WOMEN SCIENTISTS' SCIENTIFIC AND SPIRITUAL WAYS OF

KNOWING

by

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Chapter 1: Introduction

Developing scientific literacy through a curriculum linking "academic science to

the lifeworld of the student" is the historical purpose of science education in the United

States (Hurd, 1998, p. 407). Various ideas have defined and redefined science education

visions (DeBoer, 1991), and continue to play a role in the power/knowledge relation to

determine what science knowledge is to be taught (Roth, 2010). Because "emotion has

been viewed in Western philosophy as a hindrance, a countenance to reason, truth and

objectivity" (Alsop & Watts, 2003, p. 1044), school science has most often emphasized a

science that is distant from other ways of knowing. For this reason, school science may

reflect a "narrowly conceived notion of knowledge and the role knowledge plays in an

individual's life" (Cobern, 1996, p. 579) and less the way individuals come to wonder

about the natural world, know the natural world, or pursue science.

Science for All Americans (AAAS, 1990) identifies basic science, mathematics,

and technology to prepare the next generation. In addition to outlining understandings

and habits of mind, the authors state that science education should "promote aesthetic

responses" such that

> … a scientific understanding of say the formation of the stars or the blue
>
> of the sky, or the formation a human heart should not displace the
>
> romantic or spiritual meanings of such phenomena…Teachers of

mathematics, science and technology should establish a learning

environment in which students are able to broaden and deepen their

response to the beauty of ideas, methods, tools, structures, objects, and

living organisms. (AAAS, 1990, p. 204)

Integrated knowing and science education

An integration of the cognitive, aesthetic, affective, and spiritual knowing is not

new to education. Efforts to include the affective domain as necessary to learning have

been essential to the teacher prepared experiences that encourage full interaction between

a child and his/ her environment.

The education which a good mother or a good modern teacher gives today

to a child who, for example is running about in a flower garden, is the

counsel not to touch the flowers, not to tread on the grass; as if it were

sufficient for the child to satisfy the physiological needs of his body by

moving his legs and breathing fresh air. But if for the physical life it is

necessary to have the child exposed to the vivifying forces of nature, it is

also necessary for his psychical life to place the soul of the child in contact

with creation, in order that he may lay up for himself treasure from the

directly educating forces of living nature. (Montessori, 1964, p. 155)

While the work of Montessori, "Piaget and Vygotsky accent the significance of affect, it

is the cognitive reservoirs of their work… that informs much contemporary theorizing in

our field [science education]" (Alsop & Watts, 2003, p. 1044). And yet, one study

showed that ninth grade students did not focus on the cognitive but saw the natural world

as a composite of different perspectives, discussing the "aesthetic, conservationist,

religious, and sometimes scientific" perspectives (Cobern, Gibson, & Underwood, 1999, p. 559). Science education's cognitive focus, to the exclusion of other ways of knowing, may devalue aesthetic, affect, and spiritual ways of knowing in school science while student frameworks may integrate and value them.

Science for All Americans describes science as a way of knowing fundamentally different in the processes of observing, experimenting, thinking, and validating such that ideas about the physical, biological, psychological, and social worlds are comprehensive and reliable (AAAS, 1990). Bias from "the investigator, the sample, the method, or the instrument may not be completely avoidable in every instance, but scientists want to know the possible sources of bias and how bias is likely to influence evidence" (AAAS, 1990, p. 7). Post-modern philosophies question if humans can remove their lenses of "political and personal values, beliefs, and knowledge that have shaped how we perceive the world" (Richmond, Howes, Kurth, & Hazelwood, 1998, p. 898). Still, scientists are described as being alert to the possibilities of "bias in their own work as in that of other scientists, although such objectivity is not always achieved" (AAAS, 1990, p. 7). Science values objectivity, attempts to eliminate personal bias, and focuses on empirical evidence.

