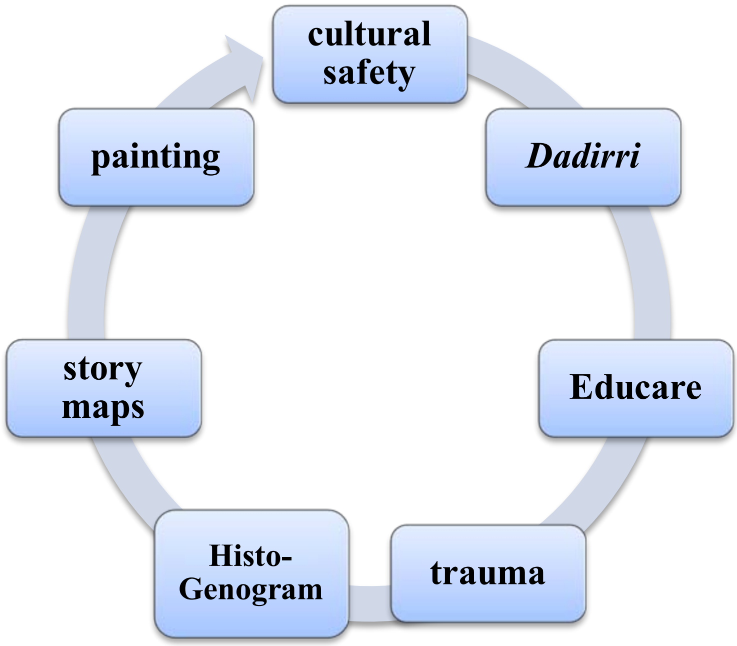
The diagram is a representation of Atkinson's (2002) model of 6 stages to healing, and can been seen below.



The Six Stages of Healing

Healing often comes via an acknowledgment of how our unmet needs are being expressed, and involves cultivating self-awareness of medicating pain, in the form of addiction to alcohol and drugs, and the subsequent expression in the form of violence (Atkinson 2002, 217). The activity of working through the historical legacy of trauma via a histo-genogram map helps people to recognise the self at the deepest level, and understand the negative re-occurring cycles of intergenerational trauma (Atkinson 2002, 217). The intention of the *Healing Fractured Relationships* program (HFR) is underpinned by ancient Indigenous practices and ways of knowing, and is designed to 'unite hearts and establish order' (Atkinson 2007a, 44). Through strong relationships we develop our sense of identity and belonging and by using the program as a ceremony, this allows the participants to deepen the knowledge of self in a ritualistic manner (Atkinson and Edwards-Haines, n.d, 3). In Indigenous communities stories, songs, dances and painting as ceremony have always contributed to the sacred law, and this enhanced the special feeling associated with relationships and enabled recognition of the interconnecting web of reciprocal responsibility and family (Atkinson 2007a, 44).

I developed the HFR program as part of my Master of Indigenous Studies degree, with the intention to heal disconnections specifically in family relationships; it involves using story maps, *Dadirri* and culturally safe strategies. The program is a cultural tool for releasing anger, sadness and happiness, and can drive out both individual and collective feelings of despair, anger and loss. A mother and her daughter agreed to participate in the *Healing Fractured Relationships program* together, and this helped to highlight the daughter's personal journey, while uncovering the responsibility between both family members to reconnect. I facilitated the process and offered a safe place for both mother and daughter to tell, and make sense, of their combined and yet individual story. The mother was provided with a platform of safety to explore the darkness of her shame as the parent. Confronting our shame allows us to recognize and let go of unwanted past behaviours. One of the most important ways to begin the healing process is to encourage people to find a *voice;* healing between family members also involves finding the ability to bear what the other has to say, while maintaining empathy (Atkinson 2002, 94; Harrison 2005, 10; Szalavitz and Perry 2010, 6). Genes are known to switch on or off in response to environmental factors, and empathy, and mirroring 'care' to traumatised individuals can determine which genes will be activated in any given moment and which ones will never reach their potential (Szalavitz and Perry 2010, 5). The program offered the mother and daughter a platform for this to occur.



The Healing Fractured Relationships Program

The *Healing Fractured Relationships* program demands honesty from participants and a genuine commitment to safety during the process. Anger can often lace family interactions when old wounds are addressed due to immense shame and guilt experienced by the parent or resentment from the child (Harrison 2005, 4). Embedded in the program are many sensitive respectful cultural protocols to ensure effectiveness and cultural safety. The way this is achieved is by all people involved being asked to develop the rules of participation, which will be different with every group and dependent on what each individual's needs are. *Dadirri* involves listening to the inner self (feelings/thoughts/reactions) and taking responsibility for internal responses (Ungunmerr, 2003). This is the 'self' that yearns for connection with all others and it's environment and that strives for spiritual reconnection with the cosmos (Atkinson 2011). Ensuring cultural safety is the first stage of The HFR program and this required that we all contributed to what that meant to those who were present, which did result in an environment free from judgment and with an atmosphere that embodied genuine support for the traumatic stories that were told (Bin-Sallik 2003, 24; Atkinson 2002, 94). I introduced *Dadirri* to the Indigenous mother and her daughter as a way of creating 'ceremony' with a tool of deep listening within a spiritual landscape; this avowed integrity of the ritual/program from the beginning.

Dadirri connected us to a healing method by using an Indigenous worldview that links the individual to all forms of life and the discovery of that within us all (Ungunmerr 2003).

Education was an integral ingredient of the program, and I spoke about trauma, death, and also explained the differences between grief, bereavement, mourning and the negative effects of victimisation (Atkinson 2007a, 34). We discussed the many examples and reactions to loss and it was apparent they were shocked at how many and *what* experiences are considered to be ‘a loss’ (Atkinson 2007a, 17). Some examples range from very personal losses such as death in the family, or never having a father figure, to loss of culture, lifestyle or even loss of an addiction (Atkinson 2007a). Participating in this ritualized program between the mother and her daughter affirmed a stronger identity of where their family has come from and where they are going as a family. Neglectful and inconsistent parenting can affect children’s ability for self-regulation and adaptability, which can interfere with stable attachment between family members (Harrison 2005, 1). This was also considered to be a loss for both the mother and her daughter. Drawing genealogy charts (the histo-genograms) can help people identify how trauma has moved down through many generations in the past to the present; and can help people to understand the concept of Intergenerational transference of traumatic stress (Atkinson 2002). Externalisation is a tool used to encourage the participants to view ‘a problem as the problem’ as opposed to viewing themselves as the problem; and is a process of naming that problem in the context of how the problem affects the person (Corey 2009). Externalisation is appropriate for addressing issues of Intergenerational trauma, because this method targets the type of internalizing Indigenous people have been forced to endure through the racist discourse and consequently lack of social acceptance (Haebich 2000 203). Deconstruction of personal stories creates an opportunity to change grand narratives about one’s life (Corey 2009).

Finally the mother and daughter were asked to draw/paint a time line from when the daughter was born to the current day. The daughter’s age was the end of the time line because this was specifically a mother and daughter ceremony, and traditionally the parent takes more responsibility in Indigenous cultures (Atkinson 2002). By discussing the daughter’s story whilst simultaneously sharing the part the mother played enabled both to make sense of the shared past. The flexibility of this program relies on individual needs, for example, if this was a husband and wife ceremony, the time line may begin with when they met each other. The participants are asked to fill in all the ‘losses’ (traumatic experiences) in their life along a time line, but also the strengths that created resilience in both their stories. These losses are shared and this was very emotionally intense when they expressed these to eachother in the ceremony. After the emotional release, the program began to wind down and we moved outside to experience the radical changes that going from *indoors* to *outdoors* cause. Studies have highlighted the enormous physiological changes that are experienced from doing this (Lawlor 1991, 130). The light sensitive pineal and pituitary glands alter hormonal activity, and the heartbeat, digestion, perspiration and excretory functions are all affected by moving from indoors to outdoors (Lawlor 1991, 130). The Hopi Indians had words that described these changes that are caused from moving from in to out, and there is a reduction in the autonomic nervous system’s (ANS) responses when a person is indoors, which are mediated by light and geomagnetism (Lawlor 1991, 130). When the mother and her daughter and I stepped outside to finish the ceremony and burn the ‘trauma time lines’ we had created, there was a notable difference in everyone’s sensory perception. This activity stimulated the limbic system (feeling brain), and a movement away from the neo-cortex (thinking brain), which is a similar experience as singing, dancing or painting, and enables a flow of creativity and emotional positivity from this natural form of stress release (Atkinson & Atkinson 2007; Lawlor 1991). The program is finalised by burning the painting of the old ‘trauma trail’, and fire enhances the closing of the ritual. Participants are asked to symbolically paint their problematic past and burn it.

As we uncover one layer another layer is revealed, and this leads to the discovery of *who I am* through a multilayered, multi phenomenon of complexities and depths (Atkinson 2002, 249).

Healing as education acknowledges there is not a destination of *being healed*, rather a journey of self-discovery and we realise there are multiple layers of loss and grief (Atkinson 2002, 249). Healing requires us to visit places that may not be pleasant, *sitting in the fire* of our memories and despair (Atkinson 2002, 250; Mindell 1995, 103). The support of the facilitator and witness is crucial to providing encouragement and an anchor. The approach of the co-collaborator/facilitator is crucial to the creation of a climate that highlights opportunities for change in the narration of personal stories and a chance to offer new perspectives to assist in the discovery of a new meaning (Atkinson 2002, 249; Corey 2009, 392). Understanding spirituality through education provides genuine nurturance to the soul searching and can replace the attempt to fill the void with drugs by re-connecting people to a deeper meaning in life and each other. Using spiritually based tools are key ingredients in the design of this program by linking the relationship between spirituality, culture and health, which is an emerging field of research (McEwan and Tsey 2009, 5; Atkinson 2002, 16). As Carl Rogers (1987, cited in Corey 2009, 392) firmly maintained, if the conditions are right, we need to have faith in the individual's ability to find their own path to healing and their ability to move forward constructively.

An empowering educaring aspect of the program was teaching the participants about the Intergenerational legacy of trauma among Indigenous Australians as a result of the brutality of Government policies. The experience of violence, alcohol addiction, sexual abuse could be traced down through the generations. People gain a sense of where they are situated within the larger picture of the collective as opposed to just focusing on individual issues within the trauma narrative. The geno-histogram really did help the participants to begin to make sense of their own life in relation to the collective experience of Indigenous Australians. The opportunity to construct a new story arose, as opposed to the destructive one of self-blame and self-hatred, and this opportunity was embraced by both participants. Externalisation promoted a deconstruction of the problematic past and an ability to disassemble those experiences, which then opened up the possibilities of changing the over-arching narratives, which often end up shaping our lives (Atkinson 2002, 249; Corey 2009, 393). The mother and her daughter deeply explored the impact of loss as the individual and the collective psyche as Indigenous people. They began to understand the impact of the grand narrative of colonisation and found they were able to locate the historical legacy of massacres; epidemics; displacement from lands; the interlinking disasters and where they fit as Indigenous people into this intergenerational structure of tragedy (Atkinson & Atkinson 2007, 40).

Conclusion

A major strength of the HFR program is the use of Indigenous cultural tools, because Indigenous specific and culturally sensitive approaches incorporate the natural connection of the kinship system. Indigenous people place a high importance on family and the health of the individual is dependent on the collective. The program is flexible and can be used with as many or as few people as required, and between different family members. The importance of this healing program relies on cultural safety, *Educaring* and *Dadirri* as spiritual and holistic healing methods. *Educaring* introduces education-as-healing, and is implemented by the use of a trauma informed lens as a response to Indigenous people and the health and social problems currently faced. *Dadirri* acts as both a way of listening and as a spiritual practice, which incorporates new avenues of relating to others that is both educational and instructive. A significant rationale for using this program is cultural safety and 'Cultural wounds require cultural medicine' (Chandler and Lalonde 2008). The program addresses trauma, addictions, violence, loss and fractured relationships. There is a learned understanding that the high violence and incarceration rates of Indigenous people are symptoms of spiritual distress experienced as Intergenerational trauma, borne from the brutality of colonization. Violence and trauma are considered up-steam issues and further up-stream is the cultural disconnection.

Weaknesses include the limited number of trained Indigenous practitioners. A problem I encountered involved being disturbed by a non-participant during the exploration of one of the trauma maps, and this had the effect of preventing one of the participants from going more deeply to those places of trauma. Safety needs to be ensured on every level, including the practical aspect of physical privacy. Cultural safety is the single most important factor to creating an environment and the platform for healing to occur and upholds a ‘container’ of security and shared respect. This needs to be defined by those who use the service, and for them to ensure there is no assault on individual identity. To be a successful and competent facilitator we need to develop awareness around our own past issues that may surface during the process (Mindell 1995, 103). I endeavored to maintain an awareness of my bodily sensations and feelings of un-comfortableness (*sitting in the fire*) at the participant’s issues that were being addressed. I was aware of the imperative to remain focused particularly when my own issues arose that were related to my past un-dealt with problems (Levine and Kline 2007, 137; Mindell 1995, 103). There were challenges triggered by some of the content that came up and this demanded an immense commitment to remain solid for those who were working though their issues. It is important that the person leading the HFR program is also supported.

Many social problems are associated with disconnection from the traditional cultural rituals and spiritual ways of being and doing. Indigenous peoples have a central role to play in developing and implementing culturally safe healing practices. The Indigenous program I created offered the relational milieu needed for genuine safety, which is a recognized psychosocial variable in epidemiological patterns of disease. Healing via educaring is culturally safe, and is a genuine Indigenous pedagogical platform used for engaging with culture. The intrinsic need for Indigenous engagement in the development and implementation of this and other programs is both an outcome and an activity of the model. Healing methods that are developed by Indigenous people ensure accessibility and culturally appropriate strategies. This program can be adapted to suit other situations and can be rolled out easily and is cost effective. When Indigenous people have control over the design and implementation of healing programs, traditional healing strategies can be used and this will ensure Indigenous inclusion and access to well-Being. Indigenous pedagogies and Indigenous ways of *Educaring* are viable approaches for the future to heal fractured relationships and cultures.

REFERENCES

Atkinson, Caroline., and Judy Atkinson. 2007. *The Biological Effects of Traumatic Stress.* Lismore: Gnibi College Southern Cross University.

Atkinson, Caroline. 2007. "The Violence Continuum: Aboriginal Australian Male Violence and Generational Posttraumatic Stress." PhD diss., Charles Darwin University.

Atkinson, Judy. 2002. *Trauma Trails, Recreating Song Lines, The Transgenerational Effects in Indigenous Australia.* Melbourne: Spinifex.

Atkinson, Judy. 2007a. *Healing The Hurts: A Loss and Grief counselor Training Program.* Lismore: Gnibi College Southern Cross University.

Atkinson, Judy. 2007b. *The Prun: An Indigenous Conflict Management Skills Training.* Lismore: Gnibi College Southern Cross University.

Atkinson, Judy. 2011. *Dadirri The Aboriginal Gift to the Nation: Listening to One another Indigenous Spirituality*. Lismore: Gnibi College Southern Cross University.

Atkinson, Judy. 2012. *Negotiating Worldviews- Indigenous Place in Academic Space*. Lismore: Southern Cross University.

Atkinson, Judy., and Christopher Edwards-Haines. (n.d). "Social and Emotional Wellbeing: An Indigenous Perspective." Paper presented at the Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra.

Bin-Sallik, Maryanne. 2003. 'Cultural Safety: Lets name it!.' *The Australian Journal of Indigenous Education* 32: 21-28.

Chandler, Michael., and Christopher Lalonde. 2008. "Cultural Continuity as a protective Factor against Suicide in First Nations Youth." in *Horizons_ A Special Issue on Aboriginal Youth, Hope or Heartbreak: Aboriginal Youth and Canada's Future* 10: 68-72.

Corey, Gerald. 2009. *Theory and Practice of Counseling Psychotherapy*. (8thedn). California: Thompson Brookscole.

Day, Andrew., Martin Nakata., and Kevin Howells. 2008. *Anger and Indigenous Men: Understanding and responding to violent behavior.* Leichardt: Federation Press.

Dayton, Tien. 2000. *Trauma and Addiction-ending the cycle of pain through emotional literacy.* Florida: Health Communications.

Doidge, Norman. 2007. *Stories of personal triumph from the frontiers of brain science: the brain that changes itself*. New York: Penguin Group.

Dudgeon, Pat., and Karen Ugle. 2010. "Communication and Engagement: Urban Diversity." In *Working Together: Aboriginal and Torres Strait Islander Mental Health and Wellbeing Principles and Practice*, edited by Nola Purdie, Pat Dudgeon, and Roz Walker, 181-191. Barton: Department of Health and Ageing.

Geldard, David., and Kathryn Geldard. 2009. *Basic Personal Counselling: A training manual for counsellors*, (6th Edn). Frenchs Forest: Pearson Education.

Haebich, Anne. 2000. *Broken Circles: Fragmenting Indigenous Families, 1800-2000.* Fremantle: Fremantle Arts Centre.

Harrison, Ann. 2005. "How Does Society Still Traumatise Indigenous Australians?." Paper presented at the RANZCP Section of Psychotherapy Conference ACT.

Hinkson, Melinda. 2007. "Introduction: In the Name of the Child." In *Coercive reconciliation: stabilise, normalise, exit aboriginal Australia*, edited by Jon Altman, and Melinda Hinkson 1-12. Carlton: Arena Publications.

Hollinsworth, David. 2006. *Race and Racism in Australia.* Melbourne: Cengage Learning.

Kneebone, Eddie. 1991. "An Aboriginal Response." In *Creation Spirituality & the Dreamtime,* edited by Matthew Fox, Joanna Macy, Veronica Brady, Elizabeth Cain, and Eddie Kneebone, Newtown: Millennium Books.

Lawlor, Robert. 1991. *Voices of the First Day: Awakening in the Aboriginal Dreamtime.* Vermont: Inner Traditions International.

Levine, Peter. 2010. *In an Unspoken Voice: How the Body Releases Trauma and Restores Goodness.* California: North Atlantic Books.

Levine, Peter., and Maggie Kline. 2007. *Trauma Through A Child's Eyes, Infancy through Adolescence: Awakening the Ordinary Miracle of Healing*. California: North Atlantic Books.

McEwan, Alexandra., komla Tsey, and Empowerment Research Team. 2009. *The Role of Spirituality in social and Emotional Wellbeing Initiatives: The Family Wellbeing Program at Yarrabah.* Cairns: James Cook University: Gurriny Yealamucka Health Service and Cooperative Research Centre for Aboriginal Health.

Mindell, Arnold. 1995. *Sitting in the Fire-Large Group transformation using Conflict and Diversity*. Portland Oregon: Lao Tse Press.

Morgan, Maria., and Neil Drew. 2010. 'Principled Engagement: Gelganyem Youth and Community Well Being Program.' In *Working Together: Aboriginal and Torres Strait Islander Mental Health and Wellbeing Principles and Practice,* edited by Nola Purdie, Pat Dudgeon, and Roz Walker 253-267. Barton: Department of Health and Ageing.

Porth, Carol., and Glenn Matfin. 2009. *Pathophysiology Concepts of Altered Health States*. Philadelphia: Lippincott Williams & Wilkins.

Roe, Joe. 2010. "Ngarlu: A Cultural and Spiritual Strengthening Model." In *Working Together: Aboriginal and Torres Strait Islander Mental Health and Wellbeing Principles and Practice*, edited by Nola Purdie, Pat Dudgeon, and Roz Walker 245-253. Barton: Department of Health and Ageing.

Rothschild, Babette. 2000. *The Body Remembers: The Psychophysiology of Trauma and Trauma Treatment.* New York: Norton.

Scaer, Robert. 2001. 'The Neurophysiology of Dissociation and Chronic Disease.' In *Applied Psychophysiology and Biofeedback* 26: 1.

Szalavitz, Maia., and Bruce Perry. 2010. *Why Empathy is Essential- and endangered: Born For Love*. New York: HarperCollins.

Townsend-Cross, Marcelle. 2013. *Indigenous Ways of Cultural Expression.* Gnibi. Lismore: Southern Cross University.

Ungunmerr, Maryanne. 2003."Dadirri the spring within." In *Dadirri* 5-7. Lismore: Southern Cross University.

Wild, Rex., and Patricia Anderson. 2007. *Ampe Akelyernemane Meke Mekarle: 'Little Children are Sacred', In our Law children are very sacred because they carry the two spring wells of water from our country within them: Report of the Northern Territory Board of Inquiry into the Protection of Aboriginal Children from Sexual Abuse.* Darwin: Northern Territory Government.

ABOUT THE AUTHOR

Tanietta Delauney: Tanietta Delauney is an Australian Wiradjuri woman and single parent. She has a Bachelor of Indigenous Studies (Trauma & Healing) degree and has just completed her Master of Indigenous Studies (Wellbeing) at Southern Cross University in NSW, Australia. Tanietta has earned the Golden Key achievement award and also the Gnibi Prize for highest GPA for her academic work in 2012. Tanietta has been working as an out-reach mentor for Indigenous youth, a tutor for Indigenous students and a student ambassador. She is a passionate advocate for community events that support cultural mores and is a volunteer for the Australian Indigenous Mentoring Experience, a member of the Indigenous Events Co-ordinating Committee, and of Kids in the Community, among other programs. Her interests include human rights/equity issues, and she is actively involved in creating a better society for Indigenous people.

Engaging Teenagers with Genetics and Genomics through a School-based Competition: Pilot Evaluation

Emma Weitkamp, University of the West of England, Bristol, UK
Dawn Arnold, University of the West of England, Bristol, UK

Abstract: As part of a university outreach programme, the authors ran an interschool competition encouraging young people (year 10, age 14–15) to explore their ideas about the likely social impacts of whole genome screening. Schools participating in the competition selected teams of 4–5 young people who participated in a one day workshop. This workshop provided an introduction to whole genome screening, what it is and what it might (and might not) be able to tell us about our future health. The workshop also included sessions on communicating scientific ideas through film (e.g. storyboarding and basic editing). Students were then instructed to create a 4–6 minute film about genomics and what issues it might present for individuals and/or society. Students reconvened for a second workshop to view and discuss the films created. This paper focuses on a thematic analysis of the films entered in the competition, exploring the issues that students raise. In addition to the thematic analysis, quantitative and qualitative data were collected that enable a preliminary exploration of student learning. This will be explored in the context of what students of this age already know and how they have built upon this learning during the competition.

Keywords: University Outreach, Genomics, School-based Competition, Evaluation

Introduction

A one-day workshop introducing genetics and human genome screening formed the starting point for a competition to create short 4–6 minute films about the implications of emerging genetic technologies for society. The competition was open to Year 10 pupils in secondary schools in the Swindon area of the UK. The project sought to use the element of competition to stimulate teenagers (aged 14–15) to learn about genetics and genomics and to explore the potential implications these technologies might have for society.

The project was sparked by the rapid drop in the price of genome screening, which is now approaching the $1000 mark. At these prices, today's teenagers are likely to have the opportunity to have their genomes sequenced. The potential availability of human genome screening technologies has sparked concern about a wide range of ethical, legal and social issues and how society should address these (see for example: Angrist, 2011, House of Lords, 2009; Nuffield Council on Bioethics, 2009) and researchers have sought to identify ways to help non-specialists make informed decisions about these technologies and the risks and benefits they may offer (see for example: Munn et al., 1999).

The project is firmly rooted in the notion that University outreach programmes have an important role to play in stimulating and maintaining young people's interest in science and science related careers (see for example: Walker, 2007). Previous studies have shown that pupils who are involved in outreach projects with scientists are more interested in science, develop new views about science and scientists and have a better understanding of the relevance of science to everyday life (Laursen et al., 2007). By developing this competition-based outreach activity specifically for teenagers, we sought to interest them in both the science of genetics and genomics as well as increasing their interest more generally in the implications of scientific advances for society.

The International Journal of Science in Society
Volume 4, 2013, www.science-society.com, ISSN 1836-6236

COMMON GROUND

Project Outline and Methods

Student groups (Year 10, ages 14–15) were recruited to the competition through a teaser leaflet provided to the Heads of Science in the Swindon School Cluster. Initial contact was made via a host school (the school willing to host the competition) and one of us [Weitkamp] presented the competition idea to a regular meeting of the Heads of Science in this cluster. Each school was invited to field up to 3 teams of 4 pupils each and we suggested that these should be pupils identified as 'gifted and talented' scientists (i.e. in the top of their year group academically). Participating schools were required to provide transport to the host school for the teams competing in the competition.

A one day workshop was developed to provide students with a starting point from which to explore the implications of genetic testing and genome screening. As participants were unlikely to have had much exposure to genetics or genomics in the school curriculum by the end of year 10, we developed the workshop to include basic information on genetics (e.g. what is DNA, what is a gene and that genes are linked to physical traits) and introduced the concept that you could screen your entire genome to learn something about yourself (e.g. your hair or eye colour, whether you are at risk of a particular disease). The workshop also included an introduction to narrative and story creation and camera use to help pupils develop coherent films and students were provided with additional resources on genetics and genomics to explore further while creating their films.

Pupils worked in self-selected groups with 2–5 members each. These groups were organised during the first workshop so that pupils could begin to work on ideas for their films during the day. At the end of the first workshop, pupils were set the following challenge:

> To create a 4–6 minute film exploring what it might mean for you to have your genome sequenced. The film should be suitable for 14–18 year olds.

Participants were given 8 days to create the film, submitting the film through their teachers. These were judged by a panel of three academic scientists/science communicators from our University, but who were not otherwise involved in the project, and one independent author. Participants were invited back to the host school for a final half day workshop on forensic genetics (which was provided to further deepen their understanding of genetics and to provide an incentive for schools to release them for the film screening), a screening of the submitted films and the awarding of competition prizes.

Evaluation Methods

A baseline questionnaire was developed to gather background data on participants' interests in science, genetics, science and society interactions and film making. This comprised yes/no, scale and open ended questions and was administered at the start of the first workshop. A final questionnaire comprising similar questions as well as questions specifically about participating in the competition was developed and implemented in the final workshop. This questionnaire was administered after the screening of the submitted films, but before the announcement of winners. In addition to the quantitative data collected through the questionnaire, semi-structured, group interviews were conducted with selected teams both toward the end of the first workshop and during the final workshop. These provided more detailed insights into participants' experiences of the programme. Interviews were coded thematically to understand the experience of the participants in engaging in the competition. Qualitative content analysis was also conducted on the films submitted by the students. This focused on two key areas: scientific content (e.g. themes relating to genetics, genomics, DNA) and social issues (e.g. aspects relating to genetic testing, impacts on families, what you might find out about yourself).

