An Application of *The Two Cultures* to Environmental Education

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Abstract: Over the past few decades, it has become evident that the natural environment is an entity that humans need to better understand. Environmental education is defined here as the teaching and learning of, and about, nature and human interaction with nature. Traditionally, the environment has been researched and taught about in a piecemeal fashion – Studies and instruction in the sciences (hydrology, land cover, soil, atmosphere, etc.) were completely separate from social issues related to the environment. However, a new approach to conducting research has permeated environmental studies whereby a *systems* approach (or a more-holistic view) is utilized that combines ideas and approaches from the sciences and humanities. Some schools are beginning to implement this approach by organizing environmental curricula in a *systems* or holistic manner. This paper provides an application of C.P. Snow's ideas in thinking about how to develop curriculum and teaching strategies that transcend the piecemeal approach (and the corresponding cultures associated with each discipline) and provide a deeper understanding for students of not only the elements of the environment, but also the ways in which they interact and their relationship to social issues.

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C.P. Snow's Ideas from *The Two Cultures*

The Two Cultures is the title of an influential 1959 lecture by British scientist and novelist C.P. Snow. Its main argument was that the communication gap between the "two cultures" of modern society, science & technology and the arts & humanities, was a major hurdle in solving complex problems. As a trained scientist who was also a successful novelist, Snow was well positioned to expound on this subject. While many found Snow's lecture useful, his ideas also had their critics, with a common criticism being that Snow was acting as a "public relations man for the scientific establishment" (Cornelius & Vincent, 1964).

Snow (1998) characterized members of the arts and humanities culture as "literary intellectuals" while scientists, particularly physical scientists, were the major constituent of the science and technology culture. Snow's description of how the arts and humanities culture viewed scientists included words such as "brash" and "boastful." "Scientists are shallowly optimistic, unaware of man's condition" (p. 5). Arts and humanities members saw themselves as more "restricted" and "constrained." Scientists claimed "literary intellectuals are totally lacking in foresight, peculiarly unconcerned with their brother men, in a deep sense anti-intellectual, anxious to restrict both art and thought to the existential moment" (p. 5), whereas scientists saw themselves as "inclined to think that it can be done, until it's proved otherwise" (p. 7).

Some critics argue that Snow's description of the science and technology culture is written in a more positive light while his description of the arts and humanities culture focuses more on what it lacks than what it is. "The scientific culture really is a culture…Its members need not, and of course often do not, always completely understand each other; biologists more often than not will have a pretty hazy idea of contemporary physics; but there are common attitudes, common standards and patterns of behaviour, common approaches and assumptions" (p. 9). Snow claims scientists have "the future in their bones" (p. 10) and their culture "contains a great deal of argument, usually much more rigorous, and almost always at a higher conceptual level, than literary persons' arguments" (p. 12).

These statements contrast with his description of the arts and humanities culture where the "spread of attitudes is wider" (p. 10), and this culture "responds by wishing the future did not exist" (p. 11). He goes on to say, "Literature changes more slowly than science. It hasn't the same automatic corrective, and so its misguided periods are longer" (p. 8). [One can conclude that Snow views *nature* as the automatic corrective for the sciences.] Literary intellectuals "still like to pretend that the traditional culture is the whole of 'culture,' as though the natural order didn't exist" (p. 14).

One of Snow's conclusions is that due to the communication gap between the two cultures, "creative chances" to solve many complex problems that face the world are being missed. However, before looking at ways in which the cultures can come together, we need to further explore their differences.

Salient Components of the Arts & Humanities

The humanities include academic disciplines that focus on the study of the human condition using traditions that are analytic, critical, or speculative. Commonly, these include philosophy, history, literature, and language. Questions such as *What does it mean to be human?* are at the core of the humanities. These questions are explored from moral, spiritual, and intellectual perspectives. Over time the humanities have come to be seen as dealing with the "why" in human existence. In many ways, the sciences are viewed as working to determine the "how" and the "when" (Stevens 1953).