Science places value on objectivity over subjectivity and does not address questions about life's purpose, life's meaning, the supernatural (AAAS, 1990) or afterlife. Still, over 71% of 1,700 elite career scientists in the United States agreed "there are basic truths in many religions" (Ecklund, 2010, p. 150). Over half of the scientists identified with a religious group, and 40% considered themselves nontraditionally spiritual, trying to "integrate their spirituality with their science" (Ecklund, 2010, p. 150). In addition, the majority of atheistic scientists were not anti-religious, many were

members of houses of worship and thought that "key mysteries about the world can best be understood spiritually" (Ecklund, 2010, p. 150). It would serve science education to explore and understand how scientists view other ways of knowing, and how scientists who self identify as spiritual integrate scientific knowing with spiritual knowing.

Challenges to the Disconnected Knowing of School Science

Evolution. Examples of disconnect can be seen at several levels. One persistent issue in science education lies in scientific explanations of how humans came to be. Antievolution groups persistently attempt to alter the science curriculum to include the creation story, consequently "evolution's rightful place in the science curriculum has not been attained" (NSTA, 2000, p. viii). Resistance to scientific explanations is not limited to antievolution activists, recently 75% of public poll respondents chose modern science's explanation for the origin and development of humans when the processes were attributed to God (Gallup, 2010). Conflicts with the teaching of biological evolution are not foreign to biology classrooms, 60% of high school biology teachers studied were "neither advocates for either evolutionary biology or nonscientific alternatives" (Berkman & Plutzer, 2011, p. 404). An advanced degree does not foster an acceptance of evolution in teachers with a belief conflict, twelve of forty-eight in-service teachers earning a master degree in mathematics and science education perceived their beliefs as incompatible with the teaching of evolution. Teacher explanations were dominated by a creationist point of view that claimed the "biblical explanation for the origin of species as having a higher level of acceptability and plausibility than the scientifically based explanation of evolution" (Nadelson & Nadelson, 2010, p. 852). The role of God in human origins, as opposed to scientific explanations that exclude God, seems to be at the

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heart of the creation vs. evolution debate. Each side attempts to privilege one way of knowing over the other.

  Gender. Another ongoing challenge lies in gender differences with respect to science attitudes, achievement, learning preference, doctorates earned, and employment. Historically males have shown more positive science attitudes and a higher yearly science academic achievement as compared to females, with the disparity continuing to increase through secondary school (Bacharach, Baumeister, & Furr, 2003; Brotman & Moore, 2008; Osborne, Simon, & Collins, 2003; Weinburgh, 1995). While psychological studies show that on average males have a stronger interest in systemizing and females have a stronger interest in empathy, "the primary causes of the gender gap in academic science and mathematics, we suggest, are social and historical rather than genetic and psychological" (Sommers, 2009, p. 25). Female students in one study provide reasons for their low interest in science, describing science as without morality and a human element, about a world devoid of people (Belenky, Clinchy, Goldberger, & Tarule, 1986), while others describe science as an "uncaring, passionless, and even violent discipline" (Miller, Blessing, & Schwartz, 2006, p. 377). These negative perceptions of science may be due to female students' learning preference for personal and cooperative connected knowing described by Belenky et al. (1986) where belief is valued over doubt and theory is tied to experience. The alternative to connected knowing is separate knowing, an impersonal and often adversarial approach based on objective reasoning (Belenky, et al., 1997). According to Lundeberg and Moch (1995) separate knowing is valued over connected knowing in science classes.

Females who do choose to study science select people-oriented majors at a higher rate than their male peers (Miller, et al., 2006). Doctorate degrees earned by women seem consistent with a people-oriented preference; women earned 50.6% of biological sciences, 61.3% of anthropological, and 72% of psychology doctorates in 2008. Women were least represented in physics, engineering, and earth sciences, earning less than 20% of the doctorates in each (NSF, January 2009). The impact of women on science education has never been greater, of all scientists and engineers employed at educational institutions from preschool to university research institutions, 60% of positions are held by women (NSF, January 2009). Gender differences in science attitudes, achievement, learning preference, degree earned, and employment warrant further study to understand how women become interested in science, how women learn school science, and how women choose a career in science and science education.