Results and Discussion

A total of 23 pupils participated in the competition from 3 different schools. This resulted in six films submitted for judging. All 23 participants completed preliminary evaluation questionnaires. However, only 20 pupils were able to attend the final half day workshop, owing to a mixture of exams and other school events and as a result, only 20 final evaluation questionnaires were received for analysis. As expected, 17 out of 23 participants reported being unfamiliar with genetics and genomics at the start of the workshops. Despite being high academic achievers in science, less than half of the participants report reading about science outside school and 3 (out of 23) find science uninteresting. It was also clear that, while a few students claimed to have watched a film or TV show about genetics or genomics, the majority did not engage with this area of science outside school. In comparison, familiarity with film and film making was much greater (see Figure 1). Furthermore, nearly all (21 out of 23) watch YouTube videos, suggesting that participants will be familiar with short film clips as required for the competition. This familiarity with the medium was also evident in the qualities of the films produced, which were considered to be technically competent in all but one case. The films also used a variety of standard narrative formats, including news reports (2), music video (1) and documentary (1). One film was fairly didactic, taking a format similar to that of an animated powerpoint presentation. The final film had both narrative and technical issues that made it noticeably poorer quality.

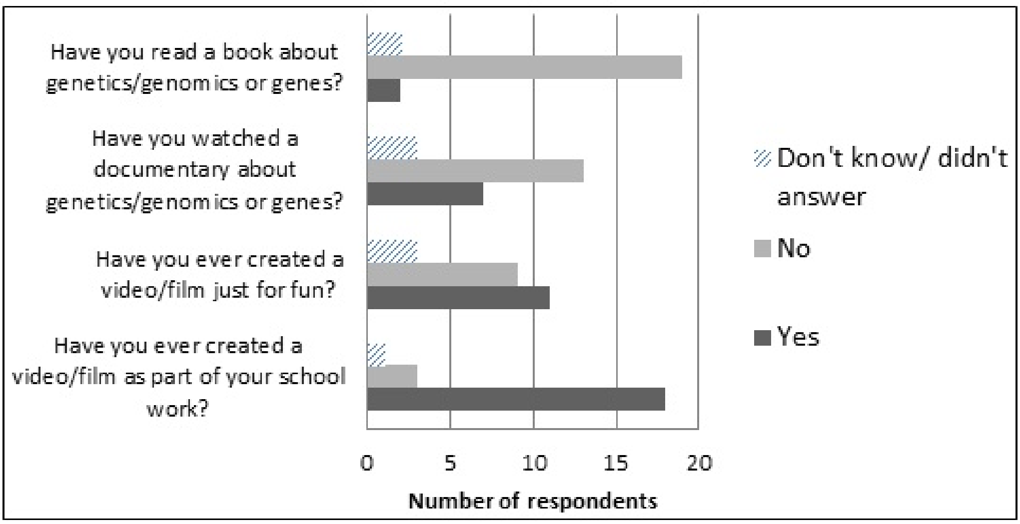


Figure 1: Participants' Familiarity with Genetics/Genomics and Film Making before Participating in the Workshop

We explored participants' interests in the impact of science on society both in the preliminary questionnaire and in the follow up evaluation (see Figure 2). The findings suggest that the project encouraged young people to think about the impacts of science on society and to increase their interest in this area. Pupils also report that the project encouraged them to think about genomics, a subject area which they had not previously encountered. There is also clear evidence that the participants enjoyed making the film and would like the opportunity to make another film about a science topic.

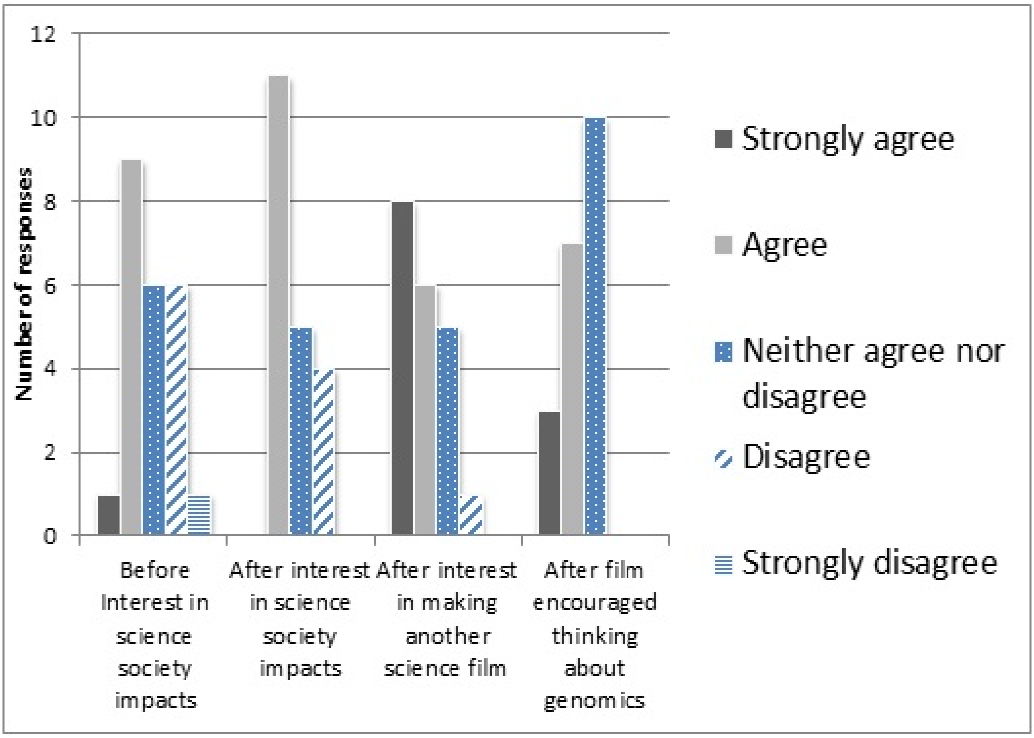


Figure 2: Participants Reporting of the Impact of the Workshop on Thinking about Genomics and Science and Society Impacts

These findings are supported by the qualitative interviews which show that the participants found the project stimulating and engaging.

> "I liked learning about different people's opinions, like how controversial it is"–Round Reference team

> "It was really fun, such a laugh to do"–Jacob's experience team

But did this enjoyment of the film making process translate into factual content about genetics and genomics in the films submitted to the competition? Up to a point, the answer is yes, though the depth of engagement with the subject matter was more limited than we had hoped. All the films produced included some content related to genetics or genomics, though this was often fairly superficial. In all cases, genome screening was linked to disease or disease risk and in 5 out of 6 films an explicit link was made between genes and traits. However, only 2 films defined the term 'gene', while 3 films provided a definition of 'genome'. Use of the double helix image to represent DNA was prevalent, with 5 out 6 films containing this image.

The picture is a little better when it comes to engaging with the wider societal implications of genomics and genetic testing. Participants identified a number of issues and discussed these either in positive or negative frames. In all cases, pupils sought to achieve a balance between positively and negatively framed issues. Positively framed issues comprised: being able to make lifestyle changes to reduce the risk of disease (4/6); potential for personalised medicine (2/6); and to learn more about yourself (2/6). Negatively framed issues comprised: increased worry and stress (4/6); uncertainty about the future (3/6); commercial use or abuse (e.g. insurance premiums rise) (3/6); and the cost of testing (e.g. money could be better spent) (2/6). A final category which was presented both positively and negatively was that it might be useful if you were planning to have kids (but it was unclear how the information would be put to use). This last was mentioned in 3 out of 6 films. Finally, there was a tendency to conflate genetic testing and genomics in the presentation of both the scientific details and the social issues these might raise.

Conclusions

Genomics raises important questions for society, which are being discussed in academic and policy circles (see for example: House of Lords Science and Technology Committee, 2009). This project sought to engage teenagers, a group likely to have access to personal genomics technologies at some point during their lives, with both the science behind the technologies and the social issues they raise. A single, one-day workshop, enabled young people to engage with basic concepts relating to genetics, but it did not allow much discussion of questions of certainty and risk related to testing for non-Mendelian genetic diseases or that will arise with genome scanning techniques. Nevertheless, participants did start to engage with questions of risk and the concept that genetics is not the only factor that determines characteristics or disease risk. For future projects in this area, we recommend either running additional workshops to enable greater discussion of risk and uncertainty related to these technologies, or a tighter focus for the competition that would encourage participants to explore genetic science in more depth, for example focusing on issues more closely linked to the curriculum, such as genetic engineering or cloning.

It was clear that creating a film acted as a stimulus for the groups to consolidate the information presented in the one-day workshop and to a limited extent to develop their knowledge further through additional research. This research took the form of reading and viewing information available on the internet and also through short surveys of their friends and colleagues at school (i.e. to gather wider opinions on the social issues). In its current format, the project was successful at stimulating discussion and consideration of some of the ethical, legal and social issues that may arise as genomic technologies become more widely available. Importantly, students reported that they enjoyed making the film and would like to engage in this type of activity again. This combined with the generally good standard of narrative and technical production of the films suggests that the format for the competition is appropriate to the age group.

REFERENCES

Angrist, Misha, 2011. *Here is a human being: at the dawn of personal genomics*, New York: HarperPerennial.

House of Lords Science and Technology Committee, 2009. "Genomic medicine." Available online from: www.parliament.uk [Accessed 20th November 2012].

Laursen, Sandra, Carrie Liston, Heather Thiry and Julie Graf. 2007. "What good is a Scientist in the Classroom? Participant Outcomes and Programme Design Features for a Short-duration Science Outreach Intervention in K–12 Classrooms." *CBE Life Science Education* 6(1):49–64. doi: 10.1187/cbe.06–05–0165.

Munn, Maureen, Peggy O'Neil Skinner, Lane Conn, H. Geraldine Horsma, Paula Gregory. 1999. "The Involvement of Genome Researchers in High School Science Education." *Genome Research* 9:597–607. doi: 10.1101/gr.9.7.597.

Nuffield Council on Bioethics, 2009. "Medical profiling and online medicine: the ethics of 'personalised' healthcare in a consumer age." London: Nuffield Council on Bioethics.

Walker, Steve. 2007. "Outreach Activities: a summary for UK university physical science departments." Hull: The Higher Education Academy Physical Sciences Centre. Available Online: http://www.heacademy.ac.uk/assets/ps/documents/Outreach_guide_May_ 2007.pdf [Accessed 20th November 2012].

ABOUT THE AUTHORS

Dr. Emma Weitkamp: Emma Weitkamp is a lecturer and practitioner in science communication. As well as contributing to the MSc in Science Communication offered by the University of the West of England, Bristol, Emma has run several projects that explore the intersection of science and society with young people. These include the EPSRC funded ScienceComics.uwe.ac.uk project, a web-based resource for primary school students and teachers that comprises comics, teaching resources and games about materials science; and It's My Baby, a Wellcome Trust funded project exploring drama-based workshops as a tool for engaging secondary school pupils with issues around genetic testing.

Dr. Dawn Arnold: Dawn Arnold (UWE, Bristol) is a Professor in Molecular Plant Pathology with over 18 years experience working with the bacterial plant pathogens P. syringae pathovars pisi and phaseolicola and their interaction with their host plants pea and bean. This work involves molecular genetic characterisation of the genes involved in the pathogenicity process towards plants and also how the bacteria can evolve to overcome host resistance.

Primary Teachers' Conceptions about Science Teaching and Learning

Panagiota Antoniadou, Greece
Michael Skoumios, University of Aegean, Greece

Abstract: The study of teachers' conceptions about issues related to science teaching and learning is of particular significance because those conceptions often influence the way that teachers interact with students and apply the curriculum and teaching material. Although secondary science teachers' conceptions about teaching and learning have been extensively investigated, research on primary teachers' conceptions is limited. The present study investigates primary teachers' conceptions about issues related to science teaching and learning (meaning of learning and teaching, purpose of teaching, teaching tools, main teaching practice, classroom organization, teachers' strategies to deal with students' errors in science). A written questionnaire was used as a data collection method, which was based on the views about teaching and learning of the three dominant approaches to science teaching and learning (transmission, discovery and constructivist). The questionnaire was applied to 173 primary teachers in Greece. The frequencies and the percentage frequencies of teachers' answers per question were determined. It emerged that teachers' conceptions are related to the views of constructivist and discovery approach. In particular, it was concluded that the majority of teachers activated conceptions about the meaning of learning, purpose of teaching and classroom organization, which are consistent to the views of the discovery approach, whereas their conceptions about the meaning of teaching, teaching strategies and teachers' strategies to deal with students' errors are consistent to the views of the constructivist approach to science teaching and learning.

Keywords: Teachers' Conceptions, Teaching, Learning, Science Education

Introduction

In modern societies, science plays an increasingly important role, therefore it is necessary to construct basic scientific knowledge and develop such skills and attitudes that will enable students to effectively face the problems of everyday life and to participate in society as active citizens. Despite the importance given to the science education, learning outcomes are not satisfactory (OECD, 2004; 2010). It is thus apparent that a need for further study of the learning process concerning science education has arisen.

The study of the educational process includes students, the program and teaching materials, as well as teachers. This work focuses on teachers. In particular, it focuses on conceptions of teachers on a range of issues related to science teaching and learning.

Teachers' conceptions usually affect teaching practices (Isaacson, 2004; Ozkal, 2007; Pintrich et al, 199; Reinders, 1996; Savasci, 2006). The way in which the teaching material is used appears to depend on the teachers' conceptions of issues related to teaching and learning (Mellado, 1998; Tobin at al., 1994). The choice of teaching methods and students' overall treatment largely depends also on teachers' conceptions (Aguirre & Speer, 2000; Hashweh, 1996; Levitt, 2001). Therefore, the investigation of teachers' conceptions about teaching and learning is of significant importance.

Although, secondary science teachers' conceptions about teaching and learning have been extensively investigated, research on primary teachers' conceptions is limited. The study of primary school teachers' conceptions for a wide range of issues related to science teaching and learning is the subject of this paper.

The International Journal of Science in Society
Volume 4, 2013, www.science-society.com, ISSN 1836-6236

Theoretical Framework

Teachers' Conceptions

A number of terms have been referred to the conceptions such as ideas, orientations, beliefs, attitudes, approaches, views, and intentions. Among those terms, "conception" is the most commonly used one. Moreover, there are various definitions that synthesize what conception is and the factors influencing teacher conception (Kagan, 1990; Pratt, 1992; Richardson, 1996; Sigel, 1985). Pratt's (1990) definition of teachers' conceptions is compatible with the scope of this study. Pratt (1992) defines conceptions as: "… specific meanings attached to phenomena that then mediate our response to situations involving those phenomena. We form conceptions for virtually every aspect of our perceived world, and in so doing, we use those abstract representations to delimit something from, and relate it to other aspects of our world. In effect, we view the world through the lenses of our conceptions, interpreting and acting in accordance with our understanding of the world." (p. 204).

Conceptions and perceptions have been used interchangeably by Kember (1997). Conceptions and beliefs are stated as different things and it is asserted that conceptions are more accessible, they can be formed consciously, and they carry personal meanings while beliefs are "driven by emotions" (Entwistle, Skinner, Entwistle & Orr, 2000, p. 10). Richardson (1996) provides three sources of teacher conception: (a) personal life experiences that shape a teacher's worldview, (b) experiences as a student with schooling and instruction and (c) formal knowledge including pedagogical content knowledge.

Science Teaching Approaches

There are three dominant teaching approaches to educating students in science: transmission, discovery and constructivist approach. The views of three dominant approaches for science teaching on a number of issues related to teaching and learning are presented below.

Transmission Approach

The transmission approach to science teaching and learning was dominant until the early 19th century. According to this, knowledge is transferred from the teacher to the students (Symington & Kirkwood, 1995). Learning is considered as memorization and recall of knowledge and teaching is a process of transferring knowledge (Barnes, 1976; Bloom, Englehart et al., 1956). The aim of teaching is that students should be able to reproduce what they were taught. The teaching strategies adopted by the teacher in particular, is the lecture (monologue), the questions and in some cases, demonstration experiments (Ashiq, Azeem & Shakoor, 2011) which aim to verify theory. The main teaching practice is that in which students affirm scientific principles by carrying out experiments proposed by the teacher. Related to classroom organisation, students work individually. Moreover, wrong student' responses are thought to hinder the progress of teaching and for this reason, the objective is to avoid them.

Discovery Approach

This approach emerged in the 1960's. According to this, knowledge is not transferred from the teacher to the student, but discovered by the student with the proper guidance of teacher (Sund et al., 1967; Thier, 1970). Learning is considered as a discovery of new knowledge (Fleer, 2007). A discovery approach shifts the teaching process from the teacher to the student. Teaching, therefore, is the process of discovering knowledge by the students themselves. The aim is not for the student to memorize large amounts of information, but to be able to explain what he has discovered (Hodson, 1985). Teaching strategies used in discovery approach are: experimentation, questions, investigation and discussion (Fleer, 2007). The teaching practice that prevails is one in which students discover scientific principles following elements of the scientific method (Hodson, 1985). Students are divided into groups, where each student undertakes a specific project. Wrong answers are not punished or ignored, but are seen as useful, because they are considered to help the teacher understand students' deficiencies and make appropriate adjustments to the course of instruction.

Constructivist Approach

Since the mid 1970's there has been a shift towards constructivist approach to teaching and learning. According to this, knowledge is neither transferred from the teacher to the student, nor discovered by the student, but constructed by the learner. Students construct their own knowledge about scientific phenomena through an interactive process between the initial conceptions they have already created and the educational environment (Driver, 1983; Osborne & Freyberg, 1985; Scott, 1987). The assumption that the learner constructs knowledge implies that the student is the one who decides to change his conceptions. Before students' education in schools begins, they have already formulated their own conceptions about science (Driver et al., 1985; Driver et al., 1998). According to the constructivist approach, learning aims to change or modify the initial knowledge of the student. Knowing the students' conceptions allows the teacher to better organize material for more effective teaching (Driver & Oldham, 1986; Shepardson, 2002). Teaching is considered as a process where students actively construct new knowledge based on their initial conceptions. Teaching is considered effective when a student is able to give explanations according to his/her conceptions. Teaching strategies and tools appropriate for the application of the constructivist approach are cognitive conflict, brainstorming, concept maps, discussion, analogies, experiment, educational software and simulations. The experimental data that contradict existing conceptions, after discussion, are likely to result in changing conceptions of students (Isaacson, 2004; Skoumios & Hatzinikita, 2005). Students work collaboratively, as the process of constructing new knowledge passes from the social and personal level. In the framework of social constructivism, science learning is considered a process in which the students construct knowledge through both individual and social processes (Driver et al., 1994). Knowledge is personally constructed but socially mediated: "the individual and social components [of constructivism] are parts of a dialectical relationship where knowing is seen dualistically as both individual and social, never one alone, but always both" (Tobin & Tippins, 1993, p. 21). Furthermore, according to this approach the wrong answers of the students are useful, because they are witness to the thought processes of the student (Skoumios & Hatzinikita, 2006).

Literature Review

Research that has been performed on teachers' conceptions about science teaching and learning, focuses only on a few issues related to teaching and learning, including the relationship between teachers' conceptions and the practice adopted in classroom (Cronin-Jones, 1991; Hashweh, 1996; Savasci, 2006), the relevance of conceptions with the principles of constructivist theory (Levitt, 2002; Mashmood, 2007), the way they perceive learning and teaching and the goal of teaching (Mashmood, 2007; Ravitz, 2000; Shumba, 2011), the degree of participation of students (Ashiq, Azeem, Shakoor, 2011), the role of teachers and students in teaching (Cronin-Jones, 1991; Holf-Reynolds, 2000; Mashmood, 2007; McLaughlin, 1991; Simmons et al. 1999; Shumba, 2011; Wallace & Kang, 2004), the classroom organisation (Holf-Reynolds, 2000; Mashmood, 2007), practices and strategies that are mainly applied (Hashweh, 1996; Holf-Reynolds, 2000; Shumba, 2011), the application of investigations and experiments (Luft, 2001) and the type of evaluation applied (Mashmood, 2007; Ravitz, 2000 ; Savasci, 2006). In addition, most studies have been carried out to investigate secondary teachers' conceptions (Cronin-Jones, 1991; Holt-Reynolds, 2000; McLaughlin, 1991; Roehrig and Luft, 2004; Simmons et al., 1999; Van Driel, Verloop, Wobbe, 1998; Woolley et al., 1999). Research on primary school teachers is very limited (Beck et al., 2000; Levitt, 2001). From these studies it was concluded that generally, although teachers do not hold conceptions fully compatible with the constructivist approach, their conceptions have a tendency to side with student-centered approaches.

However, surveys that study teachers' conceptions about several dimensions of constructivist approach to science teaching and learning haven't been carried out. What is more, surveys that investigate teachers' conceptions about the constructivist approach, as opposed to the other two teaching approaches, discovery and transmission haven't been carried out, as well. As a result, the need for further investigation of primary teachers conceptions for a wide range of dimensions related to the teaching and learning of science has emerged.

Objectives of the Study

This paper focuses on exploring primary school teachers' conceptions of issues related to science teaching and learning. Specifically, it investigates the teachers' conceptions about meaning of learning and teaching, purpose of teaching, teaching tools, main teaching practice, classroom organization and teachers' strategies to deal with students' errors.

Method

Design of the Study and Participants

The research was conducted in three stages. In the first stage, a questionnaire was formed in order to highlight teachers' conceptions about science learning and teaching. In the second stage, the questionnaire was applied to primary teachers in Greece. In the third stage, the responses of teachers were analyzed.

The survey involved 173 primary school teachers who teach science. The sample was stratified by conducting sampling to ensure that it would be as representative as possible in terms of the type of school (private/public), geographic region, sex and years of service of teachers.

The Questionnaire

In order to detect the teachers' conceptions on issues related to science teaching and learning, a questionnaire with multiple choice questions was created. The construction of the questionnaire was done in stages.

Table 1: Views of the three dominant teaching approaches (transmission, discovery and constructivist) on issues related to the meaning of learning and teaching, purpose of teaching, teaching tools, main teaching practice, classroom organization and teachers' strategies to deal with students' errors.

Issues	**Transmission approach**	**Discovery approach**	**Constructivist approach**
Learning	Memorization and recall of knowledge	Discovery of new knowledge	Change or modify the original conceptions
Teaching	Process of transferring knowledge to students	Knowledge discovery process by students	Process of constructing knowledge by students according to their initial knowledge
Purpose of teaching	The student must be able to reproduce what was taught	The student must be able to explain what was discovered	The student must be able to give explanations based on his initial conceptions
Teaching strategies and tools	Lecture, question, experiment	Investigation, question, discuss, experiment	Cognitive conflict, brainstorming, questions, discussion, concept maps, experiment
Main teaching practice	The teacher or the students affirm scientific principles by performing experiments proposed by the teacher	Students discover scientific principles following elements of the scientific method	Students construct new knowledge about the phenomena through an interactive process of initial conceptions that have been created for them and the educational environment
Classroom organization	Students work individually	Students work in groups where each member carries out a project	Students work collaboratively
Teachers' strategies to deal with students' errors	The error is considered as lack of knowledge and must be avoided	The error is considered as lack of knowledge and must be avoided	The error is a "witness" of the thought processes of the individual

Research issues were: meaning of learning and teaching, purpose of teaching, teaching tools, main teaching practice, classroom organization and teachers' strategies to deal with students' errors. This was formulated into a table that included the views of each of the three teaching approaches in science on the above issues related to teaching and learning (see Table 1). The data in this table formed the basis for the creation of queries and proposed alternative responses for the questionnaire.

Initially, the questionnaire was given to ten teachers. There was a discussion with the teachers for feedback. Afterwards, it was given to two researchers in the field of science education. According to the observations obtained, corrections were made. The final questionnaire included 7 questions.

Data Collection and Analysis

A questionnaire was used for data collection. The time needed for teachers to respond to the questionnaire was about five minutes.

The research data were the responses of teachers in the questionnaire. The responses of teachers were analyzed according to the data in Table 1. The frequencies and the percentage frequencies of teachers' answers per question were determined.

Results

The Meaning of Learning

Table 2 presents the results concerning the responses of teachers on the meaning of learning. Table 2 shows that the majority of teachers perceive learning as discovery of new knowledge (65.9%). The notion that learning is a modification of the original knowledge held by students is expressed to a smaller degree (28.9%). The number of teachers who consider learning as memorization and recall of knowledge is limited (5.20%).

Table 2: Frequencies and Percentage Frequencies of Teachers' Conceptions of the Meaning of Learning

Conceptions	N	N%
Learning is knowledge memorization and recall	9	5.20
Learning is discovering new knowledge	114	65.9
Learning is modification of initial knowledge	50	28.9

The Meaning of Teaching

Table 3 presents the results concerning the responses of teachers on the meaning of teaching. Table 3 shows that the prevailing opinion is that teaching is a process in which students construct new knowledge based on the initial conceptions (69.36%). One fourth of teachers perceive teaching as a process of knowledge discovery, (24.86%), while a limited number of teachers felt that teaching is a process of transfer of knowledge from the teacher to the students (5.78%).

Table 3: Frequencies and Percentage Frequencies of Teachers' Conceptions of the Meaning of Teaching

Conceptions	N	N%
Teaching is transfer of knowledge	10	5,78
Teaching is discovery of knowledge	43	24,86
Teaching is constructing new knowledge based on the initial conceptions	120	69,36

The Purpose of Teaching

Table 4 presents the results concerning the responses of teachers on the purpose of teaching. Table 4 shows that the conception of "objective of the courses is for the student to explain what he discovered" is more popular compared with other concepts. Conceptions "goal of teaching is to give the student an explanation based on the initial knowledge" (20.23%) and "goal of instruction is for students to reproduce what was taught" (17.92%) are less popular.

Table 4: Frequencies and Percentage Frequencies of Teachers' Conceptions for the Purpose of Teaching

Conceptions	**N**	**N%**
The purpose of teaching is the student to explain what he discovered	107	61,85
The purpose of teaching is the student to give an explanation based on the initial knowledge	35	20,23
The purpose of teaching is the student to reproduce what was taught	31	17,92

Teaching Strategies and Tools

Table 5 presents the results concerning the responses of teachers on teaching strategies and tools used by teachers. Table 5 shows that the preferred strategies and tools applied by most teachers in the teaching of science, is cognitive conflict, brainstorming, questions, debate, concept maps and the experiment (64,74%). Fewer teachers argue that implement exploration, questions, discussion, experiment (33.53%), and limited is the proportion of teachers who use the lecture, questions and experiment as mainstream teaching strategies (1.73%).