> The humanities are distinct from sciences and social sciences in being centered about the meanings of life to man as an individual. Their disciplines of research and subjects of teaching deal with his experiences and his expressions of self. His ideas and feelings are made known articulately in language, symbolically through all the arts, and with philosophical or historical concern for values as he turns toward the inner or outward meanings of human existence. All recorded signs of what man has found in himself and

> in the world about him are brought within the disciplines of the humanities, to be given form by scholars and teachers for use by all men in present and in future time (p. 1).

Many modernists propose that the study of the "great works" of literature and art can shed light upon fundamental questions of humanism. The use of a "great books" curriculum has been used to teach the humanities (Levi 1970; Stevens 1953).

Language

Language is a central component of the humanities. It is an individual's strongest and most flexible mode of self-expression by opening a direct path into the depths of one's personality. "The vocabulary of an individual tells at once who he is in point of thought and total experience" (Stevens 1953 10). Arguing over the meaning of words (like *culture* in the present example) is a common practice in the humanities. "And with good reason. Without agreement on meaning there can be no true discourse, no valid criticism" (Lepkowski 1980 21).

Levi (1970) also claims that language is critically important to the humanities. He maintains that if science is the study of nature, then the humanities are the study of the works of man. If science utilizes procedures that adhere rigorously to the categories of understanding, then the humanities emphasize those qualities which are contributed by the imagination. If science utilizes a language which is impersonal, referential, and objective, then the humanities cultivate a language which is dramatic, emotional, and drenched with human purpose.

> The relevance of this formulation to the problem of the two cultures is, I think, clear, for it suggests the uneasy mutual confrontation of the language of the understanding and that of the imagination. In terms like *true and false propositions, error, scientific law, causality, chance, prediction, fact, equilibrium,* and *stasis*, we have a series of concepts in what I will call "the scientific chain of meaning." In terms like *appearance and reality, illusion, destiny, free will, fortune, fate, drama, happiness, tragedy,* and *peace*, we have a series of concepts in what I will call "the humanistic complex" (p. 59).

However, according to Lengyel (1968), the rate of change of language in the humanities is very slow. He asserts that language refuses to absorb sudden changes to the point where the English speaking population of the 21st century understands Shakespeare, and Shakespeare would understand our language as well. However, the sciences have, since the time of Shakespeare, developed many new languages, such as a variety of computer languages that would be completely foreign to even the greatest scientific minds of even a few decades ago.

Values

Another central component of the humanities is values. Levi (1970) uses the old cliché of the sciences teaching facts and generalizations about facts while the humanities "teach values." He declares that values are the unifying principle of the humanities, or, "at the very least, that the humanities 'have to do with values,' is a proposition expressing almost universal agreement among professors of art, literature, philosophy, and history, in the learned journals of the humanities" (p. 34). The humanities are commonly seen as teaching values and judgment that reveals underlying wisdom. "They enable us *to ask and to answer* what it means to live well. From them we *derive* our notions of freedom, justice, and compassion" [emphasis in original text] (p. 35).

Philosophy

Philosophy represents yet another central component of the humanities. According to Stevens (1953), the philosophies that surround the lives and thoughts of humans are even more interesting than the compelling history of the human race. Studying philosophies allows one to "reflect on the most intimate states of human consciousness and to find himself in the thoughts of others. Far beyond all histories, philosophies represent personality. The individual himself is in them. They can show us the full scale of being, spiritually, intellectually, and emotionally. Philosophies therefore open the mind and heart to what is near at hand in oneself and in others" (p. 107). These philosophies are intricately embedded in human values.

Salient Components of Science & Technology

In many ways, science refers to a systematic methodology, with the goal being to collect accurate observations about natural phenomena and to organize these data in useful ways to make predictions, based on hypotheses used to develop experiments. The sciences can be broadly categorized as pure science (the collection of observations and the explanations of these observations) or applied science (the application of scientific findings to specific human needs), with academic disciplines that include life science, physical science, earth science, and space science. Empirical approaches based on data, models, logic, and reasoning distinguish the sciences from the traditions of the humanities.