General Statement of the Problem

School science divides wondering about nature from aesthetics, affect, and spirituality using an artificial barrier that may not represent how individuals come to science, individuals learn science, or the ways of knowing of scientists. If the goal of science education is to develop scientifically literate citizens who may become science teachers and scientists, then educators should understand how to link the "academic science to the lifeworld of the student" (Hurd, 1998, p. 407). It would be informative for science education to hear women scientists describe how they came to science, the relationship between their science and spiritual ways of knowing, and the science they portray in their teaching.

Significance of the Study

Focusing on female career scientists who teach, this study adds a new dimension to science education studies and studies of spiritual and scientific ways of knowing. This study extends the research on women in science, by examining the life experiences that lead spiritual women to pursue a career in the natural sciences; it adds to the current body of knowledge regarding the relationship between scientific and spiritual knowing, and explores how spirituality may inform science teaching. This study may promote dialogue regarding; 1) the paths to science through connected and separate knowing, 2) the relationship between the cognitive and affect aspects of learning and knowing, 3) the relationship between knowledge, purpose, and meaning, 4) the nature of women's science knowing, and 5) how ways of knowing are portrayed in science teaching.

Research Questions

This study explores women scientists who maintain a strong spiritual position as they pursue and apply scientific answers to questions about the natural world. The aim of the study is to understand how these women came to science, how they relate science and spiritual knowing, and how their science and spiritual knowing may inform their science teaching. The specific questions that guide the research are:

1) How do women scientists come to science?

2) How do women scientists relate spiritual and scientific knowing?

3) How do women scientists portray spiritual and scientific knowing to others?

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Definitions of Terms

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For the purpose of this study the following definitions will be used.

Case: unit of study is the individual, the spiritual woman of science

Doctrine: code of practice of a religion, dynamic, interpreted by individuals

Dogma: code of practice of a religion, static, interpreted by authority

Faith: trust and commitment in self, others, and the Sacred or the Divine beyond evidence

Sacred text: writing which a religious tradition considers central to the foundation of the tradition, often believed divinely revealed or inspired

Science: the knowledge resulting from a process of scientific knowing, and scientific research

Scientific knowing: how scientist's come to know, may result in furthering scientific knowledge and scientific understanding

Spirit of All That Is: Spirit, or spirits (plural), Sacred, vast, mysterious, imminent and alive transcendent life force and power through which some Native Americans relate to the physical/ spiritual world (including Anna)

Spirituality: sense of connectedness with something non-physical such as the Sacred, the Divine, a deity, Spirit of All That Is

Spiritual knowing: the way, path, ritual, or practice leading to connectedness with the Sacred, the Divine, a deity, Spirit, or supernatural

Religion: all cumulative traditions of faith, a group structure to spirituality, a community with shared basic beliefs regarding the Sacred, the Divine, may share a sacred text such as the Bible

Chapter 2: Review of Literature

This study's purpose is to understand how women scientists who self identify as holding a strong spirituality came to science, how they relate science and spiritual knowing, and how they portray science. To place this study within the context of the relevant literature, this review begins with an overview of the views of science to better understand the beginning of science and the modern views of Western science. The second section is a review of the major theories of knowledge development with subsections on personal construction, social construction, and conceptual change. An overview of current theories regarding intellectual, ethical, and moral development is found in the third section. The fourth section presents views regarding faith, religiosity, and spiritual development over the lifetime. Included in the fifth section is an overview of women's moral development and women's ways of knowing. The last section reviews the diverse paths of women to a science career.