Table 5: Frequencies and Percentage Frequencies of Teachers' Conceptions about Teaching Strategies and Tools

Conceptions	**N**	**N%**
Effective teaching strategies and tools are lectures, questions, experiment	3	1.73
Effective teaching strategies and tools are investigations, discuss, experiment	58	33.53
Effective teaching strategies and tools are cognitive conflict, concept maps, experiment	112	64.74

Main Teaching Practice

Table 6 presents the results concerning the responses of teachers on main teaching practice. Table 6 shows that most teachers consider teaching practice as the dominant one in which students construct new knowledge about science phenomena through an interactive process of initial conceptions that have already created for them and the educational environment (76.3%). Less popular is the practice where students discover scientific principles following elements of the scientific method (19.08%). Finally, few teachers follow that in which students affirm scientific principles by carrying out experiments proposed by the teacher (4.62%).

Table 6: Frequencies and Percentage Frequencies of Teachers' Conceptions of the Main Teaching Practice

Conceptions	N	N%
Students construct new knowledge about science phenomena through an interactive process of initial conceptions have created for them and the educational environment	132	76.30
The teacher or the students affirm scientific principles by performing experiments proposed by the teacher	8	4.62
Students discover scientific principles following elements of the scientific method	33	19.08

Classroom Organization

Table 7 presents the results concerning the responses of teachers on classroom organization. Table 7 shows that the majority of teachers prefer students to work in groups, where each member has to carry out a project (56.07%). A comparatively smaller percentage of teachers believe that students should work collaboratively (39.88%). Lastly, the number of teachers who propose the individual work of students is limited (4.05%).

Table 7:Frequencies and Percentage Frequencies of Teachers' Conceptions for classroom Organisation

Conceptions	N	N%
Students work individually	7	4.05
Students work collaboratively	69	39.88
Students work in groups where each member has to carry out a project.	97	56.07

Teachers' Strategies to Deal with Students' Errors

Table 8 presents the results concerning the responses of teachers on the strategies to deal with students' errors in science. Table 8 shows that the teachers chose only two of the three answers. Specifically, the majority of teachers perceive the students' errors as a useful element in teaching, as students' wrong answers reveal the thought processes of the students (79.77%). Comparatively fewer are the teachers who think wrong answers help the teacher to understand the shortcomings of the students (20.23%). Note that no teacher supports the view that the wrong answers of the students make the teaching difficult.

Table 8: Frequencies and Percentage Frequencies of Teachers' Conceptions about Strategies to Deal with Students' Errors

Conceptions	N	N%
Students' errors are considered as lack of knowledge and must be avoided	0	0.00
Students' error are useful as they show lack of knowledge	35	20.23
Students' error is a "witness" of the thought processes of the individual.	138	79.77

Conclusions and Discussion

This work aimed to investigate primary school teachers' conceptions on issues related to science teaching and learning. Towards this, a questionnaire was answered by 173 primary teachers who teach science. The analysis of the responses of teachers showed the emergence of conceptions of teachers on the meaning of learning and teaching, purpose of teaching, teaching tools, main teaching practice, classroom organization and teachers' strategies to deal with students' errors.

Relating to the meaning of teaching and learning, most teachers who participated in the survey showed that they perceive learning as discovery of new knowledge (conception refers to discovery approach) and teaching as a process of constructing new knowledge based on the original knowledge (conception referring to the constructivist approach). Regarding the purpose of teaching, most teachers expressed the view that the student should be able to explain what he has discovered (which refers to discovery approach). It is worth noting that a limited number of teachers gave answers about the learning and teaching towards the transmission approach. It is concluded that although the conceptions of most teachers about teaching are towards constructivist approach, their conceptions about the meaning of learning and the purpose of teaching express the aspects of the discovery approach.

On instructional strategies and the dominant teaching practice, it was found that teachers are trying to implement significantly practices that are consistent with the constructivist approach in everyday school life. To a lesser extent, they are in favor of the discovery approach and a minimum percentage expresses transmission conceptions. More specifically, teachers prefer to use cognitive conflict and brainstorm, strategies that are consistent with the constructivist approach where main teaching practice is the one where students construct new knowledge about the phenomena through an interactive process between their initial conceptions about these phenomena and the educational environment (conception refers to the constructivist approach).

It also emerged that most teachers organize students into groups each member of which has to carry out a project (referring to discovery approach), while wrong answers of the students are considered useful, because they helps teachers to understand students' way of thinking (conception referring to the constructivist approach). Noteworthy is that none of the teachers adopts the transmission view that wrong answers make it difficult to teach. We conclude that in matters of this category teachers mainly express conceptions consistent with the constructivist approach, except for classroom organization.

These results suggest that primary school teachers' conceptions are towards the discovery and constructivist approach. It is shown, that teachers have not developed a fully consistent personal theory compatible with the conceptions of constructivist approach. The majority of them adopt a mix of conceptions mainly consistent with the constructivist and discovery approach. Another important finding is that, in all aspects of teaching and learning that were studied, a limited percentage of teachers express conceptions towards the transmission approach.

These findings regarding primary school teachers' conceptions about learning and teaching can be attributed to the fact that the new elementary science textbooks in Greece are towards discovery approach, while graduates of education departments have been also taught the constructivist approach to science teaching and learning.

The conclusions of this study are in agreement with those of many related studies that focus on secondary school teachers. Specifically, the findings of many studies are consistent with the assertion that the pedagogical conceptions of teachers do not fully comply with the constructivist approach, however could be characterized as student-centered (Ashiq, Azeem & Shakoor, 2011; Cronin-Jones, 1991; Levitt, 2002; Ravitz, Becker & Wong, 2000; Savasci, 2006; Simmons et al., 1999; Shumba, 2011; Van Driel, Verloop & de Vos, 1998). Moreover, in several studies it is highlighted that teachers are not only adopting a particular approach, but as the present study shows, they appear to reflect conceptions of different approaches (Lorsbach & Tobin, 1992; Mashmood, 2007; Tobin, 1990; Wooley et al., 1999).

This study focused on a relatively small number of teachers and this is a restriction in relation to its results. A better understanding of the conceptions of teachers should include a larger number of teachers. Also the use of the interview or the combination of questionnaires and interviews are likely to let us explore, in greater depth, the conceptions of teachers on the teaching and learning of science. The combination of questionnaires and semi-structured interview is a method that can reduce the disadvantages of exclusive use of questionnaires or interviews and simultaneously exploit their advantages (Roehrig & Luft, 2004; Tsai, 2003).

Despite these limitations, this study contributes to research on the conceptions of teachers since it illuminates the findings of the conceptions of teachers of primary education on issues of science teaching and learning, a subject on which research data was limited. The findings of this study are useful to those involved in shaping and developing training materials and curricula. The research evidence suggests that teachers generally implemented in a satisfactory manner the innovations which are consistent with their conceptions. One of the causes of failure of a series of innovations seems to be that not always the teachers' conceptions are taken into account (Mellado, 1998; Tobin at al. 1994). Primary school teachers' conceptions on issues related to science teaching and learning will provide baseline data for the pedagogical training programs for teachers and candidates for introductory training programs and continuing education in the teaching of primary school teachers.

The issue of the impact of teachers' conceptions on the adopted practices in schools is particularly important to be investigated and according to the findings of some studies (Beck, Czerniak, & Lumpe, 2000; Haney, Czerniak & Lumpe, 1996; Haney & McArthur, 2002; Hashweh, 1996; Levitt, 2002; Roehrig & Kruse, 2005) teachers' conceptions are directly related to their teaching practices, whereas according to the findings of some other studies (Mellado, 1998; Simmons et al., 1999) a clear relationship between the perceptions of teachers and teaching practices does not exist. It is therefore proposed to investigate systematically whether the teachers' conceptions on science teaching and learning are consistent with their teaching practices in the classroom.

REFERENCES

Aguirre, Julia and Natasha Speer. 2000. "Examining the Relationship between Beliefs and Goals in Teacher Practice." *Journal of Mathematical Behavior* 18(3): 327-356.

Ashiq Hussain, Muhammad Azeem, Azra Shakoor. 2011. "Physics teaching methods: scientific inquiry vs traditional lecture." *Inernational Journal of Humanities and Social Science* 1(19): 269-276.

Beck Judy, Charlene Czerniak and Andrew Lumpe. 2000. "An Exploratory Study of Teachers' Belief Regarding the Implementation of Constructivism in Their Classrooms." *Journal of Science Teacher Education* 11(4): 323-343.

Cronin-Jones, Linda. 1991. "Science Teacher Beliefs and Their Influence on Curriculum Implementation: Two Case Studies." *Journal of Research in Science Teaching* 28(3):235-250.

Driver, Rosalind. 1989. "Students' Conceptions and the Learning of Science". *International journal of science education* 11(5): 481-490.

Driver Rosalind, Edith Guesne and Andree Tiberghien (Eds). 1985. *Children's Ideas in Science,* Milton Keynes, UK: Open University Press.

Driver Rosalind, Hilary Asoko, John Leach, Eduardo Mortimer and Philip Scott. 1994. "Constructing Scientific Knowledge in The Classroom." *Educational Researcher* 23(7): 5-12.

Driver, Rosalind and Valerie Oldham. 1985. "A Constructivist Approach to Curriculum Development in Science." *Studies in Science Education*, 13: 105-122

Entwistle Noel, Don Skinner, Dorothy Entwistle and Sandra Orr. 2000. "Conceptions and Beliefs about Good Teaching: An Integration of Contrasting Research Areas." *Higher Education Research & Development* 19(1): 5–26.

Fleer, Marilyn. 2007. "Concept formation: A cultural-historical perspective". In M. Fleer (Ed.), *Young children: Thinking about the scientific world*. Watson ACT: Early Childhood Australia, 11-13.

Haney Jodi, Charlene Czerniak and Andrew Lumpe. 1996. "Teacher Beliefs And Intentions Regarding The Implementation Of Science Education Reform Strands." *Journal of Research in Science Teaching* 33(9): 971-993.

Haney, Jodi and Julia McArthur. 2002. "Four Case Studies of Prospective Science Teachers' Beliefs Concerning Constructivist Teaching Practices." *Science Education* 86(6): 783-802.

Hashweh, Maher. 1996. "Effects of Science Teachers' Epistemological Beliefs in Teaching." *Journal of research in science teaching* 33(1): 47-63.

Hodson, Derek. 1985. "Philosophy of science, science and science education." *Studies in Science Education* 12: 25-57.

Holf-Reynolds, Diane. 2000. "What Does The Teacher Do? Constructivist Pedagogies and Prospective Teachers' Beliefs about the Role of a Teacher." *Teaching and Teacher Education* 16: 21-32.

Isaacson, Leanna. 2004. *Teachers' perceptions of constructivism as an organizational change model: A case study*. Doctoral Dissertation. University of South Florida.

Kagan, Dona. 1992. "Implications of Research on Teacher Belief." *Educational Psychologist* 27: 65-90.

Kember, David. 1997. "A Reconceptualisation of the Research into University Academics' Conceptions of Teaching." *Learning and Instruction* 7(3): 255–275.

Levitt, Karen. 2001. "An Analysis of Elementary Teachers' Beliefs Regarding the Teaching and Learning of Science." *Science Education* 82(1): 197-214.

Lorsbach, Anthony and Ken Tobin. 1992. Constructivism as a referent for science teaching. In *Research Matters to the Science Teacher.* National Association for Research in Science Teaching, 5, 7.

Mahmood, Nasir. 2007. "Elementary Science School Teachers' Beliefs about Science and Science Teaching In Constructivist Landscape.*" Bulletin of Education and Research* 29 (2): 59-72.

McLaughlin, Milbrey Wallin. 1991. "Enabling professional development: What have we learned?" In Ann Lieberman & Lynne Miller (Eds.), *Staff development for education in the '90s: New demands, new realities, new perspectives*. New York: Teachers College Press, 61-82.

Mellado, Vicente. 1998. "The Classroom Practice of Pre-Service Teachers and Their Conceptions of Teaching and Learning Science.*" Science Education* 82(2): 197-214.

OECD (Organisation for Economic Cooperation and Development). 2004. *Learning for tomorrow's world: First results from PISA 2003*. Paris: Author.

OECD (Organisation for Economic Co-operation and Development). 2010. *PISA 2009 Results: What Students Know and Can Do.* Paris: Author.

Osborne, Roger and Freyberg, Peter.1985 "*Learning in science: The implications of children's science."* Portsmouth, NH: Heinemann.

Ozkal, Kudret. 2007. *Scientific epistemological beliefs, perceptions of constructivist learning environment and attitude towards science as determinants of students approaches to learning*, Unpublished Master Thesis, Middle East Technical University, Ankara.

Pintrich Paul, Ronald Marx and Robert Boyle. 1993. "Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factor in the process of conceptual change." *Review of Educational Research*, 63:176-199.

Pratt, Daniel. 1992. "Conceptions of Teaching." *Adult Education Quarterly* 42(4): 203-220.

Ravitz Jason, Henry Becker and YanTien Wong. 2000. *Constructivist-compatible beliefs and practices among U.S. teachers* (Teaching, Learning & Computing Report 4.) Irvine, CA: Center for Research on Information Technology and Organizations, University of California.

Reinders, Duit. 1996. "The Constructivist View in Science Education. What It Has To Offer And What Should Not Be Expected From It.*" Investigacoes em Ensino de Ciencias* 1(1): 40-75.

Richardson, Virginia. 1996. "The role of attitudes and beliefs in learning to teach": In John Sicula (Ed.) *Handbook of research on teacher education.* New York: Macmillan, 102-119.

Roehrig, Gillian and Rebecca Kruse. 2005. "The Role of Teachers' Beliefs and Knowledge in the Adoption of a Reform-Based Curriculum." *School Science and Mathematics* 105(8): 412-422.

Roehrig, Gillian and Julie Luft. 2004. "Constraints Experienced By Beginning Secondary Science Teachers Implementing Scientific Inquiry Lessons.*" International Journal of Science Education* 26(1): 3-24.

Savasci, Funda. 2006. *Science teacher beliefs and classroom practices related to constructivist teaching and learning,* Doctoral Dissertation, Ohio State University.

Shepardson, Dan. 2002. "Bugs, butterflies, and spiders: children's understandings about insects." *International Journal of Science Education* 24(6): 627-643.

Shumba, Almon. 2011. "Teacher's Conceptions of the Constructivist Model of Science Teaching and Student Learning." *Kamla-Raj* 13(3): 175-183.

Sigel, Irving. 1985. "A conceptual analysis beliefs". In Irving Sigel (Ed.), *Parental belief systems: The psychological consequences for children.* Hillsdale, NJ: Erlbaum, 345–371.

Simmons Patricia, Allen Emory, Tim Carter, Teresa Coker, Brian Finnegan, Denise Crockett, Lon Richardson, Robert Yager, John Craven, John Tillotson, Herbert Brunkhorst, Mark Twiest, Kazi Hossain, James Gallagher, Don Duggan-Haas, Joyce Parker, Fernando Cajas, Qasim Alshannag, Sheryl McGlamery, Jerry Krockover, Paul Adams, Barbara Spector, Tom LaPorta, Bob James, Kristin Rearden and Kay Labuda. 1999. "Beginning Teachers: Beliefs and Classroom Actions*." Journal of Research in Science Teaching* 36(8): 930-954.

Skoumios, Michael and Vassilia Hatzinikita. 2005. "The role of cognitive conflict in science concept learning." *The International Journal of Learning* 12(7): 185-193.

Skoumios Michael and Vassilia Hatzinikita. 2006. "Research-based teaching about science at the upper primary school level." *The International Journal of Learning* 13(5): 29-42.

Sund Robert, Leslie Trowbridge, Bill Tillery and Kenneth Olson. 1967. *Elementary science teaching activities: A discovery laboratory approach*. Columbus, Ohio: C. E. Merrill Books.

Symington, David and Valda Kirkwood. 1995. "Science in the Primary School Classroom". In B. Hand & V. Prain (Eds.), *Teaching and learning in science: the constructivist classroom.* Sydney: Harcourt Brace, 193-210.

Thier, Herbert. 1970. *Teaching elementary school science: A laboratory approach*. Lexington, Mass.: Heath.

Tobin, Kenneth. 1990, "Research on science laboratory activities; in pursuit of better questions and answers to improve learning*." School Science and Mathematics* 90(5): 403-418.

Tobin, Kenneth and Campbell McRobbie. 1996. "Cultural Myths As Constraints To The Enacted Science Curriculum." *Science Education* 80(2): 223-241.

Tobin Kenneth, Deborah Tippins and Alejandro Gallard. 1994. "Research on instructional strategies for teaching science." In Dorothy Gabel (Ed.), Handbook of research on science teaching and learning. New York: Macmillan, 45-93.

Tsai, Chin-Chung. 2002. "Nested Epistemologies: Science Teachers' Beliefs of Teaching, Learning and Science." *International Journal of Science Education* 24(8): 771-783.

Tsai, Chin-Chung. 2003. "Taiwanese Science Students' and Teachers' Perceptions of the Laboratory Learning Environments: Exploring Epistemological Gaps." I*nternational Journal of Science Education*, 25 (7): 847-860.

van Driel Jan, Nico Verloop and de Vos Wobbe. 1998. "Developing Science Teachers' Pedagogical Content Knowledge." *Journal of Research in Science Teaching* 35 (6): 673-695.

Wallace, Carolyn and Nam-Hwa Kang. 2004. "An investigation of experienced secondary science teachers' beliefs about inquiry: an examination of competing belief sets." *Journal of Research in Science Teaching* 41(9): 936-960.

Woolley Jacqueline, Katrina Phelps, Debra Davis and Dorothy Mandell. 1999. "Where Theories Of Mind Meet Magic: The Development Of Children's Beliefs About Wishing." *Child Development 70*(3): 571-587.

ABOUT THE AUTHORS

Panagiota Antoniadou: Panagiota Antoniadou obtained her first degree in Informatics from the University of Piraeus in 2008 and her Msc in Education from the Department of Primary Education at the University of the Aegean. Her research interests include teachers and students' conceptions about learning and teaching.

Dr. Michael Skoumios: Michael Skoumios obtained his first degree in Physics from the National and Kapodistrian University of Athens in 1987, a second degree in Education from the University of Aegean in 1992, and his PhD in Science Education from the Hellenic Open University in 2005. His research interests include science concept learning and teaching science in primary and secondary schools. He is currently teaching Science Education in the Department of Primary Education of the University of the Aegean (Greece).

Fieldwork in Geology: Teachers' Conceptions and Practices

Patrícia Albergaria Almeida, University of Aveiro, Portugal

Abstract: The learning of geology taught at secondary schools has undergone changes over time. Many researchers look for new strategies or try to reformulate the existing ones in order to improve the methods of teaching this subject and to contribute to the emergence of active, critical and assertive citizens. Fieldwork is an increasingly used strategy for integrated learning in the area of Geosciences. In this investigation, we sought to identify the type and frequency of fieldwork implemented by geology teachers. We also aimed at understanding the importance of fieldwork in the teaching of geosciences. For that purpose, a survey was drafted and answered by 16 Biology and Geology 11th grade teachers. Results show that the majority of teachers resort to fieldwork up to three times each year. Also, teachers understand that the most adequate type of fieldwork for this level of teaching is Problem Solving Fieldwork. However, the majority of the activities carried out by teachers show that they usually implement Directed Observation Fieldwork type. These results indicate that teachers need to receive training at the level of the implementation of problem solving fieldwork.

Keywords: Geology, Geosciences, Fieldwork, Teacher, Conception, Practice, Secondary Teaching, Secondary Education, High School

INTRODUCTION

> "*Geology is less easily learned from textbooks than the other natural sciences. Education of students in the field is therefore essential. Without extensive field activities, the earth sciences–and thus also the earth scientists–have no future.*"
>
> Van Loon (2008, p. 248)

The subject of Biology and Geology taught in Portuguese Secondary Schools has undergone several changes over the years. Many researchers look for new strategies and reshape existing ones, which will ultimately help to improve learning and to educate active, critical and assertive citizens.

In the last Curricular Revision for Portuguese Secondary Education, which included both general and technological courses, the Ministry of Education defined guidelines such as the introduction of practical elements and the emphasis on experimental teaching. This methodology has played a pivotal role in the teaching of Sciences, and it is generally well accepted by teachers. Fieldwork is an increasingly used teaching–learning strategy, and enables an actual integrated learning of Geosciences.

Compiano (1991, p. 12) underlines the importance of fieldwork:

> *"we cannot lose sight of the role played by fieldwork as a source of knowledge. As practice, the field represents both the place where information is taken from for theorisation, as well as the place where those theories are tested."*

The International Journal of Science in Society
Volume 4, 2013, http://science-society.com/, ISSN 1836-6236

COMMON GROUND

In fact, fieldwork must be understood in the broad sense. Field trips must not be seen as mere site visits, rather as opportunities for direct contact with geology and the environment. Compiano (1991, p. 14) also stresses the pedagogical relevance of fieldwork in the teaching of Geosciences:

> *"the field can be a channel for knowledge, processes and concepts. It can generate problems but also be an integration agent for Geosciences, constructing a widespread vision of nature and environment."*

This study focuses on the importance of fieldwork in the teaching and learning of Geology. This paper reports only a part of a wider research project, carried out as part of a Masters in Biology and Geology Teaching, which covers:

1. the type of fieldwork and how frequently it is implemented by Geology teachers;
2. the importance given to fieldwork by teachers and students;
3. the role played by fieldwork in helping to understand geological phenomena and concepts included in the subject of coastal erosion, according to students.

This paper focuses on the importance of fieldwork, as well as on the type of fieldwork and how frequently teachers implement it. Thus, the aims of this paper are as follows:

1. to understand the importance of fieldwork given by teachers;
2. to understand the role played by fieldwork in helping to comprehend geological concepts and phenomena;
3. to ascertain how frequently secondary education teachers admit implementing fieldwork;
4. to identify and to characterise the type of fieldwork implemented by secondary education Biology and Geology teachers;

The following sections present a brief review of the literature on fieldwork in the teaching and the learning of Geology, as well as a description of the methodology used. The final section will present and discuss results, conclusions and limitations.

Literature Review: Fieldwork

Considering its conceptions and demands, which focus on the teaching and learning of sciences, the Secondary Education Portuguese Curriculum recommends a methodology whereby students actively participate in activities which help them to develop scientific reasoning, and ultimately to understand the world around them. According to Leite and Pereira (2004), scientific knowledge is not merely acquired through experiencing everyday situations. Teachers are responsible for organising knowledge according to student age and school settings.

Thus, fieldwork is fundamental to teaching sciences, and teachers play a crucial role in meeting the objectives of this type of work.

There are numerous references to fieldwork in the Secondary Education Portuguese Curriculum, especially regarding Geology. For example, "analysing problem–based cases linked to regional planning and geologic risk"; "identifying geological resources and their applicability under a Scientific, Technological, Social and Environmental perspective"; "developing a geological heritage valorisation approach (Earth memory)".

Therefore, it is important to know the opinion of Biology and Geology teachers on the value of fieldwork and how frequently it should be implemented. Over the past years, researchers have shown an interest in this type of practical work. For instance, Dourado (2001) carried out a study which characterises conceptions and practices of teachers regarding practical work. The results show that teachers are satisfied with the way fieldwork is implemented. However, traditional classes are still predominant, and students have limited intervention at the initial stages.

Authors such as Rebelo and Marques (1999) also intended to know conceptions and practices implemented by teachers regarding fieldwork. Similarly, they found that this is an extremely useful strategy, which helps students to learn geological concepts. The same authors observed that not many teachers organise field trips, and that the preparations required are still very much centred around the teacher. They also found that there is a frequent lack of coordination between field trips and the syllabus.

According to Pedrinaci, Sequeiros and Garcia de la Torre (1994), the main difficulties associated to fieldwork for the majority of teachers are:

1. lack of funding/financial means;
2. high number of students per class;
3. lack of safety assurance;
4. teachers ignore locations of geological interest;
5. lack of coordination between field trips and the syllabus.

Types of Fieldwork

Various authors have presented classifications regarding fieldwork. According to McLure (1999), depending on how each teacher organises field trips, visits may include a plan which students can closely follow, or they can happen without any guidance. Nevertheless, various authors have included field trips in more than two categories.

Carneiro and Campanha (1979) cited by Compiani and Carneiro (1993) classified field activities in four categories, according to the aims of the field trip:

1. *Illustrative activity*, whereby the different concepts previously taught in class are merely illustrated to students;
2. *Motivational activity*, the objective is to motivate students for a certain subject which is then taught in class;
3. *Practising activity*, teachers guide students performing a technical skill;
4. *Problem solving activity*, students are encouraged to solve or propose a problem.

On the other hand, Brusi (1992) classified fieldwork in three groups, according to the roles given to teachers and to students during the activities:

1. *Directed fields trips*, using a lecturing approach teachers explain everything and students listen passively. Teachers play the head role;
2. *Semi–directed field trips,* teachers resort to didactic elements such as guides or agents with local knowledge in order to enrich the visit;
3. *Self–directed field trips,* students play an active role and gear the visits towards themselves, thus improving their learning experience.

In 1993, Compiani and Carneiro classified different fieldwork implementations in five groups, according to their didactic role:

1. *Illustrative*, teachers resort to fieldwork in order to show or consolidate concepts taught in the classroom. Teachers define the rhythm of the activities, pointing out what should be observed, and formulating and answering their own questions;
2. *Inductive*, teachers resort to fieldwork in order to sequentially guide observation and interpretation processes, thus enabling students to solve a problem previously posed. This way, teachers are either directly conducting the activities, or supported by a guidebook,

designing the coordinating activities. Learning tasks add value to the processes for obtaining information, placing a greater emphasis on the scientific method;

3. *Motivational,* fieldwork aims at raising the students' interest for any given problem. Spectacular elements of nature or life experience are valued, as well as the way students' affectively relate with the environment. Conjectures, doubts and questions about nature elements, which students ignore, are emphasised;
4. *Practising*, implementing fieldwork aims at sequentially teaching new skills, with increasing levels of complexity. Thus, the activities' sequence is completely structured by teachers, and students can gain new skills if they individually work those techniques;
5. *Researching*, fieldwork either provides the resolution of a given problem, or leads to the formulation of one or several problems. In both cases, students independently decide which steps to take: elaborating hypotheses, structuring interpretation and observation sequences, and deciding amongst themselves on strategies for validating reflections and conclusions.

According to Garcia de La Torre (1991), the ideal scenario would be to organise short and frequent field trips on one specific subject. The author recommends including several activities in the same trip, in which there would be several observations. Garcia de La Torre (1991) believes that one field activity should include three moments: before the trip, the actual trip and after the trip, which would happen as follows:

1. A few days before the visit, students must be given information on the visiting site. Students must ask questions to other students about the visiting site;
2. After answering the questions previously raised, the first hypotheses must be discussed in work groups of 4 or 5 students who will end up reaching an agreement;
3. Teachers select observation points and on the day of the field trip new questions and new problems will be posed during observation. The guidebook must never be shut. New hypotheses will emerge from answering questions.
4. In the following days, students must form small work groups and review unconfirmed hypotheses. Revising bibliographic, watching a video and slide projection may help answering questions and explain concepts;
5. Finally, students must explain the results of their research with a final debate. The results of the different groups may or may not coincide with the arguments, and new contradictions may result in new conclusions.