The scientific method seeks to boil down the complexities of nature in replicable ways. Some consider it to be an “objective” process, whereby scientists strictly follow a procedure that must answer to nature and be able to be reproduced by others. Scientists attempt to minimize the influence of personal biases. “Human emotions are excluded as far as possible from scientific discipline” (Cornelius and Vincent 1964 92). The scientific spirit has been portrayed as “dynamic, optimistic, and humanitarian. Knowledge, for the scientific protagonists, is to be found in nature through scientific methods, not in literature through authoritarian tradition. This knowledge and the human virtues engendered by the scientific spirit are more appropriate for a modern, progressive world than those that the humanistic tradition yield” (Bieniek 1981 421).

A critical step in the scientific method is for a hypothesis to be developed. Hypotheses are contentions that are not yet well supported by data, nor have they been rendered false through experimentation. To make a hypothesis or a prediction that can be tested by observation or experiment, many scientists rely upon models, which are descriptions based on multiple observations and the patterns that have been identified from these observations. Through time and multiple experiments in a wide variety of contexts, these models and patterns may develop into a theory, a logical framework for describing the behavior of specific natural phenomena. It is common for a large number of hypotheses and several models to be bound up by a single theory. A theory can turn into a physical law when it has been tested to the point where it is determined to be fully verified.

However, scientists do not claim absolute knowledge about natural phenomena, but instead that knowledge is fluid. Scientific facts are true only by definition and are based upon agreed convention. For example, Newton’s laws of motion were taken to be scientific truths until Einstein’s work. According to Cornelius and Vincent (1964):

> For a long time physicists regarded Newton’s laws of gravitation as 100 percent so – Absolute Space, Absolute Time, Absolute Motion. Einstein’s principles of relativity shattered these absolutes. Newton was not wrong in terrestrial areas, but his laws did not always apply in astronomical areas. Einstein found a closer fit to the space-time world. Presently some genius may discover a still closer fit.
> Einstein’s work gives us a clear idea of three cardinal steps in exact science:
> First, he was worried and curious about the relation between matter and energy, and got together the knowledge already available.
> Second, he assembled his thoughts in the language of mathematics and came out with a startling hypothesis governing the conversion of matter into energy.
> Third, he proposed various experiments to verify the hypothesis, such as the bending of light rays as they passed the sun in an eclipse (p. 92).

Inductive processes are also a part of science, whereby science tries to say something about the world that is not true by definition, but can be shown to be true through specific examples of observation or experiment. However, through the use of this inductive process, a scientific theory is open to falsification if new, contrary data are collected. “Still, in the long run, a theory – no matter how beautiful or self-consistent – must provide predictions that conform to nature, or it will be discarded” (Friedman 1999 13).

It is critical in the scientific process to make every relevant step publicly available, which permits peer review and replication of published results. Ongoing review and experiment and observation replication by multiple scientists in multiple contexts operating independently of one another provides the ultimate test for scientific findings. “To fudge an experiment, to slant a conclusion, to report anything but the whole truth as one knows it alone in the night, brings ignominy and oblivion. There can be no secret processes, no patent medicines, no private understandings or payoffs on the side. The calculations must be laid on the table, face up, for all the world to see. In this sense, science is perhaps the most *moral* of all man’s disciplines” [emphasis in original text] (Cornelius and Vincent 1964 92).

Melding the Traditions

In the early 1960’s, it seemed implausible that the gap between the two cultures could ever be crossed. According to Michael Yudkin:

> There are three stages to Sir Charles’s argument: first, that there exists a mutual failure of contact and comprehension between scientists and non-scientists. Next, that this failure is at least unfortunate, and probably dangerous. Finally, he claims that it is possible to find ways of crossing this chasm of understanding, and that all efforts should be made to close the gap. The first of these propositions cannot be seriously doubted; for scientists and non-scientists to understand one another’s work requires a huge stretching of the intellect, and the effort needed becomes constantly greater. The idea that this is universally to be regretted has scarcely been disputed; but it is the conclusion of the argument – that it is possible to make a significant improvement in the intellectual relationship – that is open to the most serious criticism (Leavis 1963 53-54).