Views of Science

Early Western science was influenced by Aristotle, who saw reality in a physical world that was knowable by observational experience, from the outermost heavens with Earth at the center. Providing a philosophical, and observational framework for the study of the meteorological and biological, Aristotle laid the foundations for natural philosophy (Lindberg, 2007). Rediscovered and accepted in the Middle Ages, Aristotle's natural philosophy became the official philosophy of the Roman Catholic Church despite his views of an eternal cosmos without a beginning or end having conflicts with the story of creation. Francis Bacon reconciled Aristotle's natural philosophy with Christianity using the utility science could provide to theology, effectively smoothing natural philosophy

into a natural theology based in induction and empiricism. Astronomy aided the development of the religious calendar, articles of faith in nature guided scriptural interpretation, and nature provided ways to convince unbelievers. As per Bacon, "theology directs the sciences to their proper end" so that together science and religion functioned as a single wisdom (Lindberg, 2007, p. 236).

Bacon outlined a scheme for classifying knowledge as history, poesy, and philosophy linked to the faculties of the mind (memory, imagination, and reason). He posited history as facts or factual events of the past, poesy as that which could be imagined, and reason as that which could occur or theoretically occur. In doing so Bacon effectively elevated the reasoning of natural philosophy and natural theology over the humanities (history and the arts). Natural theology under Bacon's structure, should build stepwise from one axiom to the next, each one being tested against nature through the processes of observation and experimentation. Following such a path the wall of scientific knowledge could be built brick by brick, where one negative would not collapse all previous knowledge but instead guide each inquiry in the direction of truth. Over time through a uniform progression, scientific knowledge would become increasingly more accurate (Lindberg, 2007).

Contrary to Bacon's uniform building of science knowledge, Thomas Kuhn (1962) described the enterprise of science based on the study of science history. According to Kuhn, science progresses both through normal science and scientific revolutions. Normal science proceeds within a paradigm of questions addressing only those problems perceived as having solutions. In this way, normal science research works within the boundaries of the puzzle, with many scientists working as 'puzzle-builders'.

Viewpoints, preconceptions, theories, laws, and procedures consistent with the paradigm (puzzle rules) are developed and maintained. In time, anomalies emerge provoking researchers to question the assumptions, beliefs, or practices of the paradigm. Conflict arises within a paradigm promoting a scientific revolution, a shifting away from the current paradigm toward the justification and shaping of a new paradigm. Through Kuhn's historical and relative lens, science is a social enterprise where nature's anomalies provoke changes in thought. Theories in science are humanly constructed representations bounded within the thoughts of the prevailing paradigm.

Modern science today is founded on a scientific worldview that assumes a consistent and predictable world where systematic study reveals patterns. Limited to questions that can be answered and tested against nature's empirical evidence, scientific knowledge is produced through observing natural events, testing hypotheses, and developing theories. Being durable, yet tentative, science can be changed toward increased accuracy. Science is a human enterprise for extending understanding, not unalterable truth from absolute authorities. The body of Western scientific knowledge is the collected and constructed human representations of observed evidences, tested against nature, and accepted by the Western scientific community.

Views of Knowledge Development

Personal construction

Jean Piaget observed and interviewed children as they played, interacted, and performed tasks, using their words and behaviors as evidence to explain how their minds worked. In Piaget's theory of cognitive development, new knowledge is individually constructed through a process of reorganization of experiential knowledge during the

stages of maturation (Piaget & Inhelder, 1966/ 2000). Prior knowledge, concepts, and skills are influential in the acquisition and arrangement of knowledge. Piaget's stages of an individual child's cognitive development increase in complexity from newborn infant into adulthood. In the first stage, sensori-motor, infants actively work to learn and distinguish themselves from the rest of the physical world. Infant perception is limited to the first person, they as if objects out of view cease to exist. The development of object permanence was a milestone toward understanding the separate and permanent existence of objects and themselves. Toddlers and young children in the second stage, pre-operational, use language and pictures to represent objects and find it challenging to see situations through an alternative point of view. While viewing a model mountain, children were asked what a person across from them sees. They respond by describing the mountain from their own point of view. Children at this stage may see an intact cookie as a lesser amount than a cookie broken into two pieces. In the third stage, concrete-operational, the older child and preteen are capable of logically thinking through situations of conservation of mass, number, and amount. The water poured from a tall cup into a short cup is logically understood to be the same amount of water. Ten marbles placed to form a short line are noted to be the same amount as ten marbles spread farther apart to form a longer line. In the last stage, formal operations, the teenager and adult understand abstract propositions used to test hypotheses. The formal operational thinker has the depth of reasoning to understand the validity of a logical argument as independent of factual truth.