Pedrinaci et al. (1994) and Del Cármen and Pedrinaci (1997) have classified fieldwork into four categories: Traditional Field Trip, Field Trip as an Autonomous Discovery for Students, Field Trip as a Directed Observation by the Teachers and Problem Solving Field Trips.

The *teachers lead the Traditional Field Trip* and the students do not have an active role. The teachers' main concern is to follow a plan and to orderly pass on knowledge to the students, as directly and quickly as possible. This type of activity coincides with the transmission model. In this type of fieldwork, teachers plan the trip alone, in which each stop should be selected, and write an observation guidebook which is then distributed to students. During the field trip, teachers point out what to see, how to observe and register observations, and how to interpret information. This way, students absorb knowledge uncritically, and limit their activity to taking notes. The logic behind this type of work is that of an enclosed and outdated Science.

Field Trip as an Autonomous Discovery for Students is a response to the transmission model of education. In this type of fieldwork, students play a central role. While Traditional Fieldwork limits learning to concepts, Field Trip as an Autonomous Discovery for Students emphasises procedures, values and attitudes. Thus, and after carrying out experiments with 10 to 14 year old pupils who had to make their own observations, collect pertinent data, etc, Pedrinaci et al

(1994) concluded that the questions posed after the observations had not brought great progress in terms of knowledge of the visited site.

In the *Field Trip as a Directed Observation*, teachers carefully plan the trip, selecting observation points, defining the types of observation in each site and how to register information. Also, teachers write a guidebook to hand out to students. However, teachers loose their central role to students during the field trip, when teachers become tutors. They then become responsible for helping students with any questions about the guidebook, and may even help answering questions. This model contains elements of the previous two–it gives students the responsibility of observing and reaching their own conclusions. They can use the guidebook as a substitute to teachers (Traditional Field Trip). For this type of fieldwork, the authors consider that sometimes students may not fully grasp why they should observe certain locations and objects instead of others. Often they are not aware of the relevance of the cases observed and criteria chosen. Students may even carry out activities without understanding their purpose, or how to get to the conclusions intended by teachers. Nevertheless, and according to Pedrinaci et al. (1994) and Del Cármen and Pedrinaci (1997) these problems can be easily overcome, resorting to preparation work with the observation guidebooks so that students can be made aware of the objectives of these activities. In spite of the limitations of this type of fieldwork, and according to the aforesaid authors, the trips will only have successful outcomes with motivated students and when there is enough time to carry out the activities.

Problem Solving Fieldwork attempts to overcome some of the difficulties and limitations of the previous models. It encompasses three moments: before the trip, the trip and after the trip.

Before the field trip–the activities lead to the formulation of a problem, which students answer through conceptual or empirical research. Thus, it is necessary that the formulated problem is clear to students. It must be linked to what was taught in class, thus dealing with relevant aspects which can then be interpreted from one or several theoretical perspectives.

Once the meaning and purpose of the problem is clearly understood, students must write a guidebook which will be used as an observation hypothesis. At this stage, it is advised that the information is compared between small groups of students and the whole class. Teachers define criteria and pose questions to help students confront ideas. The purpose of this exchange is to enrich the debate, through clarifying and comparing alternative proposals. It seeks coherence, rather than unifying proposals. This process encourages motivation and discussion amongst students. It avoids abstract activity planning and introduces new questions or elements suggested by the students.

The comparison stage of hypotheses elaborated before the trip occurs *during the field trip*. Each student will carry out previously defined observations and take measurements and notes.

However, new problems may arise. Some must be approached at the site, while others will have to be discussed on another occasion. During the field trip, students have their own individual work plan which enables them to work autonomously. At this stage, teachers ensure the plan is followed, even though changes may occur, and will require objectivity and accuracy during observation. This activity stimulates reflection and improves reasoning through the justification of statements leading to new questions. Similarly, teachers will suggest other options and will point out observations which might have gone unnoticed.

After the field trip–students and teachers reflect on the different stages of the process. It is important that students note down all the information, including any changes, and share their conclusions with the class. Students will also present and discuss the outcomes, and will inform which techniques and resources were used. Students will understand that knowledge is built with team effort. Teachers ensure accuracy and facilitate information exchange, and above all link with the syllabus.

Methodology

This research is both quantitative and qualitative, and data was collected through indirect observation. Tenth and 11th years Biology and Geology teachers answered a survey, for the academic year 2009/2010.

The survey was elaborated based on the consulted literature, as well as on the research objectives. Teachers were required to give personal information (age, gender, qualifications) and how frequently they resort to fieldwork. They were also asked to point out which elements of the syllabus were pertinent for implementing fieldwork and to describe an activity they had carried out.

Table 1: Aims Associated to each Question of the Survey

Aims	Question	Type of question
To understand the importance given by teachers to fieldwork	1	Closed
To characterise the factors which constrain the use of fieldwork	2	Closed
To characterise the factors which improve fieldwork	3	Closed
To identify the type of fieldwork	4	Closed
To identify the type of fieldwork	6	Open
To identify fieldwork practices which Biology and Geology teachers admit using	5	Closed
To understand the role played by fieldwork in facilitating comprehension of geological concepts and phenomena	5	Closed
To understand how teachers meet their objectives	6 and 7	Open

The surveys were administrated directly and indirectly (Quivy e Campenhoudt, 1998), and comprise both closed and semi–closed questions, as well as open questions. Table 1 presents the aims associated to each question of the survey and its type.

Two strategies were adopted for processing the answers. With regards to closed and semi–closed questions, categories were previously defined, whereas no such categories were defined for open questions. In this case, the surveys were read, and then answers were analysed and categories were defined (Ghiglione e Matalon, 1995).

During the academic year 2009/2010, 16 Biology and Geology teachers working in Oporto, Portugal, were invited to participate in this study. All accepted the invitation and answered the survey about fieldwork in the teaching and the learning of Geology. The analysis of personal information shows the profile of the 16 teachers (Table 2).

Table 2: Characterisation of Teachers

Characteristics		Frequency (f)	Percentage (%)
Age	Under 31 years old	2	12,5
	31 to 40 years old	5	31,3
	41 to 50 years old	7	43,7
	Over 50 years old	2	12,5
Gender	Female	12	75,0
	Male	4	25,0
Employment period	Under 5 years	4	25,0
	Between 5 and 15 years	3	18,7
	Between 16 and 25 years	7	43,8
	Over 25 years	2	12,5
Qualifications	BSc	13	81,3
	MSc	2	12,5
	PhD	1	6,2

Results and Discussion

With regards to the first question, asking how frequently fieldwork is implemented for Biology and Geology (Table 3), it is possible to verify that the majority of respondents implements fieldwork as an educational strategy (62,5%), one or three times a year. No teacher implements fieldwork more than four times each year.

Table 3: Frequency and Percentage of Fieldwork Implementation (N=16)

Fieldwork	Frequency (f)	Percentage (%)
Do not implement	6	37,5
Implements 1 to 3 trips per year	10	62,5
Implements 4 to 6 trips per year	0	0
Implements over 6 trips per year	0	0

Considering previous studies carried out by Rebelo and Marques (2000) and Dourado (2001), the results presented contradict these authors. However, it is important to emphasise that previous studies dealt with larger samples. What in fact happens, and considering the literature, is that the percentage of teachers who do not resort to fieldwork as an educational strategy is higher than those who do. Thus, it can be generally accepted that the majority of the respondents, which contradicts most of the studies dedicated to this subject, selects these activities.

Given the classification proposed by Dourado (2001), the reasons stated for not implementing fieldwork by teachers were divided in three main groups, as presented in Table 4. Solely the teachers who had previously answered that they do not implement fieldwork (n=6) responded to this question.

Table 4: Reasons Stated for not Implementing Fieldwork (n=6)

Reasons		Frequency (f)	Percentage (%)
Teachers' Difficulties	Lack of field trip experience	3	50,0
	Unruly and unmotivated students	1	16,6
Syllabus and school management difficulties	Extensive syllabus	5	83,3
	Lack of cooperation by the members of the school council	2	33,3
Logistic and financial difficulties	Fieldwork complexity and organisation	3	50,0
	Distant location of adequate sites	2	33,3
Others		4	66,6

The difficulty most often stated by teachers for not implementing fieldwork is extensive syllabus (83,3%). Nieda (1994) had also mentioned it as one of the causes for not carrying out fieldwork. Lack of fieldwork experience (50%) and the complexity of its organisation (50%) are also stated as reasons for not resorting to this strategy. Pedrinaci et al. (1994) also mentioned the organisation difficulties as an obstacle to the implementation of fieldwork.

Other reasons include the need for parental authorisation for leaving the school during classes' time, and the fact that students miss other classes. These reasons may be included in the category "syllabus and school management difficulties".

The difficulties pointed out are classified in three groups, as presented in Table 5.

Table 5: Groups of Reasons for not Implementing Fieldwork (n=6)

Reasons for not implementing fieldwork	**Percentage (%)**
Teachers' difficulties	25,0
Syllabus organisation and school management	43,8
Logistic and financial difficulties	32,5

The third question of the survey asked teachers to suggest ways of improving fieldwork implementation. Some suggestions were preselected, but teachers could list others they considered important.

Table 6: Suggestions for Improving Fieldwork Implementation (N=16)

Suggestions for improving fieldwork implementation	**Frequency (f)**	**Percentage (%)**
Reducing the number of students per class or splitting large classes	9	56,3
Providing the necessary materials and equipment	4	25,0
Reducing the syllabus	8	50,0
Teachers cooperation	5	31,3
Attending training on fieldwork	7	43,8
Parents and school management support	3	18,8
Improving local knowledge	2	12,5

Table 6 shows that the suggestion most often stated by teachers for improving fieldwork implementation was reducing the number of students per class (56,3%), followed by reducing the syllabus (50%), attending training on fieldwork (43,8%), and teachers cooperation (31,3%).

These results show consistency with those of the previous question, since the reasons stated link with extensive syllabus, lack of experience in fieldwork, organisation complexity and lack of teachers cooperation for this type of activity.

Teachers were also asked to state how the guidebook (Table 7) should be used and what is the best procedure for implementing it (Table 8). The majority of teachers (75%) believe they should suggest the guidebook. However, 68,7% stated that they should also write it, as opposed to 6,3% of the respondents who think the guidebook should be based on textbooks.

Only 25% of respondents think teachers and students should jointly write the guidebook.

Table 7: Ways of Dealing with Field Guidebook (N=16)

<table>
<tr><th>Field Guidebook</th><th colspan="2">Frequency (f)</th><th colspan="2">Percentage (%)</th></tr>
<tr><td>Suggested and written by teachers</td><td>11</td><td rowspan="2">12</td><td>68,7</td><td rowspan="2">75</td></tr>
<tr><td>Suggested by teachers and based on textbooks</td><td>1</td><td>6,3</td></tr>
<tr><td>Jointly written by teachers and students</td><td>4</td><td rowspan="2">4</td><td>25,0</td><td rowspan="2">25</td></tr>
<tr><td>Written by students, aided by teachers</td><td>0</td><td>0</td></tr>
<tr><td>Should not be used (students should follow instructions instead)</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

No respondent believes students aided by teachers should write the guidebook, and all respondents think the guidebook should be used in fieldwork activities.

Table 8 shows that the majority of teachers (56,3%) believe fieldwork should be carried out by students in small groups. Nevertheless, 18,8% of respondents believe that teachers should ensure implementation and students should remain as observers.

6,3% of respondents refer that students should be individually responsible for implementation. The same percentage states that the activity "*should be implemented individually by students, under teachers guidance*".

Table 8: Ways of Implementing the Procedure (N=16)

Procedure implementation	Frequency (f)	Percentage (%)
Teachers implement the procedure and students observe	2	12,5
Teachers implement the procedure aided by students	3	18,8
Students organised in small groups implement the procedure	9	56,3
Students individually implement the procedure	1	6,3
Others	1	6,3

Given the results presented in Tables 7 and 8, and considering the classification proposed by Pedrinaci et al. (1994) and Del Cármen and Pedrinaci (1997) regarding different types of fieldwork, it is possible to see that respondents believe the type of fieldwork they implement is Problem Solving Fieldwork. Respondents also believe that this is the most adequate method. The majority (56,3%) believes students organised in small groups must implement it. Nevertheless, and considering Table 7, none of the respondents mentions that the guidebook must be written by students aided by teachers, rather written by teachers and students.

Also, 18,8% considers teachers aided by students must ensure fieldwork implementation–Directed Observation Fieldwork. This is reinforced by 68,7% of respondents stating that guidebooks must be suggested and written by teachers.

However, only 12,5% of respondents considers that teachers must ensure implementing the procedure, and students must remain observers, which fits into Traditional Fieldwork.

Question five asked teachers to point out which 11th and 12th year Geology topics of the Biology and Geology syllabus could apply to fieldwork. Considering the results presented in Table 9, fieldwork is most used in 11th year classes, due to the fact that the syllabus includes the elements most mentioned by teachers.

With regards to 10th year, the elements of the syllabus teachers most often refer to for implementing fieldwork are: "Rocks, Earth's historic archives", from Theme I and "Volcanology", Theme II, with 56,3% and 37,5%, respectively. For Theme II teachers do not mention more syllabus elements, whereas for Theme I teachers also refer three extra units, namely "The measure of time and Earth's age" (25%), "The Earth and interactive subsystems" (12,5%) and "Earth, an ever changing planet" (6,3%).

Table 9: Topics of the Syllabus for Implementing Fieldwork (N=16)

Year	Syllabus	Frequency (f)	Percentage (%)
10th	**Theme I: Geology, the geologists and their methods**		
	1. The Earth and interactive subsystems	2	12,5
	2. Rocks, Earth's historic archives	9	56,3
	3. The measure of time and Earth's age	4	25,0
	4. Earth, an ever–changing planet	1	6,3
	Theme II: Earth, a very special planet		
	1. Methods for studying the inside of the Earth	0	0
	2. Volcanology	6	37,5
	3. Seismology	0	0
11th	**Theme IV: Geology, everyday problems and materials**		
	1. Anthropic occupation and planning issues		
	1.1. River basins	3	18,8
	1.2. Coastal areas	13	81,3
	1.3. Mountain areas	6	37,5
	2. Important Geological Processes and Materials in Terrestrial Environments		
	2.1. Main formation stages of sedimentary rocks	2	12,5
	2.2. Magmatism	3	18,8
	2.3. Fragile and Ductile deformation, cracks and bends	10	62,5
	2.4. Metamorphism	9	56,3
	3. Sustained Exploitation		
	3.1. Energy resources	4	25,0
	3.2. Mineral resources	1	6,3
	3.3. Water resources	0	0

With regards to 11th year syllabus, the most often referred element was "Coastal Areas" (81,3%) and the less referred "Mineral Resources" (6,3%).

Considering these results, the most often mentioned subthemes are geological aspects which may be found in the area of Oporto, which may explain the large disparity between the aforementioned syllabus elements.

Teachers were also asked to state the reasons for using this strategy as a didactic resource (Table 10). This question was linked to the previous one, which means it could only be answered by who had described a field activity (n=10).

Table 10: Reasons stated for Implementing Fieldwork (n=10)

Reasons for implementing fieldwork	Frequency (f)	Percentage (%)
Student motivation	5	50
Understanding the concept	8	80
Contacting with geological phenomena and on site knowledge	7	70

Basically, teachers give three reasons for implementing fieldwork as an educational strategy. The most mentioned reason is understanding the concept (80%) ("*During field trips students have the opportunity of visualising and consolidating an important share of the concepts taught in the classroom*"), followed by the contact with geological phenomena and on site knowledge (70%) ("*Science, especially Geology, must be understood and as such only an on site field activity will make that possible*"). Students' motivation comes last with 50% ("*contact with reality becomes more appealing…*").

Finally, teachers were asked to describe a field activity which they had carried out. In general, the great majority stated that teachers themselves prepared field trips on the previous day, informing students about the selected location, choosing sites where observations would take place and what type of observations, as well as how registration should be carried out. These elements were appropriately registered in the guidebook written by the teachers who would then hand it out to students. During the field trip, students perform their tasks planned in the guidebook, and once the trip was over students had to write a report with all the work they had done. Excerpts of the answers given by the teachers clarify of which type of fieldwork was used:

> *"Initially I approached the subject in the classroom, wrote a guidebook about what was going to be observed and wrote pertinent questions in the actual guidebook (…) during the visit students had the opportunity to use the knowledge previously acquired in the classroom (…)."*

> *"The guidebook was written by myself (…) and included several stops where students answer questions previously written by me and performed their tasks (…)".*

> *"(…) the activity began in the classroom, where students acquired the necessary knowledge before the visit (…) during the field trip students filled in a field guidebook with a set of questions about different stops (…)"*

Although the majority of teachers implemented a Directed Observation Fieldwork, they considered the Troubleshooting Fieldwork the best method for implementing it.

Conclusions, Limitations and Implications

This study generally concludes that, for the sample studied, the percentage of teachers implementing fieldwork is higher than the percentage which does not. Furthermore, the difficulties expressed by teachers for not implementing fieldwork are essentially due to the extensive syllabus as well as the organisation complexity of fieldwork and the lack of teachers' experience in this type of activity. Teachers suggest reducing the number of students per class or splitting large classes, reducing extensive syllabus and attending training on fieldwork. These suggestions coincide with the reasons stated for not implementing fieldwork.

With regards to the guidebook, the majority of respondents believe it should be suggested and written by the teachers. Considering procedure implementation, teachers think that students in small groups should carry it out.

Thus, the type of fieldwork most often used by teachers is Directed Observation, despite considering that Problem Solving is the best method. In 2001, Dourado warned for the need to rethink ways of implementing fieldwork and benefit from its use. More recently, Nunes and Dourado (2009) once again emphasised the importance of how fieldwork is implemented.

Regarding the syllabus, the following 11^{th} year units were selected by teachers as the most suitable for implementing fieldwork, in order of preference: Coastal areas, Fragile and ductile deformation, cracks and bends and metamorphism.

Finally, the reasons given by teachers for implementing fieldwork essentially stimulate students motivation, helping to better comprehend concepts and also to contact with geological phenomena and on site knowledge.

The main limitation of this study is the small sample, as well as the fact that all teachers work in the same geographical area. This way, it would be pertinent to increase the sample in future researches, both in number of teachers and the location of the schools where they teach. A comparative analysis between inland and coastal areas is suggested, in order to ascertain which are the locations selected by teachers for implementing fieldwork, and to verify if these locations match the contents of the syllabus.

Looking into the outcomes of this research, Biology and Geology teachers should receive more initial and in–service teacher training, in order to keep them up to date with innovative teaching strategies. In using these practices, teachers would be helping students to learn concepts, develop skills and improve their behaviour. Institutions should therefore create opportunities so that science teachers can help change attitudes and values, and raising an interest for science amongst students.

It would also be pertinent to observe Biology and Geology field trips, in order to gain a better understanding of fieldwork activities.

Overall, it is interesting to know the importance of fieldwork as an extrinsic motivational factor, in order to stimulate the comprehension of geological concepts and phenomena, as well as to formulate questions and problems on Geosciences related subjects.

REFERENCES

Brusi, David. 1992. El treball al camp en ciències naturals [Fieldwork in natural sciences]. In A. M. Geli de Ciurana and M. R. Terradellas i Piferrer (Eds.), *Reflexions sobre l'ensenyament de les ciències naturals [Reflexions about natural sciences teaching] (pp. 157–194)*. Barcelona: Eumo Ed.

Compiani, Mauricio. 1991. "A relevância do trabalho de campo no ensino de Geologia na formação de professores de Ciências" [The relevance of fieldwork in the teaching of Geology in the training of science teachers]. *Cadernos do IG/UNICAMP,* 1: 2–25.

Compiani, Mauricio and Carneiro, Celso dal Ré. 1993. "Os papéis didáticos das excursões geológicas." [The didactic roles of geologic field trips]. *Enseñanza de las Ciencias de la Tierra*, 1: 90–98.

Del Cármen, Luis and Emilio Pedrinaci. 1997. El uso del entorno y el trabajo de campo [The use of the environment and the fieldwork]. In L. Cármen (Ed.), *La enseñanza y el aprendizaje de las ciencias de la natureza en la educación secundaria [Teaching and learning natural sciences in secondary teaching] (*pp. 133–154). Barcelona: Universitat Barcelona e Editorial Horsori.

Dourado, Luis. 2001. "O trabalho prático no ensino das Ciências Naturais: situação actual e implementação de propostas inovadoras para o trabalho laboratorial e o trabalho de campo." [Practical work in the teaching of Natural Sciences: present situation and implementation of innovative proposals for laboratory work and fieldwork]. *Unpublished PhD thesis*. Braga: Minho University, Portugal.

Garcia de La Torre, Enrique. 1991. "Recursos en la Enseñanza de la Geología–La Geologia de campo." [Resources in teaching Geology–Field Geology]. *Investigación en la Escuela [Research School]*, 13: 340–353.

Ghiglione, Rodolphe and Benjamin Matalon. 1995. *O inquérito–teoria e prática [Inquiry–theory and practice]*. Oeiras: Celta Editora.

Leite, Carlinda and Rosalina Pereira. 2004. *A vida na Terra–Livro do Professor [Life on Earth–Teacher Book]*. Lisbon: Lisboa Editora.

McLure, John. 1999. How to guide a fieldtrip. *Science Activities*, 36: 3.

Nieda, Juana. 1994. Algunas minucias sobre los trabajos prácticos en la Enseñanza Secundaria [Some minutiae of practical work in Secondary Teaching]. *Alambique. Didáctica de las Ciências,* 2: 15–20.

Nunes, Inês and Luis Dourado 2009. "Concepções e práticas de professores de Biologia e Geologia relativas à implementação de acções de Educação Ambiental com recurso ao trabalho laboratorial e de campo." [Biology and Geology teachers conceptions and practices concerning the implementation of Environmental Education actions using laboratory work and fieldwork]. *Revista Electrónica de Enseñanza de las Ciencias*, 8: 671–691.

Pedrinaci, Emilio, Leandro Sequeiros, and Enrique Garcia de la Torre. 1994. "El trabajo de campo y el aprendizage de la Geologia." [Fieldwork and learning Geology]. *Alambique. Didáctica de las Ciencias*, 2: 37–45.

Quivy, Raymond and Luc Van Campenhoudt. 1998. *Manual de investigação em Ciências Sociais [Research book about social sciences]*. Lisbon: Gradiva.

Rebelo, Dorinda and Luis Marques 1999. O trabalho de campo no ensino das Geociências: concepções dos professores [Fieldwork in the teaching of Geosciences: teachers' conceptions]. In V. Trindade et al. (Eds.), *Metodologias do Ensino das Ciências–Investigação e Práticas dos Professores* (1ª ed.). Évora: Évora University.

Rebelo, Dorinda and L.uis Marques 2000. *O trabalho de campo em geociências na formação de professores: situação exemplificativa para o Cabo Mondego [Fieldwork in Geology teacher training]*. Aveiro: Aveiro University.

Van Loon, A. J. Tom 2008. "Earth reflections: geological education of the future". *Earth–Science Reviews*, 86: 247–254.

ABOUT THE AUTHOR

Dr. Patrícia Albergaria Almeida: University of Aveiro, Portugal

Producing Legitimacy through the Notion of Science in a Multinational Company: An Anthropological Approach to Scientific and Common Sense Knowledge

Razvan Ionescu-Tugui, National School of Political Science and Public Administration, Romania

Abstract: If science defines itself as representing a field of knowledge and practices, based on its own methodology and epistemology, using the notion of science or the technologies which are supposed to accompany it in contexts outside the scientific field, as the everyday behavior or the markets, entails a different understanding of its foundations or more then that a legitimating process and not a investigatory one. My position is based on an ethnographic research on what in an anthropological approach I describe as a magical healing ritual in a massage center from Bucharest of a multinational company which operates in the business of selling alternative health care products. This healing ritual consists in a spine massage, which every person can benefit from daily, indefinitely and free of charge as part of the marketing and selling strategy that the company, that also sells massage devices, carries. Showing how science comes to be defined by clients and the employees of the massage center and how it serves as a source of authority for the effectiveness of the massage devices in this particular context, I propose, following loosely the ideas of anthropologist Alfred Gell, that science and its applications in this common sense form are conceived as magic.

Keywords: Science Authority, Common Sense and Science, Legitimation of Markets

INTRODUCTION

The influences on the scientific knowledge by the cultures and the practices of those who produce it or the influences of the science and the accompanying technologies on society have been in the last decades and still are a major preoccupation in history, sociology, anthropology or philosophy. This article, originated from the anthropological tradition in investigating these topics, will focus on a particular case of the influence of science in society. From the beginning, the subject of science was a major preoccupation for anthropological inquiry. The methodological and epistemological inclination of anthropology for comparisons raised the problem of similarities and differences between Western science and the more distant (cognitive and often geographical) magic and religion (Evans–Pritchard 1976; Malinowski 1948).

More recently, the anthropology had a key role in the deconstructivist and relativist side of the barricade (Latour and Woolgar 1986), in what would be called the "science wars". Because the fieldwork was conducted in a multinational which operates as an informal provider of alternative health care services and products, this article will tackle the subject rather from the point of view of the theoretical developments of medical anthropology without losing sight of the more general framework of general anthropology and social science theory. Closely linked

The International Journal of Science in Society
Volume 4, 2013, http://science-society.com/, ISSN 1836-6236

with the relativist concept of ethnoscience, the concept of medical pluralism from medical anthropology presumed an equal importance of different medical traditions, biomedicine being just one of them. Many anthropologists have expressed more or less explicitly that biomedicine, as a representative of modern science and technology, enjoys great privileges because of the hegemonic nature in which it was imposed (Cross and MacGregor 2010, 1595). Compared to biomedicine, CAM (Complementary and Alternative Medicine) was seen favorably as a form of resistance, "at least subtly" in front of the crushing domination of this healing tradition, characterized by elitism, bureaucratization and hierarchization (Singer and Baer 2007, 146). Moreover, from a culturalist understanding of class, it was considered that "social categories also construct different health understandings, behavior patterns, and medical subsystems to coincide with their respective views of reality" (Singer and Baer 2007, 143–144).