However by 1970, crossing this chasm did, in fact, seem possible. According to Levi (1970):

> We need to distinguish between (1) *subject matters*, (2) treatments of subject matter or *methods,* and (3) ultimate aims or *attitudes* in the practitioners who use these methods on these subject matters. In my opinion we shall have to maintain that there are no

> *intrinsically* scientific or artistic subject matters. There are only scientific or artistic *treatments* of subject matter. Thus it follows that as subject matter, such broad and general concepts as 'nature' or 'man' or 'society' are neither exclusively scientific nor humanistic in character. Wordsworth and Newton have provided the two alternative treatments of 'nature.' Rembrandt and Vesalius have provided the two alternative treatments of 'man.' Durkheim and Balzac have provided the two alternative treatments of 'society.' And it follows that these differences tend to be mirrored and perpetuated in the differing treatments of professors of English literature as against professors of physics, professors of art as against professors of anatomy, professors of French literature as against professors of sociology [emphasis in the original text] (p. 43).

As discussions and research continued, a growing belief that students should develop understandings of how science, technology, and society mesh with one another began to take hold. These understandings would include concepts, ideas, and ways of thinking from the humanities. Studies in Science-Technology-Society (STS) grew out of the social turmoil of the 1960's when many were questioning values in the United States. By the late 1980's, STS had been refined to descriptions of the interactions of science and society. At this time, Kenneth Keniston, chairperson of the STS program at the Massachusetts Institute of Technology, defined it as "a multidisciplinary enterprise…It is above all a project, and the center of the project is to try to somehow understand the complicated two-way relationship between science and technology on the one hand and the rest of culture-society-politics on the other. Getting smart about that relationship, seeing it and understanding it, and doing justice to its knowledge and complexity are the center of the project" (Lepkowski 1989 14). A National Science Teachers Association (1982) position paper proclaimed:

> The goal of science education during the 1980's is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use their knowledge in their everyday decision making. The scientifically literate person has a substantial knowledge base of facts, concepts, conceptual networks, and process skills that enable the individual to continue and learn logically. This individual both appreciates the value of science and technology in society and understands their limitation

The STS movement in the schools was supported by a closer look at how science was being conducted in the laboratory. An examination of revolutionary work in the sciences helped to challenge the paradigm that scientific thinking only occurred through the use of rigorous deduction and controlled inferences from empirical observation. There was now an appreciation for the role of imagination (a humanistic approach) in scientific work. The use of metaphors, analogies, speculation and intuitions (all examples of humanistic traditions) came to the fore. Some argued that these elements had always had their place in the scientific process. Thus in the 1980's through today, more has been discussed about the similarities of mental operations between the sciences and the humanities, even though some of the similarities seem to be rather strained (Collini 1998).

This shift in thinking about the work that occurs in the sciences has had a few watershed moments, none of which was more important than the Nobel Prize winning work on non-equilibrium thermodynamics by Belgian chemist Ilya Prigogine. An outcome from his scientific process was to shoot down determinist claims of classical science:

> In the 18th and 19th centuries, science became so all-powerful through its conceptual and technological successes that certain philosophers began believing that its techniques served as universal models for everything from the control of textile looms to the design of societies. Marxism represented the apex of this materialist philosophy based on the science of the machine. Discover the principles and the formulas, it said, and the results were foregone: a new man, a utopian society free of classes. In the West, behavioral psychology was most representative of this philosophy through the work of Harvard psychologist B.F. Skinner. The Skinner school said human beings could be programmed in more rational ways than society already programs them. As a result, evil could be erased in a couple of generations.
>
> Humanist philosophers, novelists, poets, artists, and theological thinkers scoffed at such extensions of science. But the current was powerful because science worked so well in so many domains. All humanists were distressed because they didn't have the proof to back up their intuition and common sense. Moreover, they themselves were victimized by growing "scientization" in their own fields, a form of physics envy.
> But now Prigogine comes along to tell them that on the basis of his work on non-equilibrium chemistry, nature can be seen as nondeterministic, that life is, in the end, a work of art, a fascinating novel with a surprise ending, unpredictable and exciting because the future cannot be determined…He says the state of non-equilibrium is the normal state of nature, not equilibrium as most of applied science has believed…Reversibility and determinism apply only to limiting, simple cases, while irreversibility and indeterminacy are the rule (Lepkowski 1980 23-24).