Having the possibility to name other healing traditions as informal or just complementary and alternative from a high status position, conventional medicine was seen by numerous anthropologists as being a weapon of exclusion of other healing practices and beliefs. From another point of view, if the categories of science and CAM can describe in an ideal and generalized form some objective aspects or processes, from a particular and realistic perspective the boundaries seem to become fuzzy (Cross and MacGregor 2010, 1595). In general, the infiltration of CAM or folk medicine into biomedicine can be observed in the institutionally accepted form of integrative medicine, in the case of cultural embededness in local biomedicines (Lock and Nguyen 2010, 90) or in the use of other medical practices and beliefs by individual physicians. Considered by most of the anthropologists as more humane and more sensitive to cultural contexts of patients, for some of them the overlappings of biomedicine and CAM were met with concern, being seen as a way of "cooptation", through which the latter become just a low status branch of the former (Singer and Baer 2007, 149). From the opposite direction, the incorporation of science in CAM was analyzed in the perspective of the latter craving of authority and high status (Miles 1998, 218).

The article will attempt to tackle a narrower and a more modest subject: the authoritarian role of modern technology and science in defining an ideal of production and effectiveness when objectified in the public discourse and the marketplace. But even so, the context put forward by the science wars is difficult to avoid. It seems that the anthropological critique of science and technology suffered a setback from the relativist and constructivist discourse (Latour 2004, 231; Lambert 2009, 19). Following this shifting in discourse, the article aims to consider the medical evidence found in different medical practices within the anthropological and social science framework. But as medical anthropological literature has shown many times, the sources of biomedical authority are not exclusive to its claimed efficiency. These sources of authority, although indirectly linked to the efficiency, are found in the potent meanings to which the modern science and technology are associated (Miles 1998, 211). By reference to patients and physicians who must face the oncological realities, DelVecchio Good captures the role of modern medical technology in shaping a "medical imaginary" which offers so much hope in contemporary world (DelVecchio Good 2010, 275). Starting from this context of interpretative and imaginative forms of science and technology, the article discusses the authority and the subsequent processes of legitimation taken in the marketplace by an informal alternative health care provider.

Context and Methodology

This article is based on a research conducted in a community health center or showroom in Bucharest, part of a marketing and sales strategy of a multinational company[1]. The ethnographic

[1] For anonymity reasons, the name of the company was withheld from this article.

research started in September 2008 and is still in progress as part of a doctoral program[2]. This company, which is present on the markets of more than 70 countries and has opened more than 3,000 such health centers in the world, has known a real success in Romania. The exceptional aspect of this business consists of providing free health services on an indefinite period and without special access conditions to convince consumers of the qualities of the marketed devices.

Methodologically, this article is the result of many months of participant observation in the products' presentation in the health center, of 18 interviews with members and employees, but also of analysis of documents available on the web or of the internal documents made available by the company (poems and confessions about the company written by the members).

The underlying assumption on which the company operates is that in this way the beneficiaries can test on the "first hand" or with their own bodies the devices and to see, in this supposedly transparent way, the results. The spine massage consists of ventral and dorsal application of a "projector", a heated rectangular object that has several protrusions, in 15 positions along the spine, covering a period of about 40 minutes. The projector acts on the body through the power of helium, of the jade stone and of infrared lights, three parts invested with many attributes that manifest through five well–known principles recognized in the center: thermo–massage, acupressure, moxibustion, vertebrotherapy.

Besides the massage itself some conditions of access to the devices are imposed to the beneficiaries: they are obliged to listen and participate for at least 2 or 3 hours in a sustained and well–defined social interaction in the daily presentations of the company staff, which are held continuously for 9 hours a day, roughly six days a week. These obligations are explained by the need of information and training for a better use of the devices. In this way the company, through its continuously trained employees, deploys and maintains through these particular social relationships a not very systematized but homogeneous body of knowledge about the nature of body and illness or the causes of illness and the efficiency of devices. What the company aims is to produce and reproduce through the presentations in their ensemble and especially in the interaction between employees and customers, evidenced in "confessions" of the latter, a particular understanding of the effectiveness of the massage, to create the convincing and dramatic picture of the effectiveness of the massage device, in order to market the massage devices or to increase the number of people who visit the center.

The massage center is presented as a showroom which depends in its functioning on the consumers of these services who decide to purchase the product. The reasons to purchase can be triggered, with the broad involvement of the company, by convenience, by the belief that better results can be obtained by using the equipment more than what the company can make available each day in the center, or by the desire, quite often unfulfilled, of sharing the products with the members of the family. The period of purchasing of the equipment by the members varies, but despite financial sacrifices and difficulties encountered for the purchase of such expensive equipment as compared to the average purchasing power in Romania, the buyers come mainly from middle and lower classes.

Thus, even though because of the lack of space, this article will avoid a more detailed presentation of Romanian health care system, it is partly relevant from a social and cultural point of view that Romania, as a post–socialist state, is in a position to have a moribund state health system, a legacy of the welfare state from the socialist period, attacked by the new morality of the market (Andaya 2009, 365–367), and a private health system. This combination makes the access to health services for many disadvantaged groups, in which *grosso modo* pensioners are included, difficult (Friedman 2009, 379). In a broader perspective, the meanings through which the members relate to what the massage center implies may have originated in

[2] Beneficiary of the "Doctoral Scholarships for a Sustainable Society" project, co–financed by the European Union through the European Social Fund, Sectoral Operational Programme Human Resources and Development 2007–2013.

the global processes that are increasingly focusing on raising the attention paid to body and health (Fabrega 1996, 137; Turner 1992) or in lack of recognition which generally the elderly face in industrialized societies (Todorov 2009, 109). As retired persons from the working class, they are confronted, together with the end of their social roles, with the loss of recognition of others. Despite the attempts of the employees of giving a new meaning to this activity, for many of its members the daily presence at the massage center became a "job". On the other hand, for many of them it is visible during their conversations that before this form of socialization, made possible by the daily participation to the massage, their existences were marked by loneliness, hopelessness and depression. Perhaps because of the reintegration into this community, the members recognize in the device the ability to "rejuvenate". Moreover, as patients of conventional medicine, the members are complaining of being treated as objects for many reasons which exceed the highly circulated argument about the alleged mind–body dualism of biomedicine. Thus, even if ultimately they are part of an economic rationalization and instrumentalization, by reporting to the status of retired persons or patients, the members can experience the recognition from others in the massage center. The members can live with the idea of the opportunity of accessing free health services or of being empowered to pursue on their own a better health, in a society that makes this access more and more difficult. At the individual and pragmatic level, participating at the massage can find its justification in the desire to manage the pain that comes to destroy the everyday meanings of life.

As a panacea, the massage device "yields results" by applying it to the spine, which is symbolically represented as the "root" or "nucleus" of the body, from where the nerves associated with the different symptoms start, but also by increasing the blood flow, which supposedly helps eliminate toxins. The massage device produces effects on the body which are supposed to be unique, according to the particularity of each body, disease period, age and lifestyle. Like the diseases, heat transmitted by the projector, which is often represented as a form of energy, accumulates in the body, buying equipment and using it more often leading to more and better results and cessation of massage leading to losing all the results. On the other hand the employees affirmed in other moments, in accordance with the naturopathic principle, that the device has only the quality to "stimulate" and "help" the body, which is capable to find the healing resources in itself.

Authority of Science and Technology in Business

The company builds its own legitimacy both on the functioning and the effects of its products, through multiple authoritative sources. If the effects of the device are legitimized by reference to the experience of the users, an issue I treated in another article and about which there is little to say here, this article will refer in particular to the legitimation of the functioning principles of the device by the company. The most important sources of authority used by the company, according to its own classification, with variations depending on the channels of communication, are the science and the technology, the alternative medicine or the folk remedies. Thus from the Romanian company's site content are emphasized the alternative medical aspects of the operation of the device. On the other hand, in other official materials readily available on the web, it is stressed the pooling of the Eastern principles and Western technology or, in another expression, the combining of "the ancient principles of Eastern medicine with modern principles of Western medicine". In a video on the homepage of the company's international site, a chiropractor and a professor in medicine at a major American university and at the same time a practitioner and apparently a user of the device express in the form of a testimonial their favorable position on its effects. All these materials are yet largely inaccessible to ordinary members of the health community center. Mostly working–class retirees, aged between 60 and 80, the members learn about the functioning principles of the device especially from the presentations and daily interactions with the employees. Besides the frequent reference to folk remedies and the very rare mentions to the chiropractice, Chinese medicine, reflexology, herbal medicine, naturopathy, the general explanations used by all these medical systems are expressed tacitly in the products presentations. In the same time the science and technology are always an explicit part in the center's discussions. The amazing heterogeneity and apparent contradiction that these sources of authority present, in this cultural and social context, raise questions on the implicit definitions used by members and employees and on the role, understanding and imaginary of science and technology in society. In the following paragraphs, the relations which the science and technology have with the other medical systems are discussed more thoroughly in this context.

The devices marketed by the company are probably named as R–380 and M–2400 in order to objectify their technological nature. At a basic level, employees suggest the quality and the efficiency of these devices by reference to known technological products, identifiable through brands of cars and electronics, of the producer's country of origin, namely South Korea.

At another level, the scientific and technological aspect of the device is considered in relation to the biotechnology and more generally to medical technology. Although in Romania it is registered as a personal thermo–massage equipment, the center's employees do not forget to mention that in some states, "more developed" than Romania, as USA, Russia, South Korea, Canada or even Hungary, it is registered as a medical device. The lack of this regulation in Romania is attributed to the inaccuracies of the Romanian laws and on a higher level to a profound lack of understanding from the medical community and officials. The discourses, which became common in Romanian society, about the difference between Romania and other European civilizations or Western civilization, are accompanied in the center by the prospect of a global society in which everyone will have such a device in the house. This medical future proposed by the company through the innovation of its devices is based on the reference to these "developed" or "civilized" countries that seem to be at the vanguard of those who determine or predict the future signs. The case of USA regulation, in which FDA recognized the marketed devices as medical devices of class I and II, is relevant in many respects. In terms of testing clinical efficacy by scientific standards, according to FDA the company can only claim for the marketing of the device that it serves to the "temporary alleviation of minor joint and muscle pain, muscle relaxation, temporary alleviation of minor joint pain associated with arthritis, temporary increase of local blood flow when applied". Placing it in the class I or II, which employees mentioned in some situations, but without entering into further explanations, means that the company had to pass for its products the general and special controls for safety and efficiency, without having to pass a scientific review, as is the case of class III of medical devices. Thus based on these regulations, the massage device could find its place next to the elastic bandages or examination gloves in class I and powered wheelchairs or infusion pumps in class II[3]. All these details are overlooked in the interaction between employees and members, the legitimation of their healing practices being implicitly done in reference to the medical devices which are found in class III in the FDA and who give the measure of the medical technology's development, such as pacemaker, titanium hip, diagnostic device or cochlea ear.

The idea of the recognition of the device with the status of a medical device is often accompanied by mentioning the company's research laboratories and the fact that the device is the result of the conducted studies. The employees had spoken about its acceptance as a medical device in Hungary in several occasions. In Hungary it is said to have been admitted due to some studies that had shown that people feel better or by its ability to diagnose the presence of a single cell of cancer in a woman through a menstruation pain, in an apparently popular case in this country. In another case, the employees mentioned one clinical trial, in progress at the moment that this article is written, which studies the effects of the devices on diabetes patients. This study could follow the normal procedures for an evidence–based medicine, at least until

[3] http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/Overview/GeneralandSpecialControls/default.htm

proven otherwise, because it appears to be under the auspices of a Romanian medical state institution. The frequent mention of this study in the center before the subsequent results is significant in itself in presenting the claims for the scientificity of the device.

Mention of powerful states but especially of the U.S., which is actually described as (and probably is) the first market for the device, except South Korea, aims to stimulate the medical imaginary of which Good speaks, fed by the common sense knowledge which is found in popular medical dramas and medical news and by the knowledge of the role played by these countries in developing and using such medical technologies.

Although the health services are free of charge, the prices of the devices are high enough for the purchasing power of the working class Romanian members, maybe to suggest the quality of the medical technology, but not high enough to make them completely inaccessible. Given that in our global society the medical technologies come to be equivalent to expensive health services, it is significant that buying such a device is presented by the company's staff as achieving a "dream". Having in a way a fieldwork similar to mine, Ann Miles writes about the different forms of legitimation, as diverse as science, nature and tradition, which are used in the packaging and marketing of natural medicines by the Ecuadoran salespersons for the poor clients/patients from Cuenca. For her, the popularity of biomedicine, drugs in particular, for the poor from Cuenca is based in part on the "symbolic potency" of the dominant elites who introduce and practice biomedicine and of latent promises offered by science in general and contemporary medical science and technology in particular (Miles 1998, 218). In relation with the argument about science and technology potency, the concept of "enchantment of technology", which although is incomparably richer in theoretical insight, being related to a theory of art and ritual and including a more vast understanding of the concept of technology, it could be nevertheless useful (Gell 1992, 57). In a short but insightful article, the same author explores more directly these ideas, finding that modern technology plays in our world the role which magic had played, due to the ideal means of production and the low transaction cost which it suggests (Gell 1988, 9).

Given the regional and structural inequalities in the access to biomedical technology it is important to frame even the medical imaginary in what may be called a "political economy of hope" (DelVecchio Good 2010, 275).

The many medical explanations offered at the center have produced a heterogeneous medical system in which biomedicine has a place. Besides the structural similarities and differences between biomedicine and alternative medicine, the relationship between allopathic medical practices and knowledge and company's medical system is more ambiguous. If from an elitist and abstract perspective this heterogeneous medical system may seem conflicting, from a lay and more practical perspective this is not the case. More than this, biomedicine can be simultaneously a resource for legitimation of the company's activities and the object of criticism. In accordance with natural medicine, the devices are described as natural, based on jade stone properties, helium and infrared, which more generally would represent the land, the air and the sun, which make them, according to this type of argument, to be safe, namely without the side effects or contraindications. The employees repeated many times that these devices "do not radiate, electrocute, cut, inject", but maybe the main object of criticism in the daily presentations is the high consumption of drugs and the negative effects that this could generate or the allegedly great number of unnecessary surgeries. The devices are constructed as a complementary or alternative measure to medicines or surgery depicted as an evil, even though sometimes a necessary evil. What probably reveals the political and legislative power of biomedicine in contemporary society is that, in these contexts, the employees feel the need to repeat that in the last instance the authority to decide the reduction of the number of prescription drugs belongs only to the physicians.

In other instances, the employees undervalue the practices and the knowledge of doctors and simultaneously they empower the people in the center. According to this account, in a consult what the doctor does is to ask the patients what they feel. The story goes that the people are "the best doctors" because they could know the best what is going on with their bodies. Diagnose and treatment could become in part a private practice if you have the proper knowledge and if your reference is your personal bodily sensations. The authority of the personal experience in assessing the effects of the device makes that what the members consider as being scientific to be in fact common sense knowledge. According to an "unstandard definition" of a universalistic notion of common sense (Geertz 1975, 233), this article sustains that science, in its idealized form, came somewhat in accordance with "naturalness" (naturalism being just the Western form of it) and "practicalness" of science, not necessary with his "thinness" and "accessibleness" and not a bit with his "immethodical–ness". For Gramsci, a well–known figure in social sciences, the concept of common sense serves to understand what appears as "naturalness" in popular culture (Crehan 2011, 277), because for him, unlike for most of the anthropologists, culture is conceived as the lived experiences of class and "the result of the interaction of myriad historical forces" (Crehan 2011, 276).

The employees mention different narratives about doctors depending on what they need in constructing the meaning in the presentations. They are either used as powerful sources of legitimacy when in the comments of the members or employees they appear as users in personal or commercial purposes, as supporters of the massage center or when through them are explained some of the effects of the device, but at other times they are criticized for corruption and high costs, limits in knowledge or bad bedside manners. In fact, to all these criticisms directed to biomedicine, the company brings a countermeasure in the practices and ideologies used, by promoting egalitarian access, by introducing the free of charge health services or by the quality of care and attention offered. Even though the company avoids explicitly to identify the health center with a clinic, her employees with the medical staff or the massage with a treatment designed to cure diseases, on the other hand the device is called "general hospital", especially because of the alleged quality of the device to address all the problems in the body due to massaging of the spine, which in a manner inspired by the chiropractic principle, as mentioned, is the "the core" or "the root" of the body.

The authority of medical science can be observed in the manner in which anatomic terms or the seemingly medical and scientific concepts are used. As was said above, employees avoid engaging in discussions with members about diagnosis or disease but rather intended to bring the discussion in the direction of an anatomical reality. The explanations which follow from this reality present themselves as common sense evidence. Besides the emphasis on the vertebral spine, objectified in many images, anatomical chiropractic charts, anatomical models, the discussions are very often stuffed with terms like "blood stream", "nerve connections", "nerve centers", "blockages" in the "functions" of the nerves, which reminiscent of past and already recognized evidences of science, are now fragments in what make the "natural" in the common sense knowledge.

Meridians and energy points, chiropractic explanations, massages, folk remedies and biomedicine find their place around an etiology of afflictions in the vertebral spine, without any theoretical problems. More than being in competition or opposition with CAM, science and technology, or more exactly the common sense which incorporates them, produce in this case an integrator effect. The modern technology and science, which have the authority to generate so much trust and hope, is present in the way in which the company depicts its products. But science is also conceived by the employees and perceived by the members to be, in a more general and non–specific understanding, a thorough body of traditional and practical knowledge. In one of the presentations, one of the company's employees said that "these devices are made on the basis of folk remedies" and after a few sentences they added, referring to the most expensive of the devices: "Now technology has advanced. Research goes further." As already mentioned earlier, the concepts that are used, including science, nature or tradition, could have fuzzy boundaries in practice.

If the article discusses more about the way in which the company legitimates its activities and not about the knowledge and the attitudes of the members, it is not necessarily a methodological error. The company not only meets with some external knowledge and attitudes, but also creates from pieces new knowledge and new attitudes for the members.

The following stanza (in a personal approximate translation) comes from a poem written by a member about the company in one of the poetry competitions it organized:

"The pain which appears and brings the old age
We want to stop it, to expel the sadness.
And now the scientists are always searching
To find the cure that makes the life painless."

Conclusion

As a first conclusion, this case can show the way in which marketing and sales forces in the marketplace manipulate popular representations of techno–science in order to legitimate their activities. More than a simple search for authority for an informal health provider, these actions are part of a larger process of social and cultural control in the name of profit. Because, like magic, the technology and science let the impression that the desired result is possible through the ideal mode of production which it incorporates, these are powerful resources to be used in the economy. Although the members benefit in many ways from the social and cultural context in which they are immersed at the center, unfortunately for them the access to high–tech medicine is mainly an illusion.

Even though many of the observations and theoretical constructions about biomedicine and CAM are very useful, the second conclusion is that in general, the rather rough dichotomy between these two, in recent postmodernist literature, fails to capture the highly complex assemblages of forces and the contradictions which make their fusion in one particular moment. Rather than appearing as being equal in form and opposite in their relation of power, given the binominal hegemony–resistance construct, all the healing practices and beliefs can be analyzed in different layers and reported always to a particular context. From another perspective, the relations of power can be observed in the way in which common sense class realities come to surface and the consequently the effect they have on people's lives. My perspective is more close to those "who are concerned not only with the subjective positioning of our informants "truth" but also with the realities of political economy and global forces as trey impact on people's lives and well–being" (Lambert 2009, 19).

Figure 1: Company's Poster Which Depicts an Image of a Science Laboratory and the Headquarters and also the Manufacturing Facility from Korea

REFERENCES

Andaya, Elisa. 2009. "The Gift of Health: Socialist Medical Practice and Shifting Material and Moral Economies in Post–Soviet Cuba." *Medical Anthropology Quarterly* 23 (4): 357–374.

Crahan, Kate. 2011. "Gramsci's Concept of Common Sense: a Useful Concept for Anthropologist?." *Journal of Modern Italian Studies* 16 (2): 273–287.

Cross, Jamie, and Han MacGregor. 2010. "Knowledge, Legitimacy and Economic Practice in Informal Markets for Medicine: A Critical Review of Research." *Social Science & Medicine* 71: 1593–1600.

DelVecchio Good, Mary–Jo. 2010. "The Medical Imaginary and the Biotechnical Embrace: Subjective Experiences of Clinical Scientists and Patients." In *A Reader in Medical Anthropology: Theoretical Trajectories, Emergent Realities,* edited by Byron J. Good, Michael M. J. Fischer, Sarah S. Willen and Mary–Jo DelVecchio Good, 272–283. Chichester: Wiley–Blackwell.

Evans–Pritchard, E.E. 1976. *Witchcraft, Oracles, and Magic among Azande*. Oxford: Clarendon Press.

Fabrega, Horacio Jr. 1997. *Evolution of Healing and Sickness*. Berkeley: University of California Press.

Friedman, Jack R. 2009. "The 'Social Case': Illness, Psychiatry, and Deinstitutionalization in Postsocialist Romania." *Medical Anthropology Quarterly* 23 (4): 375–396.

Geertz, Clifford. 1975. "Common Sense as a Cultural System." *The Antioch Review* 33 (1): 5–26.

Gell, Alfred. 1988. "Technology and Magic." *Anthropology Today* 4 (2): 6–9.

Gell, Alfred. 1992. "The Technology of Enchantment and the Enchantment of Technology." In *Anthropology, Art and Aesthetics*, edited by Jeremy Coote and Anthony Shelton, 40–66. Oxford: Clarendon Press.

Lambert, Helen. 2009. "Evidentiary Truths?: The Evidence of Anthropology through the Anthropology of Medical Evidence." *Anthropology Today* 25 (1): 16–20.

Latour, Bruno. 2004. "Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern." *Critical Inquiry* 30: 225–248.

Latour, Bruno, and Steve Woolgar. 1986. *Laboratory Life: The Construction of Scientific Facts*. Princeton: Princeton University Press.

Lock, Margaret, and Vinh–Kim Nguyen. 2010. *An Anthropology of Biomedicine*. Chichester: Wiley–Blackwell.

Malinowski, Bronislaw. 1948. *Magic, Science and Religion and Other Essays*. Glencoe: The Free Press.

Miles, Ann. 1998. "Science, Nature, and Tradition: The Mass–Marketing of Natural Medicine in Urban Ecuador." *Medical Anthropology Quarterly* 12 (2): 206–225.

Singer, Merrill, and Hans Baer. 2007. *Introducing Medical Anthropology*. Lanham: AltaMira Press.

Todorov, Tzvetan. 2009. *Viața comună: Eseu de antropologie general*. Bucharest: Humanitas.

Turner, Bryan. 1992. *Regulating Bodies: Essays in Medical Sociology*. London: Routledge.

ABOUT THE AUTHOR

Razvan Ionescu-Tugui: He is a PhD student in Sociology at the National School of Political Science and Public Administration. His field of interest is medical anthropology and anthropology of the body, being centered on the discourses and practices around the "healthy" body in late capitalism. He has a BA in History at the University of Bucharest with a major in Historiography and History of Ideas. He also has a MA in Anthropology at the National School of Political

Science and Public Administration and a MA in Marketing at the Academy of Economic Studies in Bucharest.

Mad Scientist: Should Traver 1951 Be Retracted and How

Matan Shelomi, University of California, Davis, USA

Abstract: In 1951, entomologist Jay Traver published in the Proceedings of the Entomological Society of Washington her personal experiences with a mite infestation of her scalp that resisted all treatment and was undetectable to anyone other than herself. Traver is recognized as having suffered from Delusory Parasitosis: her paper shows her to be a textbook case of the condition. The Traver paper is unique in the scientific literature in that its conclusions may be based on data that was unconsciously fabricated by the author's mind. The paper may merit retraction on the grounds of error or even scientific misconduct "by reason of insanity", but such a retraction raises the issue of discrimination against the mentally ill. Does the scientific community have an obligation to retract such a paper or demand a letter of concern by the editors? In this workshop, participants will discuss what should be done about the Traver paper, and the conclusions of the meeting will be implemented by the workshop author.

Keywords: Retraction, Publication, Scientific Misconduct, Delusory Parasitosis, Mental Illness

The workshop dealt with a paper published by Dr. Jay Traver, a respected zoologist from the University of Massachusetts, in 1951 in the *Proceedings of the Entomological Society of Washington* (*PESW*). In the paper, Traver herself claims to have been infested with a mite and describes her myriad unsuccessful attempts to treat the condition and her experiences with the medical community. She also included drawings of mites she allegedly found on her pillows and claims infested her. Today, Traver is recognized as most likely having the condition known as Ekbom's Syndrome or Delusional Parasitosis/Infestations (DI), in which patients believe they have insects or other creatures in their bodies despite any and all evidence to the contrary. (The term Delusional Infestations is more accurate, for it takes into account the related condition known as Morgellon's disease, in which patients believe "fibers" are infesting their body, but which is otherwise identical to traditional Delusional Parasitosis in all ways.) The condition is estimated to affect 100k–250k Americans (Hinkle 2011), predominately affecting middle-aged Caucasian women of any educational background. Traver's account provides ample evidence that she had DI, and her conclusions, which do not follow from her findings and which are highly suspect, have been thoroughly rejected by the entomological community since her paper was published (Hinkle 2000, 2011; Poorbaugh 1993). It is believed that, had she not been a member of the scientific community and had DI been a more well-known condition at the time, her account would have never been published (Shelomi 2012a).

Given that the conclusions in the paper are false, the question arises of whether or not scientific misconduct or error occurred here. Clearly Traver 1951 is an example of bad science: her claims have no basis in fact. The evidence she provides does not lead to her conclusions, and evidence of absence exists in the known literature that counters her descriptions of the mites' lifestyle, undetectability, and indestructibility (Babe 1995; Miller and Miller 1996; Poorbaugh 1993). Normally, bad science leading to error can be considered grounds for retraction. Furthermore, if her drawings of mites were based on hallucinations, then they count as

The International Journal of Science in Society
Volume 4, 2013, http://science-society.com/, ISSN 1836-6236

COMMON GROUND

fabricated evidence, which is scientific misconduct. Traver 1951 uniquely poses an ethical dilemma: can one retract a paper if the errors and/or misconduct were not the products of deliberate manipulation or poor methodology, but of mental illness (Shelomi 2012a)? The workshop asked what the proper response of the scientific community should be to Traver 1951: does it merit retraction and, if so, can it be retracted without any undertones of censorship or discrimination of the mentally ill? Below are the comments and conclusions reached by those in attendance at the workshop.

Traver 1951 was never retracted by *PESW*, and is frequently referenced by persons with DI as "evidence" that their bodies are truly infested. The growing presence of websites and online forums catering to the DI community, where their delusions are confirmed and supported by others with the condition, leads to increased circulation of Traver's paper without criticism. This is a problem, as confirming the delusion of a DI patient makes their condition harder to treat (Wilson and Miller, 1946). DI is increasingly becoming a web-based pandemic, meaning the continued availability of Traver 1951 has public health ramifications. This is the primary justification for action on this and other papers (Shelomi 2012b).

As far as *PESW* is concerned, the workshop concluded that a call should be sent to the current editors requesting a "Letter of Concern." While a true retraction is warranted due to the poor science and error in the paper (Shelomi 2012a), it is not desirable for three reasons. First, the entomological community has already thoroughly disproved the paper: a retraction would only formalize this consensus. Second, the DI community will never accept the retraction. Paranoia and distrust of the medical community are symptoms associated with the condition (as evidenced by Traver herself), and no evidence of any kind can shake the delusions. A retraction would likely be interpreted as a conspiracy or at least stubbornness on the part of the medical/scientific community. Third is the slippery slope that comes from a possible linkage of a retraction with the author's mental illness. Authoritarian regimes in the past and present have discredited scientists and academics based on claims of mental illness or the associated stigma. The specter of such practices clouding a retraction would be worse than the consequences of leaving it alone.

However, the paper can and should be criticized without any mention of Traver's condition. Ill or not, the fact is that Traver made serious errors in judgment, and her conclusion that the common dust mites she may have found are actually parasites that feed on humans does not follow from the evidence she provides, and has been discredited since. Due to the public health costs, *PESW* now has strong motivation to address this paper. What is recommended is a "Letter of Concern," updating readers on the [in]validity of the science in Traver 1951 and acknowledging the serious concerns expressed by the entomological community about the methods and conclusions of the paper. The editors should point out that the findings of the paper are suspicious and/or doubtful and should discourage readers from accepting Traver's conclusions blindly. All of this must be done without a word suggesting Traver may or may not have had DI. Such a Letter will appear on any database search alongside Traver's paper, meaning anyone who comes across the latter will be able to read the former. This is the suitable response for a paper when investigations into misconduct cannot be begun or concluded, and fulfills *PESW*'s obligation as a peer-reviewed journal to address issues in the literature and maintain their scientific integrity (Sox and Rennie 2006).

For maximum benefit, however, one must look beyond *PESW* and the entomological community. To better serve society, any response to Traver 1951 must be within the medical community itself. The nature of DI is that patients are more likely to go to an entomologist or dermatologist to seek identification of their "skin parasites," simultaneously avoiding psychologists or psychiatrists as they firmly believe in their own sanity. They also avoid internal medicine doctors, or otherwise go to them seeking only confirmation of their parasitosis, which is problematic due to the risk of underlying conditions (diabetes, solar elastosis, drug use and withdrawal, etc) responsible for their itching and other physical symptoms. This leads to the remarkable state where entomologists and dermatologists are more familiar with this psychological/neurological condition than psychologists, neurologists, and primary care physicians, when the latter groups are the ones who should be thoroughly investigating this disease (Hinkle 2011). The main conclusion of the workshop was that Traver 1951 should be seen as an opportunity to inject the DI literature into the psychology/psychiatry community and raise awareness of DI among the people most poised to deal with it and help those suffering from it.

Several papers have been published in the medical literature detailing case studies of persons with DI or DI-like symptoms, but Traver as a case study has been limited to a side-note in mostly entomological journals. A formal writing up of Traver's condition as a case study in a psychology journal (not to mention a medical ethics journal) by leaders in the field would be a welcome addition to the literature. The paper serves as a testament to how DI can strike anyone, and should be used as a tool both to illustrate the symptoms of DI and their severity and intensity. A Continuing Professional Development course on DI and its mental and physical comorbidities should be devised, written, and disseminated. A workshop on Traver and on DI broadly should be held at a major psychological professional association. Again, the entomological community has already discussed Traver and DI amongst itself and continues to do so because persons with DI continue to seek out entomologists for help, but those in the medical community are the ones who truly need to be made aware of the condition. The gap between the entomological, neuro/psychological, and pain/itching studies communities needs to be closed, as each field has produced works describing facets of DI, but the commonality of these findings has not yet been remarked upon and they have not been brought together to better understand the condition.

Similarly, popular treatments of DI by organizations that combat pseudoscience or which raise awareness of scientific issues, such as the Café Scientifique public service initiative, could have DI as a topic. Informing the public will help those in contact with DI sufferers, informing them both of proper ways to deal with such patients (never confirming their delusions, awareness of underlying issues causing their symptoms, etc) and of the reality of what parasites do and do not exist to assuage their own fears and prevent cases of "secondary delusions."

The workshop further addressed parallels between the DI community (which advocates online for the existence of their nonexistent parasites, demands medical research on the subject, and often poses explanations for the conditions ranging from aliens to government experiments) and other pseudoscientific or anti-scientific movements. One apparent parallel is between Traver and Andrew Wakefield, the disgraced former-doctor who published a fraudulent study in *The Lancet* linking a vaccine to autism, which was later retracted. The Wakefield fraud, and the subsequent rise of the anti-vaccination movement and subsequent surge in death and morbidity in children associated with once-preventable infectious diseases, can be compared to Traver's and others' effects on the DI community (Hinkle 2011; Shelomi 2012a,b): One bad paper in the scientific literature lends credence to a false belief with public health ramifications that outlive the paper's validity among the scientific community. The DI community's online presence is also comparable to that of the anti-fluoridation movement, climate-change denial, etc. These movements lack any scientific evidence whatsoever, whereas the "skin parasite" ideas technically have scientific support in the form of Traver 1951. What separates such movements from the DI community is the role and importance of ideology.

For example, the anti-fluoridation movement is rooted not in evidence, but in political motives such as opposition to compounds in the drinking water or general anti-government sentiment. Anti-fluoridation is just a MacGuffin towards an ultimate goal of minimized government involvement in ones' lives. Any "findings" by that community can be challenged and countered through scientific evidence, although ensuring that public policy is based on this sound science and not on the impassioned propaganda of the conspiracy theorists is a challenge (See also the anti-evolution movement). In contrast, the skin parasite community is tied not by ideology but by insanity. While distrust of the government, doctors, and scientists appears frequently among such people, no unifying patterns exist. (This is often to the frustrations of those within the community: one woman posting on a Morgellon's forum expressed her dismay that the community could not agree on the origins of the fibers, and that this lack of consensus was making them all sound crazy and lacking in credibility. She then posited her theory that the fibers are extraterrestrial nanomachines.) Also, whereas other conspiracy theorists have an underlying motive, the DI patients have no motive other than to be healed. Their frustrations are secondary to the condition, a product of a mind that prevents them from accepting any external explanation that differs from its own. This lack of ideology makes the DI community easier to ignore on a public policy standpoint, although their voices were still loud enough to inspire large-scale investigations by the Mayo Clinic and the Center for Disease Control on DI and Morgellon's Disease, both of which concluded that the claims of infestations are consistently delusions (Hylwa et al. 2011; Pearson et al. 2012).

In conclusion, the recommendation of those in attendance at the workshop was twofold. First, that *PESW* should be encouraged to issue a Letter of Concern about Traver 1951, addressing the problems with the science of the paper and noting that its findings are not reliable and likely in error. Second, that Traver's case should be reported on in the mental health or neurology literature as a case study, and that considerably more information and education on DI and its comorbidities is needed among the medical community, particularly outside of dermatology and inside neurology. The workshop cautioned against mention of Traver's possible mental health problems in any action done within the entomological community and by or towards *PESW*, but strongly encourages this in appropriate, mental health journals and contexts. The public health consequences of allowing Traver 1951 and other delusion-confirming papers to go unchallenged among the medical literature justify taking these actions now more than ever, thanks to the spread of DI-denial and pro-infestation media online and the subsequent "web-based pandemic" nature of modern DI.

Acknowledgements

Thanks to all organizers and attendees of the workshop, in particular Dr. Ivan Gill of the University of New Orleans and Dr. Steve Birch at McMaster University, Ontario. Special thanks to Dr. Lynn Kimsey and the Bohart Museum of Entomology, Davis, California.

REFERENCES

Babe, K.S. "House Dust Mite (Dermatophagoides Farinae and Dermatophagoides Pteronyssinus) Prevalence in the Rooms and Hallways of a Tertiary Care Hospital." *Journal of allergy and clinical immunology* 95, no. 4 (1995): 801–05.
Hinkle, Nancy C. "Delusory Parasitosis." *American Entomologist* 46, no. 1 (2000): 17–25.
Hinkle, Nancy C. "Ekbom Syndrome: A Delusional Condition of "Bugs in the Skin"." *Current psychiatry reports* 13, no. 3 (2011): 178–86.
Hylwa, S. A., J. E. Bury, M. D. Davis, M. Pittelkow, and J. M. Bostwick. "Delusional Infestation, Including Delusions of Parasitosis: Results of Histologic Examination of Skin Biopsy and Patient-Provided Skin Specimens." *Arch Dermatol* 147, no. 9 (2011): 1041–5.
Miller, JD, and A. Miller. "962 Ten Minutes in a Clothes Dryer Kills All Mites in Blankets." *The Journal of Allergy and Clinical Immunology* 97, no. 1 (1996): 423–23.
Pearson, M. L., J. V. Selby, K. A. Katz, V. Cantrell, C. R. Braden, M. E. Parise, C. D. Paddock, *et al.* "Clinical, Epidemiologic, Histopathologic and Molecular Features of an Unexplained Dermopathy." *PLoS One* 7, no. 1 (2012): e29908.
Poorbaugh, JH. "Cryptic Arthropod Infestations: Separating Fact from Fiction." *Bulletin of the Society for Vector Ecology* 18, no. 1 (1993): 3–5.
Shelomi, Matan.[a] "Mad Scientist: The Unique Case of a Published Delusion." *Science and Engineering Ethics* 18, no. 1 (2012). DOI: 10.1007/s11948–011–9339–2
Shelomi, Matan.[b] "Evidence of Photo Manipulation in a Delusional Parasitosis Paper." *Journal of Parasitology* (2012). PMID: 23198757. DOI: 10.1645/12–12.1
Sox, Harold C, and Drummond Rennie. "Research Misconduct, Retraction, and Cleansing the Medical Literature: Lessons from the Poehlman Case." *Annals of Internal Medicine* 144 (2006): E7–E11.
Traver, Jay. "Unusual Scalp Dermatitis in Humans Caused by the Mite, *Dermatophagoides* (Acarina, Epidermoptidae)." *Proceedings of the Entomological Society of Washington* 53, no. 1 (1951): 1–25.
Wilson, J.W., and H.E. Miller. "Delusion of Parasitosis (Acarophobia)." *Archives of Dermatology* 54, no. 1 (1946): 39

ABOUT THE AUTHOR

Matan Shelomi: Mr. Matan Shelomi is a graduate student in entomology under Dr. Lynn Kimsey at the Bohart Museum of Entomology, University of California, Davis. Through his position at the Museum, which fields calls from patients with Delusional Parasitosis on a weekly or even daily basis, he has gained much experience with the condition. This workshop is based on his most recent publication, "Mad Scientist: The Unique Case of a Published Delusion" as published in Science and Engineering Ethics. His other projects have included work in forensic entomology and insect physiology. He graduated from Harvard University in 2009, majoring in organismic and evolutionary biology. He is an NSF fellow, and a member of Mensa and the International Society for Philosophical Enquiry.

Astrological Planetary Alignment and Personality Differences: Saving us from Ignorance

Renier Steyn, University of South Africa, Pretoria, South Africa

Abstract: Astrological information often appears in newspapers and magazines. This suggests that there are readers who may believe that their birthdates relate to astrology and that this phenomenon influences their everyday lives. Many scientists, particularly psychologists, have attempted to link astrological signs with personality traits on an empirical level. The results have often been ambivalent and sometimes even controversial. Scientific evidence generally indicates that zodiac star positions do not influence different personalities. The study of planetary alignment, however, seems more complex. Results in this field often involve smaller research groups, are more difficult to interpret, and can therefore be considered as ambivalent. In this specific study a large group of 65 268 job seekers was assessed by means of a personality questionnaire, the so-called Basic Traits Inventory. The personality traits of four groups of individuals (N = 49, N = 48, N = 39, N = 36) were compared. The groups differed from each other in that all the members of a specific group shared the same planetary alignment and zodiac sign. Chronological age, as a mediator, was not taken into account as the individuals were all born in the same year (1983). No significant differences in personality traits between the groups were found. The results of this study confirm that neither zodiac star signs, nor planetary alignments, influence personality. This affirms, through scientific investigation, that astrology should be seen for what it is; namely an outmoded, archaic belief system based on mythological assumptions.

Keywords: Astrological Signs, Planetary Alignment, Personality

INTRODUCTION

The Oxford Dictionary Pro (2012) defines astrology as “the study of the movements and relative positions of celestial bodies interpreted as having an influence on human affairs and the natural world”. The dictionary also states that astrology is based on the work of ancient observers of the heavens who developed elaborate systems of explanation according to the movements of the sun, moon and planets through the constellations of the zodiac, with the aim of predicting events and casting horoscopes. The Oxford Dictionary Pro (2012) furthermore suggests that, by 1700, astrology had lost intellectual credibility in the West but continued to have popular appeal.

The continued contemporary popular appeal of zodiac-related predictions is illustrated by regular coverage in the media. It is quite common to find sections dedicated to zodiac-related statements and predictions in popular magazines and newspapers. Many websites also focus on this topic. The website newyearhoroscope.com (2012), for example, provides interested parties with daily readings containing advice such as the following: “It’s all too easy to let your upportive (sic) friends bail you out of a tricky situation today. Naturally, accepting help from allies is usually wise, but you have more to gain now by expressing your own truth than relying

The International Journal of Science in Society
Volume 4, 2013, http://science-society.com/, ISSN 1836-6236

COMMON GROUND

on others. Take advantage of the adventurous Sagittarius Moon as she visits your 5th House of Creativity. Don't be afraid to try a new approach to an old problem. If it doesn't work out as you expect, you can always resort to your backup plan later". This reading is based purely on the time of year a person was born.

Many twentieth and twenty-first century scientists have shown an interest in astrology (see Chico & Lorenzo-Seva, 2006; Dean & Kelly, 2003; Dean, Nias & French, 1997; Ertel & Dean, 1996; Eysenck & Nias, 1982; Hamilton, 2001; Hartmann, Reuter & Nyborg, 2006; Kelly, 1997, 1998; Mayo, White & Eysenck, 1978; Perry, 1995; Tyson, 1984; Van Rooij, 1994, 1999). This specific study takes into account those researchers who were interested in and focused on personality differences between individuals born under different star signs (see Hartmann, Reuter & Nyborg, 2006; Eysenck & Nias, 1982; Mayo, White & Eysenck, 1978; Van Rooij, 1994, 1999). The empirical research reports generated by these researchers generally show little support for the claims of astrology. Eysenck and Nias (1982), for example, state that behaviour can usually be explained better by non-astrological predictors. Although astrology has lost intellectual credibility in the West, many people still read astrological descriptions and predictions in the popular media and may also make decisions based thereupon.

Some scientific-mostly psychological-explanations may account for the lingering interest in astrology. Van Rooij (1994) was of the opinion that the evaluation of the accuracy of zodiac personality description in everyday life is linked to a process of selective self-observation whereby self-fulfilling biases in event observations were commonplace. For instance, an Aries-person who believes that he/she is "impulsive" will selectively observe impulsive behaviour in him/herself whilst ignoring moments that do not reflect impulsive behaviour patterns. Acquaintance with star signs could therefore be an important factor in the relationship between star signs and reported personality (Eysenck & Nias, 1982). Hamilton (1995) shared the same view. Eysenck and Nias (1982) also referred to the presence of the Barnum effect in people's appreciation of personality traits, in which personality descriptions of a general and vague nature are accepted at face value. This may explain the preference of favourable characteristics described in zodiac descriptions (Hamilton, 2001; Pawlik & Buse, 1979; Wunder, 2003).

Astrological Signs and Planetary Alignments

One of the first individuals to take a serious empirical look at the effects of the stars and planets on human behaviour was the French psychologist Michel Gauquelin. In one of his earlier works, namely "The Scientific Basis of Astrology" (1969), he concludes that zodiac star signs exercise no influence on our hereditary characteristics, nor do they play any part, however small it might be, in our lives. In one of his later publications, "Neo-Astrology: A Copernican Revolution" (1991), he concludes, however, that planetary alignments do affect our fate, and that statistical evidence supports this. The work of Gauquelin inspired many others, including Hans J Eysenck. In the book Eysenck co-authored with Davis Nias, entitled "Astrology-Science or Superstition?" (1982), they debate the matter in further detail, with some results confirming Gauquelin's findings, whilst others seem to negate these findings. This ambivalence, as well as the research stated earlier (see Chico & Lorenzo-Seva, 2006; Dean & Kelly, 2003; Dean, Nias & French, 1997; Ertel & Dean, 1996; Eysenck & Nias, 1982; Hamilton, 2001; Hartmann, Reuter & Nyborg, 2006; Kelly, 1997, 1998; Mayo, White & Eysenck, 1978; Perry, 1995; Tyson, 1984; Van Rooij, 1994, 1999), surprisingly suggests that psychology-as a discipline that forms part of the scientific community-has not yet reached consensus in its stance towards astrology.

Many astrologers and readers of astrology would argue that dividing individuals into the twelve astrological groups according to the signs of the zodiac of Western astrology (Riske, 2011; Stirling, 2010) and making predictions about individual behaviour based on these signs is simplistic and not proper practice. This simplistic link between zodiac signs and personality has been disproved through scientific endeavour. Several empirical studies have been undertaken to link personality with zodiac signs (see Moyo, White & Eysenck, 1978; Tyson, 1984; and Van Rooij, 1994, 1999) and the results tend to concur that such a relationship does not exist. In a more recent study, Hartmann, Reuter and Nyborg (2006) used data from two separate groups of 4 462 and 11 448 individuals, testing the relationship between date of birth and individual differences in personality and general intelligence. They report that in no case did date of birth, as presented in star sign format, relate to individual differences in personality or general intelligence. Steyn (2011), using a sample of 65 268, tested a possible relationship between zodiac signs and personality traits. Contrastive analysis of personality traits by astrological signs yielded no significant differences. These last two reports seem to indicate that zodiac signs do not influence personality.

However, more sophisticated astrologers would argue that it is not the broad zodiac signs that influence individuals, but that planetary alignment at the time of birth could be considered important. For example, the reading for a Leo (one of the zodiac signs of Western astrology) born on 17 August 1966 would differ from that of another Leo born on 17 August 1967, as the planetary alignments were different on the different dates. The seminal work related to planetary alignment, namely "The Mars effect: A French test of over 1 000 sports champions" (Benski, Caudron, Galifret, Krivine, Pecker, Rouzé, Schatzman & Nienhuys, 1996), suggests that this is the case. No research could be located that used a large sample and which empirically investigated the similarity (if any) between people born on exactly the same day (suggesting a similar planetary alignment).

Aim

The aim of the study was to test the null hypothesis that people who share a birthday (day and year), and who by implication were born under the same planetary alignment, do not differ in terms of personality from those who were born at a different time. Should it be impossible to reject this hypothesis, it could be considered as scientific evidence to reject the notion that planetary alignments at the time of birth affect behaviour.

Method

Participants and Setting

Participants were 65,268 job seekers with a South African government agency (mean age = 24.8 (SD = 3.9 years), females = 59%, males = 41%, Blacks = 98%, Whites = 2%, Zulu/Xhosa/Sepedi = ±20%, Venda/Tswana/Tsonga/Sotho = ±7%, Swati/Ndebele/Afrikaners = ±3%). All the participants had completed 12 years of schooling and were literate in English. As part of the selection process, they completed a personality questionnaire under the supervision of registered psychologists. The assessment was done with full compliance vis-à-vis the ethical guidelines of the Health Professions Council of South Africa and under the conditions of the Employment Equity Act, 1998 (Act No. 55 of 1998).

Measurement Instruments

Participants completed the Basic Traits Inventory (BTI; Taylor & de Bruin, 2006)-a measure of personality traits. The BTI measures five core traits, namely extroversion, agreeableness, conscientiousness, neuroticism and openness (as defined by McCrae & Costa, 1987). Taylor (2008) reports reliability coefficients varying from a high of .94 (neuroticism) to a low of .88 (agreeableness and openness) with a South African sample. She also provides some evidence on the absence of item- and scale-level bias (Taylor, 2008).

Data Analysis

The first aim was to find large groups of individuals in the data set who shared the same birthdates. First the mode year of birth was calculated. As the mode year of birth was 1983, this was considered as the year where most groups of individuals sharing the same birthdates would be found. Focusing on a single year also made sense as the age difference between individuals, which may affect their personality, was minimised through following this strategy.

Groups of individuals were identified by presenting birthdates in descending order, and then allocating unique group numbers to individuals who shared a birth date. The following dates were used, based only on the size of the group of people sharing a birth date: 1983-01-01 (N = 49), 1983-03-03 (N = 48), 1983-09-23 (N = 39), and 1983-09-03 (N = 36). The individuals in these groups shared an identical astrological planetary alignment since they were born on the same day.

One-way between-groups analysis of variance was conducted to explore whether the personality traits of people born on different dates, and therefore differing in their astrological planetary alignments, were the same.

Results

One-way between-groups ANOVAs, comparing the mean scores of the four different groups and created according to the day, month, and year of birth, revealed no statistically significant difference in any of the five BTI fields. All the p-values were greater than .50, much larger than the standard .05. The effect size, calculated using eta squared (Cohen, 1988; Steyn, 2000), was nevertheless calculated and was less than .01 in all cases. The post-hoc comparison using the Scheffe's test also indicated that not one of the groups differed significantly.

Discussion

Although some researchers suggest that people born during different planetary configurations differ in terms of personality traits and their fate (most noticeably Gauquelin, 1991), this research provided no evidence supporting their theory. Furthermore, this research provides a valuable contribution to the present understanding of astrology by supplying scientific evidence that neither planetary alignments, nor zodiac signs, can be used to differentiate or contrast individuals in terms of personality. Planetary configurations have no behavioural ramifications for humans. This affirms, through scientific investigation, that astrology should be seen for what it is, namely an outmoded, archaic belief system based on mythological assumptions. Any real-world decisions made on the basis of such a system would therefore be foolish and could be considered as a sign of ignorance.

REFERENCES

Benski, C, Caudron, D, Galifret, Y, Krivine, JP, Pecker, JC, Rouzé, M, Schatzman, E & Nienhuys, JW. 1996. *The Mars effect: A French test of over 1000 sports champions*. Amherst, NY: Prometheus.

BTI. 2006. *Basic Traits Inventory*. Johannesburg: Sub-Saharan Africa Test Distributors, Publishing and Consulting Psychologists.

Cohen, J. 1988. *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale: Erlbaum.

Chico, E & Lorenzo-Seva, U. 2006. Belief in astrology inventory: Development and validation. *Psychological Reports* 99: 851–863.

Ertel, S & Dean, G. 1996. Are personality differences between twins predicted by astrology? *Personality and Individual Differences* 21, 3: 449–454.

Eysenck, HJ & Nias, DKB. 1982. *Astrology: Science or superstition*? New York: St Martin's.

Gauquelin, M. 1969. *The scientific basis of astrology*. New York: Stein and Day.

Gauquelin, M. 1991. *Neo-astrology: A Copernican revolution*. London: Arkana.

Hamilton, M. 1995. Incorporation of astrology-based personality information into long-term self-concept. *Journal of Social Behaviour and Personality* 10: 707–718.

Hamilton, M. 2001. Who believes in astrology? Effect of favorableness of astrologically derived personality descriptions on acceptance of astrology. *Personality and Individual Differences* 31: 903–914.

Hartmann, P, Reuter, M & Nyborg, H. 2006. The relationship between date of birth and individual differences in personality and general intelligence: A large-scale study. *Personality and Individual Differences* 40, 7: 1349–1362.

Kelly, IW. 1997. Modern astrology: A critique. *Psychological Reports* 81: 1035–1066.

Kelly, IW. 1998. Why astrology doesn't work. *Psychological Reports* 82: 527–546.

McCrae, RR & Costa, PT. 1987. Validation of the five-factor model of personality across instruments and observers. *Journal of Personality and Social Psychology* 52, 1: 81–90.

Mayo, J, White, O & Eysenck, HJ. 1978. An empirical study of the relation between astrological factors and personality. *Journal of Social Psychology* 105: 229–236.

Newyearhoroscope.com. 2012. *Leo, April 11 2012*. Retrieved from http://www.newyearhoroscope.com/horoscope-2012/ on April 11, 2012.

Pawlik, K & Buse, L. 1979. Self-attribution as a differential, psychological moderator variable: Verification and clarification of Eysenck's astrology-personality correlations. *Zeitschrift für Sozialpsychologie* 10, 1: 54–69.

Perry, G. 1995. Assessing the feasibility of correlating psychological tests with astrology. In M Pottenger (Ed.), *Astrological research methods*, Vol. 1. An ISAR Anthology. (pp. 121–127). Los Angeles, CA: International Society for Astrological Research.

Riske, KB. 2011. *Llewellyn's sun sign book: Horoscopes for everyone*. Woodbury: Llewellyn Publications.

Steyn, HS. 2000. Practical significance of the differences in means. *Journal of Industrial Psychology* 26, 3: 1–3.

Steyn, R. 2011. Astrological signs and personality differences. *Journal of Psychology in Africa*, 21, 3: 493–494.

Stirling, SZ. 2010. *2011 Astrology guide nearing the portal*. Las Vegas: Wisdom Press.

Taylor, N. 2008. *Construct, item and response bias across cultures in personality measurement*. Unpublished doctoral thesis, University of Johannesburg, Johannesburg.

Taylor, N & de Bruin, GP. 2006. *Basic Traits Inventory*. Johannesburg: Jopie van Rooyen and Partners.

The Oxford Dictionary Pro. 2012. *Astrology*. Retrieved from http://english.oxforddictionaries.com/definition/astrology;jsessionid=E59E40D6BFAA623AB2D7C1F5BF6C0FE3 on April 10, 2012.
Tyson, GA. 1984. An empirical test of the astrological theory of personality. *Personality and Individual Differences* 5, 2: 247–250.
Van Rooij, JJF. 1994. Introversion-extraversion: Astrology versus psychology. *Personality and Individual Differences* 16, 6: 985–988.
Van Rooij, JJF. 1999. Self-concept in terms of astrological sun-sign traits. *Psychological Reports* 84: 541–546.
Wunder, E. 2003. Self-attribution, sun-sign traits, and the alleged role of favourableness as a moderator variable: Long-term effect or artifact? *Personality and Individual Differences* 35: 1783–1789.

ABOUT THE AUTHOR

Prof. Renier Steyn: Renier Steyn worked for 18 years as a psychologist in the South African Police Services and is presently an Associate Professor at the University of South Africa where he teaches in the field of human resources management and leadership. His academic interests include applied social psychology and research methodology. He obtained a Ph.D. in Industrial and Personnel Psychology as well as a D.Litt. et Phil. in Psychology. He is a registered research psychologist and a post-doctoral research fellow at the Semel Institute for Neuroscience & Human Behavior-situated at the University of California (UCLA)-as well as a member of the UNISA International Fellowship Programme.