Prigogine's findings helped to meld the processes used in the sciences with ways of thinking from the humanities. More and more, individuals came to understand the importance of the humanities in the work of science. Imagination, analogies, speculation, and intuition that were once thought to be only useful within the realm of the humanities were now seen as vital in moving scientific thought forward.

Today, many problems and issues are related to the environment. Once thought of as only existing in the scientific domain, the solutions to many environmental problems may well lie within the central components of the humanities – language, values, and philosophy.

An Application to Environmental Education

Environmental education can be defined as “a lifelong learning process that leads to an informed and involved citizenry having the creative problem-solving skills, scientific and social literacy, ethical awareness and sensitivity for the relationship between humans and the environment, and commitment to engage in responsible individual and cooperative actions. By these actions, environmentally literate citizens will help ensure an ecologically and economically sustainable environment” (Fortier, Grady, Lee, and Marinac 1998 1). During the 1980’s and 1990’s, it became generally accepted that the ultimate goal for environmental education was to develop responsible environmental behavior or citizenship in individuals and societies. Numerous environmental educators have touted this goal (Boerschig and De Young 1993; Culen 2001; Hungerford and Volk 1990; Hungerford, Peyton, and Wilke 1980; Marcinkowski, 2001; Simmons 1991). The skills necessary to make informed, thoughtful, and generally “better” decisions about a myriad of environmental issues is of primary concern (Arvai, J. L., Campbell, V. E., Baird, A., and Rivres, L. 2004).

Many discussions have taken place as to how to go about helping individuals make “better” decisions. One strategy has involved improving technical knowledge (e.g., in biology, ecology, chemistry) as a means of creating favorable attitudes toward the promotion of better environmental quality (Ramsey and Rickson 1976). This strategy is based on the premise that in some ways, technology has caused many of the environmental problems we face today, but, ironically, technology is also our best chance of finding solutions to these problems:

> What gets forgotten in the more sweeping and alarmist complaints about technology’s harmful impact on the environment is the fact that it is precisely further scientific advances that have enabled us to identify and analyse many of these effects (the hole in the ozone layer provides one obvious example here). The more positive, and realistic, response to such problems is surely to recognise that the capacities that have produced threatening technologies are also our best hope of producing benign ones (Collini 1998 lxiii).

However, an increase in technical knowledge (or *power* knowledge, as some describe it) does not always yield the anticipated results. We can all think of examples where an individual had all of the facts before him, yet still chose poorly when faced with a crucial decision. Bieniek (1981) claimed that there has been “an increase in the acquisition of ‘power knowledge’ – knowledge that gives us the ability to do something or understand the mechanism of something, whether it be in the realm of nature or of man. What the humanistic culture has found objectionable is that there has been a decrease, rather than an increase, in the development of ‘wisdom knowledge’ to help humans cope with their greater power knowledge” (p. 422).

A complementary strategy is to include elements that address the need for knowledge about both natural systems and “action” (i.e., decision-making) skills (Simmons 1991). As Volk and Cheak (2003) profess, “Environmental literacy demands critical thinking and effective decision-making skills. Individuals must be able to weigh sides of an issue and to make informed responsible decisions” (p. 23). These decisions will undoubtedly be influenced by the individual’s beliefs and values.

The humanities come into play when the discussion turns to fostering new beliefs and values related to major environmental issues, such as global warming. Without this paradigm shift to an ecological worldview, many environmental educators see little progress being made. Swanson (1974) stated that humans’ value systems have brought about changes in nature and its meaning which neither nature nor humans can easily accommodate. Crises of both an environmental and a spiritual nature have been inevitable. Swanson goes on to assert that the method for finding solutions to environmental problems and humans’ adaptations to our way of life in an environment that is finite in space and resources must be a humanized one. The image of a critically thinking, problem solver is derived as much from the humanist as it is from the scientist.