Driving Nanotechnology in the Netherlands: Shaping the Dutch Government's Approach to Nanotechnology

Johannes Eijmberts, Northeastern University, MA, USA

*Abstract: The promise of nanotechnology has captivated academia, industry, the general public, and governments around the world. Nanotechnology, the ability to control and manipulate matter at the nanoscale, is an enabling technology which combines biology, physics, chemistry, and information technology in an emerging field of science that might be able to transform society as we know it today. Nanotechnology offers a range of possible solutions for a whole array of social, environmental, and economic challenges, yet much uncertainty remains about the consequences of the use of nanotechnology and nanomaterials over a longer period of time. Many governments around the world have responded to the potentially revolutionary nature of nanotechnology, yet in very different ways. This leads to questions why governments take a different approach to a similar opportunity and a similar challenge. This paper reflects on drivers of science and technology policies, in particular with regard to nanotechnology. It compares the approach of the government of the Netherlands-a smaller, highly developed country in the heart of the European Union-with the be approach of the American government. As a first in the world, the US Congress established a national program to support research and development in nanotechnology: the National Nanotechnology Initiative (NNI) in 2001. The NNI is an overarching program which coordinates all efforts in nanotechnology research and development made by the 26 participating federal departments and agencies. That American approach is the benchmark in this study. The comparison of the NNI with the Dutch government approach adds to our understanding which factors drive science and technology policies, why certain factors are important, under which circumstances their weight changes, and how the international setting shapes domestic science and technology policies.**

Keywords: Nanotechnology, Science and Technology Policy, Drivers of Science and Technology Policy, The Netherlands, National Nanotechnology Initiative

*This research was supported in part by a National Science Foundation Nanotechnology Interdisciplinary Research Team award, "Nanotechnology in the Public Interest: Regulatory Challenges, Capacity, and Policy Recommendations" (SES #0609078), Christopher Bosso, PI. The views expressed are those of the author.

The promise of nanotechnology has captivated academia, industry, the general public, and governments around the world. Nanotechnology, the ability to manipulate matter at the nanoscale, is an enabling multiple purpose technology that brings together disciplines such as biology, physics, chemistry, and information technology in ways that may transform life as we know it. At such small scales, properties of well-known materials such as silver or titanium change dramatically (Whitman, 2007). Scientists foresee far-reaching applications in fields as diverse as energy production, clean water supply, preventive and therapeutic medicine, computing, and manufacturing (Project on Emerging Nanotechnologies, 2012). As such, nanotechnology has the potential to offer groundbreaking solutions for an array of social, environmental, and economic challenges.

Governments around the world have responded to that promise in different ways. The larger project behind this article explores the factors shaping different forms of national government involvement in advancing nanotechnology. For instance, is it the new and transformative nature of the technology itself that calls for an open-ended and science-dominated government approach? Or does government involvement in nanotechnology reflect established science and technology policies? In this regard, how do perceived challenges like climate change or environmental protection help to shape a government's approach to nanotechnology as compared to, for example, its economic potential?

This study seeks to understand government action on emerging scientific fields of great promise by assessing government involvement to nanotechnology in the case of the Netherlands. In comparison to the approach taken in the United States, where one arguably sees innovation in science policy to capture the exceptional potential of nanotechnology, the Dutch government approach is shaped by and reflects more established policy and institutional arrangements.

Drivers of Science and Technology Policy

What factors drive government science and technology policies? An obvious place to start is national traditions of governance and the institutional set-up of policymaking. Cultural traditions may help to set the overall context of policymaking (Katznelson, 1997; Almond, 1989), while previous political decisions might shape succeeding decisions, a path dependent response to new developments regardless of technological novelty (Arthur, 1994; Campbell, 2010; Cowan, 1991; Hacker, 2002; Pierson, 2004).

National challenges and strengths are important drivers of any nation's policy agenda. A national challenge requires a comprehensive response from government, often in the form of a wider policy program. The challenge might be nation-specific, triggered by its particular geographical location, or might be generic among similar nations, such as environmental pollution, unstable energy supply, or economic underdevelopment. As national challenges often have wide consequences, they tend to shape the order of priorities of the policy agenda, explaining why national and international priorities might differ (Hall, 2001).

Nations also have different opportunities to handle the challenges at hand, ranging from the 'luck' of geographical location, natural resources, or the size of a population, to more generic and purposeful built-up strengths, such as human intellect and ingenuity. Often the build-up of a national strength is triggered by the necessity and urgency that national challenges may pose (Henke, 2008). Size, resources, and relative power positions seem to determine how countries respond to national challenges in general (Keller, 1990). Many challenges appear to be too large to be solved by a single nation alone or require international collaboration for a more effective response (Ibid; Branscomb, 1993).

Comparing the Netherlands with the United States

In early 2001 the United States established the National Nanotechnology Initiative (NNI), the world's first national program to support research and development in nanotechnology (National Science and Technology Council, 2000). The NNI is an overarching program that coordinates and orchestrates previously fragmented and decentralized cross-discipline and cross-agency research efforts made by its twenty-six participating federal departments and agencies (Roco, 2007) (National Nanotechnology Initiative, 2012). The NNI offers a long term integrated and multi-disciplinary vision about nanotechnology development concentrated around science and technology, as determined by leading scientists (McCray, 2005). Since its establishment, the agencies under the NNI umbrella have allocated around $12 billion (National Nanotechnology Initiative, 2012) to nanotechnology research and development, investing over $2.1 billion in fiscal 2012 alone (National Science and Technology Council, 2011).

The US government moved to establish the NNI as it was understood among policy makers that the transformative possibilities of a general purpose technology such as nanotechnology demanded a cross-agency coordination to leverage all federal investments in research in the field (Lane and Neil, 2005). At the time of the establishment of the NNI nanotechnology research was at an early stage, seen as so long term, high risk, expensive, and of too uncertain outcomes that industry needed public assistance in developing nanotechnology applications for economic and societal benefits (Roco, 2001). A national program would enable the United States to maintain its global lead even as other countries were ready to increase investments in nanotechnology research (McCray, 2005) (Roco, 2001). In addition, setting up a national program helped to revive general interest in science and technology, traditionally a source of national pride (Smalley, 2000) (McCray, 2005).

The institutional set up of the NNI is arguably a novel way of coordinating otherwise separate operations by a range of federal departments and agencies, foster exchange of information, and avoid a duplication of research efforts. Such a set up emphasizes efficiency and coordination. However, as the NNI's coordinating office has no research budget to allocate itself, one might argue that the NNI is little more than an aggregator of information on the projects funded by its participants, of which the National Science Foundation (NSF), National Institutes of Health (NIH), Department of Energy, and Department of Defense are the most prominent. Even so, the prominence and the example-setting case of the NNI, the overall strength and performance of the US science and technology system, as well as American economic and political dominance makes the US a benchmark for comparison to other nations.

Like the US, the Netherlands is a highly developed industrialized democracy with an internationally oriented industry and an established science and technology system that includes well-regarded universities and research institutes. Both countries enjoy high levels of gross domestic production (GDP) and per capita incomes, and in each a large percentage of the population has access to tertiary education (college) or advanced vocational and professional training. For multiple reasons, among them to ensure national security, to protect against natural disasters, and to spur economic growth, governments in both nations have a long tradition of involvement in science and technology. Each has built a significant institutional network to support scientific and technological progress, and since the early 2000s each has established prominent positions in nanotechnology research. Moreover, industry in both countries has established substantial positions in nanotechnology-related ventures (Ministry of Economic Affairs, 2006; Ministry of Economics, Agriculture, and Innovation, 2012).

However, compared to the US, the Netherlands is a small country, with a population just under 17 million people. While the Dutch economy is relatively large in comparison to the world's largest players, it is modest in absolute size. As such, the Netherlands is a less obvious choice as a case for comparison to the US than, for instance, Germany or the United Kingdom. Yet, the strong positions of both countries in nanotechnology provide an opportunity to contrast the United States and the Netherlands, which offers a compelling new perspective on the research questions at hand.

For example, Dutch and American positions in international regimes such as the Organization for Economic Cooperation and Development (OECD) have traditionally taken different paths. Because of its military and economic dominance, the US historically has been able to go its own way, often setting the direction of scientific, technological, industrial, and economic development for the world. By contrast, the Netherlands–its people, economy, and its political system–has a long tradition of international interconnection. The nation's small size and its geographical location in Europe historically forced international engagement. The Netherlands is an active member of numerous international organizations such as the OECD, the International Organization for Standardization (ISO), and the World Trade Organization (WTO). Perhaps most critically, as a founding member of the European Union (EU), Dutch policymaking is increasingly influenced by and framed within European laws and programs. It is this relationship between the national and supranational that marks Dutch science and technology policymaking.

Traditions of Governance in the Netherlands

Traditions of governance in the Netherlands have two dimensions. One is situated at a national or domestic level, the other at the international, mainly European level. At the domestic level, a political culture shaped by consociationalism is often deemed typically Dutch. The notion of consociationalism, or consensus democracy (Kickert, 2003), describes the way the Dutch political system accommodates the preferences of key societal groups, or 'pillars', until the late 1960s (Lijphart, 1968). The idea of consociationalism is to overcome deep societal cleavages by having a political system that enables elites representing different pillars to find pragmatic solutions for broad policy issues through negotiated (often covert) settlements in which all parties have proportional input (Lijphart, 1968). Such a consensus democracy is characterized by wide and long consultation of many stakeholders and parties in the decision-making process (McCormick, 2005; WRR, 2007, MASIS Expert Group, 2009; Andeweg, 2009).

Though societal pillars have broken down since the 1960s, Dutch science and technology policy-making and research funding still reflect the consociational institutionalization that became the norm after the Second World War. To a large extent the Dutch government delegates policy preparation and research funding decisions on matters of science and technology research and development to a substantive intermediary level of consultation situated between the legislative and executive branches of government and research institutes and private enterprises that conduct research (Brickman, 1979; Van der Meulen, 1998). This intermediary level consists of multiple advisory councils and public research funding organizations, including representatives from government, independent research institutes, universities, other societal and environmental interest groups, and industry (Van der Meulen, 1998; Jongbloed, 2008). Through its participation at all levels of consultation, private enterprise is well represented in decision-making. In fact, public-private partnerships and collaboration among government, academia, and industry, in which partners share investments as well as economic or social return, are common in matters of science and technology development in the Netherlands (Versteegh, 2000; Ministry of Economic Affairs, 2004; *Life Sciences 2020*, 2010). The government promotes and supports such partnerships, often requiring industry involvement as a condition for public funding of research (Ministry of Economic Affairs, 2004; *Life Sciences 2020*, 2010).

Policymaking in the Netherlands is also strongly embedded in an international, and in particular European, setting. National Dutch policies are interlinked with European policies in two directions. From the top down, European treaties, laws, directives, and guidelines shape national Dutch policies and the way the government translates and implements European directives into national legislation. At the same time the standpoints of the Dutch government, and the input of its policymakers, experts, and interest groups, rise to the EU level, helping to mold European policies. Shaping the supranational regime of the European Union is an ongoing interplay between the Union, represented by its different institutions in which the member countries participate, and the national governments of the member states (Bovens, 2005; Rood 2005; McCormick, 2005).

Dutch Government Involvement in Nanotechnology Research

As in other countries that lead in nanotechnology development, government involvement in nanotechnology in the Netherlands has evolved since the 1990s along two streams, which increasingly coincide: (1) support of nanotechnology development and (2) addressing risks and uncertainties associated with nanotechnology. The need for broad public acceptance of nanotechnology indicates where the two streams converge: addressing risks and uncertainties, and involving the general public, is conditional for the successful development and application of nanotechnology.

In 2006 Dutch economic activity in nanotechnology ranked third in the world relative to the size of its economy, yet in absolute measures, the Dutch position is better characterized as leading the group of countries that aspire to connect to set of global leaders in nanotechnology (Ministry of Economic Affairs, 2008; Lux Capital, 2003; Ministry of Economic Affairs, Agriculture, and Innovation, 2011). Later in the decade the Netherlands placed in the top global top three (with the US and Switzerland) for nanotechnology research with highest scientific impact, based on the number of citations (Nederlands Observatorium van Wetenschap en Technologie, 2010). Despite strong scientific output, the Netherlands currently lags in nanotechnology-generated innovation. This phenomenon reflects the larger so-called European paradox, the comparative difficulty among EU countries in translating high-quality science into commercially successful applications (Ministry of Economic Affairs, 2004).

Nevertheless, in 2006 thirteen out of the thirty largest Dutch companies, accounting for two-thirds of private research and development budget in the Netherlands, engaged in nanoscale research, approximately 275 Dutch companies used nanomaterials in some way, and private enterprise finances half of all nanotechnology-related research in the Netherlands (Ministry of Economic Affairs, 2006). For its part, the Dutch government estimates it allocated a total of €150 million to nanotechnology research in 2010 (Ministry of Economic Affairs, Agriculture, and Innovation, 2011). While the NNI's budget in 2010 was $1.9 billion (National Nanotechnology Initiative, 2011), Dutch spending on R&D is comparable to the national GDP of each country.

Taken together, combined public and private investments in nanotechnology research show clear Dutch national aspirations (Walthout, van Keulen, van Est, Brom, & Malsch, 2009).

The main driver of nanotechnology development in the Netherlands appears to be economic development, innovation, and global competitiveness, and building on existing economic and academic strengths rather than developing new ones (Adviesraad voor het Wetenschaps-en Technologiebeleid, 2007; WRR, 2008). As put forward in its 2008 "Action Plan for Nanotechnology", which became the basis of its involvement in nanotechnology research, the Dutch government seeks to create a climate for sustainable and economically viable development of nanotechnology, based on four premises: (1) an ambitious agenda for research and business opportunities in the Netherlands; (2) an inclusive approach to address ethical, social, and legal issues pertaining to nanotechnology; (3) a program to stimulate public engagement in the development of an overall governance approach; and (4) an emerging regulatory model, acknowledging the risks and remaining uncertainty associated with the use and production of manufactured nanomaterials (Ministry of Economic Affairs, 2008). The 2008 plan aims to build a nanotechnology research system based on backing 'winners,' supporting the development of areas of expertise and specialization in the nation has proven strengths, such as high tech systems and materials, clean water, food, and energy (Ministry of Economic Affairs, 2012). To stimulate public engagement, the government announced a public debate on the respective benefits and risks of nanotechnology. Based on a series of public deliberation forums and other inputs, the government concluded in 2011 that the Dutch public in general is positive about the possibilities of nanotechnology while acknowledging potential negative side affects that need to be addressed. The consensus was that public funding for nanotechnology research is justified (Commissie Maatschappelijke Dialoog Nanotechnologie, 2011).

Public–Private Partnerships

In the Netherlands nanotechnology research emerged bottom-up insofar that scientists and researchers linked to industry started to do studies of the possibilities of nanotechnology, seeking, where needed, possible and desirable, additional public funding of their research through existing channels and programs (Gielgens, 2012). In response to these demands, in 2002 the government co-funded NanoImpuls, an initiative of industry, research institutes, and seven universities that its partners saw as a first phase of a more expansive and longer-term collaboration in nanotechnology research. Since then a succession of public–private consortia have advanced nanotechnology research in the Netherlands.

These consortia, however, do not resemble the US National Nanotechnology Initiative. The involvement of the Dutch government is limited to research funding and setting conditions to receive such funding, the main ones being 'matching funds' by consortia partners equal to the amount of government funding and, increasingly, the condition that some funds are allocated towards research into the risks and uncertainties associated with nanotechnology, as well as societal consequences of this emerging scientific field.

The stipulation of public funding equal to monies from other sources has become the norm for successive Dutch investments in nanotechnology research (Commissie Meijerink, 2010) (FES Initiative 2009 HTSM, Oct. 2009). NanoImpuls eventually led to NanoNextNL and its linked network of facilities NanoLabNL, which together have received government funding until 2016. Public funding of NanoNextNL is set around €25 million annually (NanoNed, 2008; FES Initiative, 2009; Ministry of Economic Affairs, Agriculture, and Innovation, 2012). Paired with the matching funds from consortium partners, the NanoNextNL program has a €250 million budget for the 2011–2016 period. Separate public funding of NanoLabNL research facilities at four Dutch universities is funded through annual appropriations, so the overall balance of funding is close to 65% public funding and 35% industry funding (FOM, STW & NanoNed, 2008). Such an arrangement allows for a prominent role for consortium partners, notably industry, in setting research priorities and suggests a rather detached though supportive role of government.

Public funding for these different nanotechnology research programs comes from the Economic Structure Enhancement Fund (FES), which allocates public income from natural gas sales to infrastructure projects, including a specific domain for 'Knowledge, Innovation, and Education.' FES fund allocations supplement the budgets of departments that submit proposals (Commissie Meijerink, 2010), such as that submitted by the Department of Economic Affairs to continue funding nanotechnology development through the NanoNextNL proposal. FES allocations are irregular and come on top of regular annual public investments in science, technology, innovation, and education, which of course may include nanotechnology-related research (Ministry of Economic Affairs, Agriculture and Innovation, 2011).

NanoNextNL and its predecessors focus on research based on traditional strengths of Dutch research and industry: electronics, nanomaterials, bio-nano applications, nano-fabrication. While mainly focused on research and development, the programs include studies into societal and ethical consequences, among them the governance of environmental and public health risks. (FOM, STW & NanoNed, 2008). For example, the government requires NanoNextNL to allocate 15% of its budget to risk-related research, thereby mandating the integration of specific risk-related research in general nanotechnology R&D (FOM, STW & NanoNed, 2008).

In contrast to the bottom up nature of Dutch nanotechnology research and development, attention to any adverse environmental and health risks of nanotechnology evolved in a more top-down, elite-driven manner. As suggested by the conditions for public funding of NanoNextNL, government advisory councils steered towards increased government involvement in nanotechnology development to make sure that risks of nanotechnology and the remaining knowledge gaps were properly addressed as a condition for the responsible development of nanotechnology and the use of nanomaterials

Integration with European Policy Directions

Equally important, the Dutch government has stated a strong preference that any Dutch regulation on risks associated with nanotechnology be embedded in European regulation (Ministry of Economic Affairs, 2008, 2010). The government argues that it is inefficient to develop a specific Dutch regulatory framework, which later has to be integrated in broader European and international agreements. Rather, so goes the reasoning, the Dutch should contribute to establishing international and European regulatory approaches that incorporate Dutch priorities and concerns. In the last decade, the Netherlands and the European Union each have put forward action plans for responsible development of nanotechnology that address risk research and public engagement (European Commission, 2005; Ministry of Economic Affairs, 2008). Each also emphasizes an evolving multi-level governance system of the European Union, in particular with regard to environmental protection, use of chemicals, and matters of public health, within the existing legal and regulatory framework.

Given the Dutch emphasis on embedding its regulatory regime into an international and in particular a European setting, Dutch representatives actively contribute to international regulatory initiatives, such as OECD working parties, the ISO technical committee, and numerous European deliberations to shape its outcomes. Dutch policy makers are concerned about the slow pace of progress in risk-related research, and have taken steps to expedite progress in international working groups and committees on these matters. The government allocated additional funds to a European research project specifically focused on acquiring data on which further regulatory action may rely. The Netherlands also seeks coalitions with other concerned EU members to pressure the European Commission in speeding up the regulatory process, and has organized conferences on nanotechnology safety in 2011 and 2012 to choose research priorities. As the Netherlands is involved in OECD and EU deliberations on these matters, it aims to streamline the topics at hand and facilitate the exchange of information (Ministry of Infrastructure and the Environment, 2012).

Increasingly the focus of science and technology policies is on the application of knowledge and on innovation to spur economic growth and advance the Dutch competitive position within Europe and globally. Nanotechnology research and development has become an important part of Dutch and European innovation policy initiatives, such as the 'Top Sectoren' program recently launched by the Dutch government and the European Horizon 2020 program (European Commission, 2011). Nanotechnology is one of the six major 'eco systems', which make up the High Tech Systems and Materials (HTSM) cluster of (Ministry of Economic Affairs, Agriculture, and Innovation, 2012). Through participants in the HTSM cluster, Dutch nanotechnology research efforts link to different European initiatives in the field such as the Nanotechnologies, Materials and New Production Technologies theme (NMP) of the EU's research framework program and ENIAC, the EU's nanotechnology public–private partnership program. The EU's Horizon 2020 innovation program includes nanotechnology as a key enabling technology on which European industrial development will build in the years up to 2020 (European Commission, 2012).

Conclusion

Over the past decade Dutch government involvement in nanotechnology has evolved from detached non-centralized funding of basic research and towards a more centralized national effort, in which nanotechnology is embedded in broader innovation programs both in the Netherlands and in Europe. In this regard, government involvement in nanotechnology development differs from the US approach. American science and technology elites moved quickly to set up a national program for nanotechnology development focused on acceleration of nanotechnology R&D and securing American prominence in this emerging field of science and technology. The

Dutch government relied on its existing channels of science and technology promotion, and only in more recent years developed a more a coherent national research agenda that allocates additional new money for nanotechnology research, integrates risk-related research in the overall research agenda, requires ‘matching funds’ for public funding, and sets an international embedding for any regulatory framework.

More telling, we see a convergence of policy priorities between national and European levels of governance: the focus to stimulate research and industrial uptake in nanosciences in order to benefit from its great opportunities; the urge to address adverse social, ethical, and legal concerns; the desire for public engagement in developing nanotechnology; and the need to balance opportunities with a clear assessment of remaining uncertainties, preferably with international collaboration.

In this regard, the Dutch emphasis on international, particularly EU, collaboration has a neo-functional aspect: international collaboration in this field is ultimately in the national interest. While the US supports international deliberations on scientific standards and risk-related research, the Netherlands sees international and European cooperation as essential for further sustainable development of nanotechnology. In fact, Dutch government involvement in nanotechnology is an example of multi-level governance (Hooghe and Marks, 2001), in which influence in policy-making is shared across different levels of government. Such a decentralized, bottom-up, multi-stakeholder approach seems to fit in with the remnants of Dutch consensus democracy.

The Dutch approach, despite being embedded in the existing national science, technology, research, and innovation system, exhibits some new paths: requirements for matching funds, the focus on private participation in publicly funded research, and the demand for integration of risk-related research into broader research programs. More interesting to note is the degree to which the societal risks dimension of Dutch nano policy is embedded in, and seeking to shape, broader EU policy frameworks. It seems, therefore, that while the Dutch may see economic development as a purely national strategy, the tendency to share research and policy on environmental and health risks at a broader EU level reflects Dutch calculations that the nation’s comparative advantage resides within broader policy networks.

REFERENCES

Adviesraad voor het Wetenschaps-en Technologiebeleid. *Weloverwogen Impulsen: Strategisch Investeren in Zwaartepunten*. Advesraad voor het Wetenschaps-en Technologiebeleid, Rijswijk: AWT, 2007.

Almond, Gabriel A. “The Intellectual History of the Civic Culture Concept.” In *The Civic Culture Revisited*, edited by Sidney Verba & Gabriel A. Almond, 1–36. Newbury Park, CA: Sage Publiciations, 1989.

Andeweg, Rudy & Galen A. Irwin. *Governance and Politics in the Netherlands*. 3rd. London: Palgrave McMillan, 2009.

Arthur, W. Brian. *Increasing Returns and Path Dependence in the Economy*. Ann Arbor, Michigan: University of Michigan Press, 1994.

Bovens, M.A.P. & K. Yesilkagit. “De Invloed van Europese Richtlijnen op de Nederlandse Wetgever.” *Nederlands Juristen Bald* 10 (March 2005): 520–529.

Branscomb, Lewis M. “The National Technology Policy Debate.” In *Empowering Technology*, edited by Lewis M. Branscomb. Cambridge, MA: MIT Press, 1993.

Brickman, Ronald and Arie Rip. “Science Policy Advisory Councils in France, The Netherlands, and the United States, 1957–1977: A Comparative Analysis.” *Social Studies of Science. Theme Issue: Politics and Science*. 9, no. 2 (May 1979): 167–198.

Campbell, John L. “Institutional Reproduction and Change.” Chap. 4 in *Oxford Handbook of Comparative Institutional Analysis*, edited by Glenn Morgan et al, 87–115. New York, NY: Oxford University Press, 2010.

Commissie Maatschappelijke Dialoog Nanotechnologie. “Verantwoord verder met nanotechnologie: Bevindingen maart 2009–januari 2011.” Den Haag, 2011.

Commissie Meijerink. “Evaluatie Procedure Fonds Economische Structuurversterking: Domein Kennis, Innovatie en Onderwijs.” Ministry of Economic Affairs-Ministry of Finance, The Hague, 2010.

Cowan, Robin. “Tortoises and Hares: Choice Among Technologies of Unknown Merit.” *Economic Journal* 101, no. 407 (July 1991): p. 801–814.

Esther, Versluis, Mendeltje van Keulen & Paul Stephenson. *Analyzing the European Union Policy Process*. Houndsmills: Palgrave McMillan, 2011.

European Commission. *Competitive Industries*. 2012. http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=competitive-industry (accessed May 2012).

European Commission. “Horizon 2020–The Framework Programme for Research and Innovation.” Brussels, 2011.

European Commission. “Nanosciences and Nanotechnologies: An Action Plan for Europe 2005–2009.” COM 2005–243, European Commission, Brussels, 2005.

FES Initiative 2009 HTSM. *Towards a sustainable open innovation ecosystem-Revised version*. Utrecht: NNI, Oct. 2009.

FOM, STW & NanoNed. *Strategische Research Agenda Nanotechnologie*. Utrecht: NanoNed, 2008.

Gielgens, Leon. “Conversation - Program Director NanoNextNL.” Utrecht, June 26, 2012.

Hacker, Jacob, S. *The Divided Welfare State*. Cambridge: Cambridge University Press, 2002.

Hall, Peter A. and David Soskice. “An Introduction to Variaties of Capitalism.” In *Variaties of Capitalism: The Institutional Foundations of Comparative Advantages*, edited by Peter A. Hall and David Soskice, 1–70. New York, NY: Oxford University Press, 2001.

Henke, Christopher R. and Thomas F. Gieryn. “Sites of Scientific Practice: The Enduring Importance of Place.” Chap. 15 in *Handbook od Science and Technology Studies*, by Edward J.

Hackett et al (Eds.), p. 353–371. Cambridge, MA: MIT, 2008.