There has been a call by many environmentalists for a modification of some people’s basic values, principles, and attitudes toward nature (Devall and Sessions, 1985; Drengson, 1980; Engel, 1993; Goldsmith, 1988; Naess, 1990; Passmore, 1995; Rojas, 1994). It has been suggested that a deliberate transformation of the current paradigm is needed to a new ecological worldview “that would embrace the intrinsic value in nature. Such a change in attitudes could promote the holistic conservation of nature rather than the preservation of only those parts of the environment that have utilitarian values placed upon them by humans” (La Trobe and Acott 2000 12).

As Weber, Hair, and Fowler (2000) assert, “Society constructs its view of the environment and of environmental problems within the context of its cultural values and its social and political norms” (p. 28). In fact, it has been argued that environmental perceptions and feelings are often more prevalent than factual environmental information in both adults’ and adolescents’ minds (Szagun & Pavlov, 1995). “Experts also indicate that, to change an individual’s behavior, knowledge about the environment must be associated with environmental sensitivity, personal beliefs, and decision making and problem-solving skills.” (Morrone, Mancl, and Carr 2001 33)

By requiring instruction in natural resources and humans’ interactions with these resources in not only elementary and secondary schools, but also teacher preparation programs, many states have laid the groundwork for an environmentally conscious and responsible citizenry. Due to the fact that environmental education is inherently interdisciplinary, efforts to define discipline-centered content and process standards have fallen short. In its place, an approach that captures the essence of both traditions from the humanities and the sciences is needed.

> Interdisciplinary training has been proposed as one way of overcoming the handicaps of specialization. Presumably this is intended to go beyond the mere borrowing or absorption of concepts, theories, and methods that regularly goes on among the disciplines. Rather it implies the need for training scholars in more than one discipline. With the subdivision of the disciplines into so many specialties, however, it has proved difficult for one person to learn even one discipline comprehensively, let alone two. Learning more than two would be beyond the pale for scholars of all but the most exceptional intelligence…Nonetheless, in the last several decades fields have grown up based on the premise that training in multiple disciplines will provide for the insights, knowledge, and skills required for coping with various kinds of practical problems facing the world (Easton 1991 13-14).

Students are taught how to think, not what to think. This means that particular stances toward environmental issues (such as hunting, recycling, industrial pollution, etc.) are not advocated one way or the other by instruction. Instead, an approach that is similar to the one used in Wisconsin is common. It consists of:

A. *Questioning and Analysis* – Students learn to pose interesting environmental questions that can be explored.

B. *Knowledge of Environmental Processes and Systems* – Students learn facts, concepts, and principles about individual components of the environment, how they interact, and interrelationships among natural systems.

C. *Environmental Issue Investigation Skills* – Armed with a question and some background knowledge, students learn the processes and skills involved in systematic queries into the environment.

D. *Decision and Action Skills* – Students use the findings from their environmental issue investigations to make a decision. The findings are balanced with the students' value system and both cultural and sub-cultural norms.

E. *Personal and Civic Responsibility* – Based on their decision, students take action (or not). This step develops an understanding and commitment to environmental stewardship.

It is quite evident that while traditions from the sciences (generating a researchable question, science knowledge, investigation skills) pervade this approach, so too do traditions from the humanities (ultimate decisions and actions based on values and norms, understanding of how one interacts with nature).

Environmental Education Examples That Meld the Two Cultures

An Undergraduate Program at a University

In addition to examples of integrated units from elementary schools (see Coskie, Hornof, and Trudel 2007 for an example of integrating environmental science and writing and McDuffie 2007 for an example of integrating precipitation and fine arts), there now exists an undergraduate degree program at Virginia Tech University in Humanities, Science, and Environment based on an interdisciplinary approach to environmental issues. It integrates cultural, political, and scientific approaches to help its graduates understand the relationship between people and the natural world in historical and contemporary contexts. In particular, emphasis within this program is placed on developing an understanding of the role of science and technology in shaping the interactions between humans and the environment. Not only are students required to go beyond introductory level coursework to develop these understandings, but they are also required to complement their scientific and technical understandings with knowledge of related humanistic perspectives, such as the role of cultural beliefs, religion, literature, and ethics in shaping the relationship between humans and nature. Virginia Tech's program is consistent with the call for "greening the college curriculum," in which suggestions are proposed to professors for including environmental concepts and issues into their liberal arts classes, including religion, philosophy, and literature courses (Collett and Karakashian 1996).

Within this program and others like it at either the university or secondary school level, global warming is a topic of discussion. A familiar adage is "There are two sides to every story." In the realm of global warming, there are many sides to this story, including personal, political, corporate, and scholarly views. One unique teaching strategy in a unit on global warming put forth by Meyer (2007) is to help students understand the origins and arguments of multiple perspectives. Students learn to sort fact from opinion and valid arguments from convincing untruths. After exploring the pros and cons of multiple perspectives, students are in a position to develop their own perspective, based on valid, defensible reasoning while also rebutting other perspectives. Once their own perspective has been developed and evaluated by the course instructor, students are asked to create a compelling argument against their view. This is difficult for many students to do, but this exercise causes the students to put themselves in another person's place and explore the world from this perspective, which is an approach with many humanistic overtones.

Contextualizing in a Humanities Course

British humanities professor Jan Oosthoek found that his students avoided science to study "real world" issues. With global warming and other environmental problems becoming real world issues, he determined that his humanities students needed to be educated on "the intricacies of climate change, ecosystem functions, toxicology, and other areas of environmental research." However, by and large, humanities students lack the scientific understandings and frameworks for investigations that underlie these issues (Schlosberg & Sisk, 2000). Oosthoek's own students claimed that having large complex scientific ideas presented as singular concepts without providing any context made it difficult for them to grasp the full meaning of the idea and develop a deep understanding.

Thus, Oosthoek decided to teach science embedded in narratives. While teaching environmental history, "complex scientific concepts were embedded within different historical topics and linked to debates. The science was embedded in narratives." The result was a much more positive response, and the students engaged much more actively with the issues than they had in prior topics. Oosthoek surmised that science has to be humanized in order to connect it to the "real world problems" that interest humanities students. He found a huge difference between contextualizing science and conceptualizing it. "Contextualizing is a method of embedding people, artifacts, places, animals, etc. in the fabric of time, culture, and space. It is a vehicle for humanizing knowledge in a humanities type inquiry." The humanities can form an interface for interdisciplinary inquiry. For example, the environmental history topic "uses time, space, culture, environment, and history as vehicles of integration (history and environment as context) and crosses over into the realm of science."

Physical data and observations are conceptualized in science by abstracting them to their "mathematical or other formalized form or empirical core and linking this to general underlying patterns and processes, sometimes referred to as laws or principles." Nikitina (2002) described conceptualizing as stripping the real world events and processes from the context that humans need to understand, and give meaning to, the world in which they live. Oosthoek concluded that "science can be humanized by stripping concepts of mathematics and abstract notions and transform them into narratives which makes it possible to integrate into humanistic discourse."

Oosthoek's findings are consistent with the work on integration by Ashmann, Zawojewski, and Bowman (2006). These researchers found a useful framework for thinking about how the sciences and the humanities could be integrated within the same curriculum. They used four different examples of how a curriculum can be integrated:

Co-existence – The sciences and humanities portions of the curriculum are discrete entities. For example, the curriculum may call for the discussion of science elements one week, humanities elements the following week, and so on.

Co-mingling – The topics discussed in the curriculum include both humanities and science, but each remains a discrete entity within the curriculum. No connections are made between elements from the humanities and elements from the sciences.

Competition – Individual ideas from the humanities and the sciences within the curriculum are selected and presented as being the most fun, the most efficient, or the most engaging. In such a situation, the sciences and humanities compete with one another for time in the curriculum.

Context – Topics in the curriculum include both humanities and the sciences, but each is seen only as a context for teaching the other. Science concepts may be embedded with personal stories that are explored, while evaluative judgments may need to be made while discussing the pros and cons of contemporary science topics, such as genetic engineering.

Each of these strategies has its advantages and disadvantages. Careful consideration must be given when choosing the appropriate strategy so that learning can be maximized. This is a topic-dependent decision made by an instructor who also considers the prior knowledge and experiences of the students in the class before choosing the optimal strategy.

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