Hooghe, Liebeth, and Gary Marks. *Multi-level Governance and European Integration*. Lanham, MD: Rowman & Littlefield Publishers, 2001.
Jongbloed, Ben and Maarja Soo. "National Report: The Netherlands." European Union DG Education & Culture, GOODUEP Project, Brussels, 2008.
Katznelson, Ira. "Structure and Configuration in Comparative Politics." In *Comparative Politics*: *Rationality, Culture, and Structure*, edited by Alan S. Zuckerman & Mark Irving Lichbach, 81–112. Cambridge: Cambridge University Press, 1997.
Keller, Kenneth, H. "Science and Technology." *Foreign Affairs* 69, no. 4 (Fall 1990): 123–138.
Kickert, Walter J. M. "Beneath Consensual Corporatism: Traditions of Governance in the Netherlands." *Public Administration* 81, no. 1 (2003): 119–140.
Lane, Thomas and Neil Kalil "The National Nanotechnology Initiative: Present at Creation." *Issues in Science and Technology*. (Summer 2005): 49–54.
Life Sciences 2020. "Partners in the Polder." *Life Sciences 2020*. 2010. www.lifesciences2020.nl/ (accessed 2011).
Lijphart, Arend. *The Politics of Accomodation: Pluralism and Democracy in the Netherlands*. Berkeley, CA: University of California Press, 1968.
Lux Capital. *The Nanotech Report 2003*: *Investment Overview and Market Research for Nanotechnology* (*Volume II*). New York: Lux Capital Group, 2003.
MASIS Expert Group. *Challenging Futures of Science in Society*: *Emerging Trends and Cutting-edge Issues*. EU 24039, DG Research, European Commission, Brussels: European Commission, 2009.
McCormick, John. *Understanding the European Union*. 3rd. Houndsmills: Palgrave McMillan, 2005.
McCray, Patrick. W. "Will Small Be Beautiful? Making Policies for Our Nanotech Future." *History and Technology*. 21 no. 2 (June 2005): 177–203.
Ministry of Economic Affairs.
- "Science, Technology and Innovation in the Netherlands." Ministry of Economic Affairs & Ministry of Education, Science and Culture, The Hague, 2004.
- "Kabinetsvisie Nanotechnologieen: Van klein naar groots." *Ministry of Economic Affairs*. 2006 November. http://www.ez.nl/content.jsp?objectid=148565 (accessed October 2009).
- "Actieplan Nanotechnologie." Brief aan Tweede Kamer–2 juli 2008, Den Haag, 2008.

Ministry of Economic Affairs, Agriculture, and Innovation.
- "Kabinetsreactie Voortgangsrapportage door Commissie van Wijzen over ICES/KIS3 (BSIK) projecten 2009." Brief aan de Tweede Kamer-December, 5 2011, Den Haag, 2011.
- "Tweede Voortgangsrapportage Nanotechnologie (Nanobrief)." Brief aan de Tweede Kamer: 110–September 23, 2011, Den Haag, 2011.
- "HTSM Road Map: 'Nanotechnology and Dutch Opportunities." *High Tech Systems & Materials*. 2012. www.htsm.nl/Roadmaps/Nanotechnology (accessed May 2012).
- *Investeren in Top Sectoren*. 2012. www.top-sectoren.nl (accessed May 2012).
- *Top Sector HTSM*. 2012. www.htsm.nl/Topsector_HTSM (accessed May 2012).

Ministry of Infrastructure and the Environment. "Inzet Nederland in Europa in de periode 2011–2014: Risico's Nanomaterialen." Brief aan de Tweede Kamer–May 22, 2012. The Hague, 2012.
Miyazaki, Kumik, and Nazrul Islam. "Nanotechnology Systems of Innovation: An Analysis of Industry and Academia Research Activities." *Technovation* 27 (2007): 661–675.
National Nanotechnology Initiative.
- *Investments by Agency*. February 2011. www.nano.gov/node/636 (accessed January 2012).

- *About the NNI -home*. 2012. http://www.nano.gov/html/about/home_about.html (accessed 2012 January).
National Science and Technology Council. "National Nanotechnology Initiative: The Initiative and Its Implementation Plan." Office of Science and Technology Policy (OSTP), Washington D.C., 2000.
National Science and Technology Council. *The National Nanotechnology Initiative*: *Supplement to the President's FY 2012 Budget*. Washington D.C.: OSTP, 2011.
Nederlands Observatorium van Wetenschap en Technologie. "NOWT Rapport Wetenschaps en Technologie Indicatoren." Ministerie van Onderwijs, Cultuur en Wetenschap, Den Haag, 2010.
Pierson, Paul. *Politics in Time*: *History*, *Institutions*, *and Social Analysis*. Princeton, NJ: Princeton University Press, 2004.
Project on Emerging Nanotechnologies. *Consumer Products*. 2012. www.nanotechproject.org/invetories/consumer (accessed March 2012).
Roco, Mihail C. "From Vision to the Implementation of the US National Nanotechnology Initiative." *Journal of Nanoparticle Research*. 5 (2000): 5–11.
Roco, Mihail C. "National Nanotechnology Initiative–Past, Present, Future. *Handbook of Nanotechnology*, *Engineering, and Technology*. 2nd ed. William A. Goddard III et al (Eds.) CRC Press Taylor & Francis Group, Boca Raton FL, USA (2007).
Rood, Jan Mendeltje van Keulen, Suzanne Nollen & Gera Arts. "Nederland en de Totstandkoming van EU-Milieurichtlijnen." Clingendael European Studies Programme, Nederlands Instituut voor Internationale Betrekkingen 'Clingendael', The Hague, 2005.
Smalley, R. E. (2000). Nanotechnology, Education, and the Fear of Nanobots. In M. R. Bainbridge (Ed.), *Societal Implications of Nanoscience and Nanotechnology*: *A Report on the September 28–29 2000 NSET Workshop* (p. 116). Washington, USA: NSF.
Van der Meulen, Bram and Arie Rip. "Mediation in the Dutch Science System." *Research Policy* 27 (1998): 757–769.
Versteegh, A.P. *Wetenschapbeleid: Een institutioneel onderzoek naar het wetenschapsbeleid van de rijksoverheid in de periode 1945–1999*. Rapport Institutioneel Onderzoek (RIO), Project Invoering Verkorting Overbrengingstermijn (PIVOT rapport 96), Rijksarchiefdienst, Den Haag: Rijksarchiefdienst/Ministerie van OCW, 2000.
Walthout, Bart, Ira van Keulen, Rinie van Est, Frans Brom, and Ineke Malsch. *Nano in the Netherlands*: *Policy Paper for the Nanotechnology Round Table Talks of the Permanent Committee for the Ministry of Economic Affairs-Jun*, *3 2009*. Ministry of Economic Affairs, The Hague: Rathenau Institute, 2009.
Whitman, Jim. "The Governance of Nanotechnology." *Science and Public Policy* 34, no. 4 (May 2007): 273–283.
WRR: Wetenschappelijke Raad voor het Regeringsbeleid
- *Europa in Nederland*. Wetenschappelijke Raad voor het Regeringsbeleid, Amsterdam: Amsterdam University Press, 2007.
- *Innovatie Vernieuwd*: *Opening in Viervoud*. Wetenschappelijke Raad voor het Regeringsbeleid, Amsterdam: Amsterdam University Press, 2008.

ABOUT THE AUTHOR

Johannes Eijmberts: Northeastern University, USA

Teaching Controversial Science: Where Values and Science Converge

Jill Manske, University of St. Thomas, MN, USA

Abstract: Scientific discovery and innovation are essential components of global progress and sustainability. However, current evidence suggests that science-based decision-making and outcomes are often challenged and countered by contrary views that rely on underlying beliefs and values rather than scientific assessment. Educators in scientific disciplines are at the forefront of many of these issues, frequently encountering them in their classrooms. Many initiatives aimed at addressing this challenge are designed to increase scientific literacy. While scientific and quantitative reasoning are important to attempt to address this disconnect, the role of personal values in decision-making must not be underestimated. This paper explores the role of college professors in supporting students as they analyze and negotiate controversial and often contentious topics in science, and discusses the role of students' values, beliefs, and perceptions on their of interpretation of scientific concepts.

Keywords: Education, Pedagogy, Controversial Issues in the Classroom

> "*In order to persuade members of the public to accept empirically sound information, it is necessary to do more than merely make such information available to them. It has less to do with differences in knowledge than differences in values*"
>
> *-D. Kahan*

INTRODUCTION: SCIENCE, POLICY, AND PUBLIC PERCEPTION

Scientific discovery and innovation are essential components of global progress and sustainability. In democratic societies, the role of scientific discoveries on informing and developing public policy is impacted by the public's understanding, views, and decisions regarding science. In such societies, the quality of decisions made by the public can have fundamental impacts on public policy. This is often articulated as a rationale for general, broad-based scientific literacy as a fundamental purpose of science education, which supports the long-term goal of developing students capable of making informed policy judgments with respect to science and society.

Despite several decades of initiatives and reforms focusing on scientific literacy, current culture is replete with examples of science-based decision-making and policy being co-opted by views that rely on underlying beliefs and values rather than valid scientific assessment. Examples include the belief that childhood vaccines are harmful, disbelief of evolution, and perceptions that scientists lack consensus on issues such as global climate change, genetically modified foods, stem cell research, and risks associated with nuclear power (National Science Foundation 2012; National Academy of Sciences 2012).

This phenomenon has received considerable attention, often labeled as "anti-science" or "denialism". Michael Specter defines "denialism" as when an entire segment of society, often struggling with the trauma of change, turns away from reality in favor of a more comfortable

The International Journal of Science in Society
Volume 4, 2013, http://science-society.com/, ISSN 1836-6236

lie, and a "denialist" as someone who "unless data fits into an already formed theory, doesn't really see it as data at all" (Specter 2009, 3). While there is likely considerable debate over these specific definitions and labels, (in fact, the "anti-science" label is employed by people on all sides of a controversial issue in reference to the people holding the opposing viewpoint), the common theme is that people rely on "unscientific" modes of assessment in their analysis of controversial issues, and promote such assessments as equally-or more-valid than assessments based on scientific data. What concerns many scientists, educators, and policy makers is that such viewpoints have moved from the fringe to mainstream, giving them the potential to impact public policy and impede progress on critical scientific problems.

Science educators have a pivotal role in the development of students who can navigate this often-controversial nexus between science and society. Education seeks to instill in students a capacity for critical thinking. To be sure, many academic institutions hold the development of critical thinking skills in such high esteem that they include it in their mission statement and/or have centers and initiatives focused on critical thinking skills. In short, critical thinking (or lack thereof) is a major ongoing discussion within higher education.

In *The Sourcebook for Teaching Science*, Norman Herr describes critical thinkers as those who draw conclusions only after they have defined their terms, distinguished fact from opinion, asked relevant questions, made detailed observations, and uncovered assumptions. Critical thinkers make assertions based on solid evidence and sound logic (Herr 2008). In science, the shorthand we most often use to describe this is "scientific literacy."

Science Literacy, Public Opinion, and Decision Making: The Disconnect

Scientific literacy and critical thinking are antithetical to cultural trends in which scientific data and consensus are disregarded or marginalized during the formulation of decisions and opinions. But despite initiatives promoting science education and science literacy, public perceptions (science literacy) with regard to controversial socioscience issues do not appear to have increased significantly. The level of factual science knowledge has remained stable for the past ten years, with many Americans giving multiple incorrect answers about basic factual knowledge of science or the scientific process. Understanding of the scientific process has stabilized after modest improvements in the 1990s (National Science Foundation 2012).

With regard to some specific socioscience issues, opinions have not merely remained stable, but science has lost ground. For example, a recent report from the Pew Research Center for People and the Press found that in 2011 substantially fewer Americans believed there is solid evidence of global warming than did so from 2006 to 2008. Furthermore, between 2006 and 2008, a higher percentage of people viewed global warming as a very serious problem than do so today. Of note to educators, the level of education was not a strong predictor of peoples' views on this issue (Pew Research Center 2011). And while public acceptance of evolution is generally high among prosperous nations, the United States stands out as an outlier among wealthy nations where only one in three adults think that evolution is true (Ipsos 2012; Miller, Scott, and Okamoto 2006). A study using data from the National Immunization Survey for the period from 1995–2001 indicated that children who received no vaccines were more likely to belong to households with higher income and to have a married mother with a college education than were children who were partially (under)-vaccinated (Smith, Chu, and Barker 2004; Omer et al. 2009).

In a study of exploring college students' pre-existing believes about science, 234 undergraduate students were asked whether or not they thought that the precautionary principle should be applied to global warming[1]. Interestingly, compared to the students who supported applying the precautionary principle to global warming, a greater proportion of students *opposed* to

[1] The precautionary principle states that scientific uncertainty should not be a reason to postpone measures to prevent harm.

applying this principle used scientific reasoning in support of their position. However, in their application of the data, they used ideologies constructed from their pre-existing beliefs to interpret the data. For example, some students acknowledged the data demonstrating that temperature and sea levels are rising, but personally minimized the significance or consequences of these changes (Mari and Jofre 2012).

These observations suggest that education alone-or at least our current approaches to education-has not been adequate to deal with what some have called a cultural war on science. Dan Kahan of the Cultural Cognition Project asserts that if we wish to persuade members of the public to accept empirically sound scientific information, we will need to do more than merely make the information available to them (Kahan and Braman 2006). Science educators are at the forefront of providing students with the scientific foundation necessary to develop the critical thinking skills required to assess complex sociocultural issues. What do educators need to address in their own teaching approaches to ensure that they are doing more than "merely making information available" to students?

There have been many teaching and pedagogical initiatives over the past several decades. Most departments have reformed their curricula, moving from traditional content-driven, lecture-based instruction to interactive classrooms, inquiry-based or thematic learning, research rich curricula, etc. However, these reforms may not have adequately explored or addressed the role of underlying culture, beliefs and values on students' receptiveness to scientific ideas. Since "anti-science" decision-making relies on underlying beliefs and values rather than scientific assessment, understanding the role of these underlying systems of belief may enable teachers to more effectively link science literacy to critical thinking, particularly in regard to controversial socioscience issues.

College professors are well educated in their specific disciplines; they are very good at teaching scientific and quantitative reasoning skills, but often have less experience or expertise to support and assist students as they negotiate controversial and often contentious topics in science. In particular, most professors lack training in understanding how cultural components can bias the views of both students and instructors, and the role of personal values in decision-making. This is crucial if we want to assist and support students in their development of scientific literacy skills needed to assess scientific claims. By definition, controversial socioscientific issues often include disagreements related to the various participants' diverging evaluations of the scientific claims involved (Kolso 2001). To understand this, we need to understand how student pre-existing attitudes and perceptions shape their evaluation of the claims.

Beyond Scientific Literacy: It's More Complicated than Content, Concepts, and Process

Yale University's Cultural Cognition Project has demonstrated that individuals of diverse cultural outlooks hold sharply opposed beliefs about a range of issues including climate change and public health. They conclude that differences in cultural outlooks are more important in shaping perceptions than any other individual characteristic including gender, race, socioeconomic status, political ideology, party affiliation, or *education* (emphasis added) (Kahan et al. 2007).

Of particular interest to educators who often direct or lead classroom conversations, is the finding that the leading factor that most impacts how individuals respond to arguments about risks associated with vaccines or climate change is the perceived values of the person making the argument, not the validity of the argument itself (Kahan, Braman, and Jenkins-Smith 2010). This corresponds to what Michael Shermer calls "in-group" bias in which we place more value on the beliefs of those whom we perceive to be fellow members of our group, and less on those from different groups (Shermer 2011, 275). For example, in a study of how teenagers made their decision on whether or not to be vaccinated against pH1N1 influenza, school (and specifically science education) was seldom used in the decision. Instead, students relied on the perceived opinion of their peer group (Lundstrom, Ekborg, and Ideland 2011). This is not unexpected for teenagers, who rely heavily on peers in decision-making (of note, most first-year college students are teenagers, so this bias should not be trivialized). However, Kahan et al. demonstrated this "in-group" bias also exists in adults (Kahan et al. 2007).

The most critical observation informing how we deliver scientific concepts to students is the finding that perceived values of the person making the argument impacted people not only when they were processing information about familiar and already controversial issues (such as climate change or vaccines). Notably, cultural world views played a critical role in determining how individuals assessed new, unfamiliar risks (e.g. nanotechnology) as well (Kahan et al. 2008). Kahan et al. concluded that polarization around a particular issue interacts strongly with the relationship between the subject's cultural worldviews and the perceived worldviews of the expert advocating the position. Extrapolating this observation to the student/professor relationship suggests that when delivering novel content or ideas to students, student perception of the instructor's values may not only impact, but may well be the *most important* criterion in determining how students assess new information; even more important than their perceptions of the instructor's scientific expertise. If this holds even partially true, it may offer a clue to the inadequacy of science literacy initiatives to significantly improve public perceptions and assessment of socioscience issues.

How Can We Understand the Impact of Student Values on Navigating Controversial Issues in Science?

How can we neutralize the tendency of our students to polarize along cultural lines as they assimilate and process information? We first need to acknowledge these cultural divides exist and appreciate the role they play in student learning. Science education has embraced the social-science intersection for decades. In 1971, the National Science Teachers Association Committee on Curriculum articulated an explicit goal of deliberate integration of science education within its social function (Zeidler 1984). Dewey's notions of the democratic classroom permeate much of our pedagogy and classroom culture. However, many of us may have not considered how a student's perception of the instructor's biases or values may impact their acceptance (or rejection) of scientific content or concepts, even within structures designed to encourage student participation and engagement with controversial issues. According to the work of Kahan et al., these perceptions are likely to have critical impact on how our students engage, discuss, and interpret what occurs in the classroom.

How can we begin to recognize and confront our own biases in the classroom? It is a rare instructor who would claim that raising controversial socioscience issues in the classroom is a neutral activity. While most would likely acknowledge that students' pre-existing values will inform their responses to these issues, we may be less likely to understand or even perceive the impact of our own values on students' thinking and responses.

To make things even more complicated, instructors must first acknowledge their own values and biases. It is tempting to think that, as scientists, we are immune to such dynamics; that we have empirical truths that can penetrate the public debate (if only the public would just understand and become enlightened). This human tendency to recognize the cognitive biases in other people, but be blind to their influence on our own beliefs has been termed "the bias blind spot" (Shermer 2011, 276). If we want to pursue an honest exploration of the role of values in science teaching and literacy, it is critical to acknowledge that even scientists are not immune to these dynamics (MacCoun 1998). Like everyone else, we rely heavily on our prior experiences and values when evaluating the reliability of new information (MacCoun 1998). Even though we come to the classroom as professional teachers, we do not leave our social identities at the door.

Does this mean that we should try to remove all clues of our values and biases from our teaching? Probably not. Even if total elimination of values, or truly "neutral" teaching were possible, most likely, it would not be desirable.

A recent study of characteristics of excellent teachers found that students tend to relate *all* aspects of teaching to their interactions with professors and their perceptions of the professors' respect and caring for them (Pattison, Hale, and Gowens 2011). This study evaluating 1,932 responses from undergraduate and graduate students found that students perceived almost everything their professor did as a reflection of the professor's respect and caring for them (e.g. class administration, course preparation and delivery, teacher motivation, and student interactions) (Pattison, Hale, and Gowens 2011). In short, even behaviors that we think are devoid of values, such as class administration and content preparation, are interpreted as reflecting our attitudes toward them. Reminding us of the adage, "excellent teachers do not teach classes, they teach students."

An example from this study that is relative to engaging socioscience controversy in the classroom was the observation that students want to be challenged by teachers; faculty who excel at this were highly regarded by students. However, if students interpret the dialogue as threatening or abusive, they dismiss the instructor's feedback (along with dismissing the instructor altogether) (Pattison, Hale, and Gowens 2011).

So where does this leave us? In summary, the following observations may be useful in guiding our further exploration of this important teaching conundrum:

- Current culture presents many examples of science-based decision-making and policy being co-opted by views that rely on underlying beliefs and values rather than valid scientific assessment.
- Despite initiatives promoting science education and science literacy, public perceptions (science literacy) with regard to controversial socioscience issues do not appear to have increased significantly. This observation suggests that our current approaches to education have not been adequate for dealing with the problem.
- Evidence of a "science literacy disconnect" whereby even though they understand the science, students assess controversial issues through their pre-existing cultural lens, reinforces the notion that pre-existing values may trump science instruction.
- Differences in cultural outlooks are more important in shaping perceptions about many controversial socioscience issues than are gender, race, socioeconomic status, political ideology, party affiliation, or education.
- Student perception of the instructor's values may not only impact, but may be the most important criterion in determining how students assess course content and information; even more important than their perceptions of the instructor's scientific expertise.
- A central characteristic of excellent teachers is student perception that professors respect and care about them. Students tend to relate *all* aspects of teaching to their interactions with professors and their perceptions of the professors' respect and caring for them.

All of this appears to leave us in a "Catch-22." Student perceptions of our values are likely to have a significant impact on our ability to educate them regarding socioscience issues. Nevertheless, we can't be "valueless" instructors, not only because we are human, but also because the values of caring and respect impact our teaching and are perceived in everything that we do in the classroom.

While admittedly complex, these apparently conflicting goals do not need to be mutually exclusive, or impossible to achieve. Moving past our current cultural stalemate around socioscience issues will require wider acknowledgement of the role values, beliefs, and biases play in teaching and learning. Science professors must admit that we, too, are human and not immune to personal and cultural bias. More importantly, we need to continue well-designed studies that explore, quantify, and evaluate the role of student and professor values in effective teaching and learning. Results of these studies should inform ongoing conversations regarding curricular reform, effective pedagogy, and faculty development, with the long-term goal of developing students capable of making informed policy judgments with respect to science and society while improving public understanding, views, discourse, and decisions regarding science.

REFERENCES

Herr, Norman. 2008. *The Sourcebook for Teaching Science*. http://www.csun.edu/science/ref/reasoning/critical_thinking/index.html.

Ipsos Global Advisory. 2012. "Supreme Being, the Afterlife, and Evolution." http://www.ipsos-na.com/news-polls/pressrelease.aspx?id=5217.

Kahan, Dan M., and Donald Braman. 2006. "Cultural Cognition and Public Policy." *Yale Law & Policy Review* (24): 147–169. http://ssrn.com/abstract=746508

Kahan, Dan M., Donald Braman, and Hank Jenkins-Smith, H. 2010. "Cultural Cognition of Scientific Consensus." *Journal of Risk Research*: 1–28. doi:org/10.2139/ssrn.1549444.

Kahan, Dan M., Donald Braman, Paul Slovic, John Gastil, and Geoffrey Cohen. 2007. "The Second National Risk and Cultural Study: Making Sense of-and Making Progress in-the American Culture War of Fact." GWU Legal Studies Research Paper No. 370; Yale Law School, Public Law Working Paper No. 154; GWU Law School Public Law Research Paper No. 370; Harvard Law School Program on Risk Regulation Research Paper No. 08–26. http://ssrn.com/abstract=1017189.

Kahan, Dan M., Paul Slovic, Donald Braman, John Gastil, Geoffrey Cohen, and Douglas Kysar. 2008. "Biased Assimilation, Polarization, and Cultural Credibility: An experimental Study of Nanotechnology Risk Rerceptions." Harvard Law School Program on Risk Regulation Research Paper No. 08–25. http://www.nanotechproject.org/publications/archive/yale2/

Kolso, Stein D. 2001. "Scientific Literacy for Citizenship: Tools for Dealing with the Science Dimension of Controversial Socioscience Issues." *Science Education* no. 85 (3): 291–310.

Lundstrom, Mats, Margareta Ekborg, and Malin Ideland, M. 2011. "To Vaccinate or Not to Vaccinate: How Teenagers Justified Their Decision." *Cultural Studies of Science Education* no. 7 (1): 193–221.

MacCoun, Robert J. 1998. "Biases in the Interpretation and Use of Research Results." *Annual Review of Psychology* no. 49: 259–87. doi: 10.1146/annurev.psych.49.1.259.

Mari, Stephanie M. and Ana Jofre. 2012. "Are Your Reasons Economic, Political, Personal, or Scientific? A Case Study Exploring College Students' Pre-existing Beliefs About Science." Paper presented at the Fourth International Conference on Science in Society, Berkely, California, November 15–17.

Miller, John D., Eugenie C. Scott, and Shinji Okamoto. 2006. "Science Communication. Public Acceptance of Evolution." *Science* no. 313 (5788): 765–6. doi: 10.1126/science.1126746.

National Academy of Sciences. 2012. "About Our Expert Concensus Reports." http://dels.nas.edu/global/Consensus-Report

National Science Foundation. 2012. "Science and Technology: Public Attitudes and Understanding." *Science and Engineering Indicators 2012*: 7.1–7.51.

Omer, Saad. B., Daniel A. Salmon, Walter A. Orenstein, M. Patricia deHart, and Neal Halsey. 2009. "Vaccine Refusal, Mandatory Immunization, and the Risks of Vaccine-Preventable Diseases." *The New England Journal of Medicine* no. 360 (19): 1981–8. doi: 10.1056/NEJMsa0806477.

Pattison, Patricia, Janet R. Hale, and Paul Gowens. 2011. "Mind and Soul: Connecting with Students." *Journal of Legal Studies* no. 28 (1): 39–66.

Pew Research Center. 2011. "Modest Rise in Number Saying There Is 'Solid Evidence' of Global Warming." http://pewresearch.org/pubs/2137/global-warming-environment-partisan-divide-

Shermer, Michael. 2011. *The Believing Brain*: *From Ghosts and Gods to Politics and Conspiracies-How We Contruct Beliefs and Reinforce Them as Truths*. New York: St. Martin's Press.

Smith, Philip. J., Susan Y. Chu, and Lawrence E. Barker. 2004. "Children Who Have Received No Vaccines: Who are They and Where do They Live?" *Pediatrics* no. 114 (1): 187–95.

Specter, Michael. 2009. *Denialism*. New York: Penguin Press.

Zeidler, Dana L. 1984. "Moral Issues and Social Policy in Science Education: Closing the Literacy Gap." *Science Education* no. 68 (4): 411–419.

ABOUT THE AUTHOR

Jill Manske: Jill Manske is a professor of Biology at the University of St. Thomas. Her research explores the intersections between immunology, infectious disease, and environmental/community health. Over the past twenty years she has served as a professor in an undergraduate biology department where she has been actively engaged in scientific literacy initiatives across a continuum from first-year non-science students to students engaged in upper-level science, technology, engineering, and math (STEM). Her academic endeavors have included direct interaction in the national discussion on science literacy and STEM education, as well as mentoring of graduate students and faculty, and serving as an external consultant to other college biology departments. Additionally, she has assisted faculty developing science curricula based on empirically validated teaching practices. Her experience at a religiously affiliated institution has provided experience and insight into students whose religious culture and views impact and influence their engagement with scientific concepts.

The International Journal of Science in Society provides an interdisciplinary forum for the discussion of the past, present and future of the sciences and their relationships to society. Journal articles range from broad theoretical, philosophical, and policy explorations to detailed case studies of particular intellectual and practical activities at the intersection of science and society.

The International Journal of Science in Society is a peer-reviewed scholarly journal.

ISSN 1836-6236

ISBN 000-0-00000-000-0