Piaget (1975) described the process of equilibration, whereby an individual becomes dissatisfied with his current thinking through cognitive conflict. In order to

restore balance the individual must adapt the new knowledge or his internal framework. Assimilation occurs when the new experience is changed such that it fits with existing knowledge. Accommodation occurs when the framework or mental concepts of prior knowledge is changed to fit the incoming knowledge. Together accommodation and assimilation relate to restore balance through equilibration, thus resulting in learning (Sugarman, 1987). Piaget described a learning process whereby new knowledge interacts with existing conceptual frameworks. New knowledge may force existing frameworks to be changed, or new knowledge may be recast to fit into existing frameworks.

Social construction

According to Lev Vygotsky's theory of social cognition (Vygotsky, 1934/1986), knowledge construction is an active process influenced by social interactions within the historical, social, and cultural context. The tools of a culture in the form of language, diagrams, symbols, and writing are the means or processes of thinking within the context of the culture. A child grasps at an object out of reach whereby the consequent reaction of another gives the grasping action the meaning of pointing. In this way, "the grasping movement changes to the act of pointing" (Vygotsky, 1935/1978, p. 56) to the other person and in the mind of the child. A child can learn beyond his ability with the encouragement and probing from a more learned other. Learning takes place in the zone of proximal development, the distance between the child's ability on his/her own as compared to his/her ability with guidance from a more knowledgeable other (Vygotsky, 1934/1986). Rather than cognitive development proceeding universally through age-related stages as per Piaget, Vygotsky emphasized the influence of culture and language as critical for developing inner thought and outward communication. In this way,

cognitive development proceeds by way of language through social interactions with more knowledgeable others, all taking place within the context of the culture.

Together Lev Vygotsky and Alexander Luria (Cole, Levitin, & Luria, 1979/ 2006) studied illiterate and unschooled individuals living in remote villages of Uzbekistan, groups that previously had been described as having loosely organized, pre-logical or primitive thought. These conclusions were "discussion[s] being conducted without the benefit of any appropriate psychological data" (p. 59). Through interviews and discussions with individuals from remote groups differing in activities, language, and culture, Vygotsky "discovered a shift in the organization of people's cognitive activity that paralleled the changes in the social organization of their work lives" (Cole, et al., 1979/2006, p. 64). A solid circle and a partial unfilled circle were not viewed as being alike, contrary to the universal laws of perception based in Gestalt theorists. Peasants did not see the likeness of the symbols to the geometric class of circles, but classified the symbols according to attributes of the concrete objects, a coin and the moon. The conclusion was drawn that the language and practical uses of objects determined the way individuals thought about the world. Thought was the product of social interactions using cultural tools such as gestures, language, and symbols.

Conceptual change

During the 1970's and 1980's the work of Piaget was highly influential in science education, providing a framework to study learning as the development of scientific conceptions. Synthesizing ideas from Piaget and Kuhn, learning science was seen as a process of conceptual change (Posner, Strike, Hewson, & Gerzog, 1982). Analogous to scientific enterprise, conceptual change begins as conflict within the paradigm,

effectively moving the learner toward accommodation or paradigm shift. From this viewpoint, the work of teachers becomes one of providing the conditions to promote the accommodation and assimilation of new concepts into a student's existing schema, effectively provoking conceptual change. In order for a learner to accept a new conception, learners must become dissatisfied with existing conceptions such that the new conception is not only intelligible and appears initially plausible, but also suggests fruitfulness (Posner, et al., 1982). The nature of an individual's conceptual ecology is critical to the possibility of moving toward conceptual change. A conceptual ecology can be described based on three aspects: 1) epistemological commitments in the form of successful explanations and what is accepted as knowledge, 2) metaphysical beliefs about science and the concepts of science, and 3) other knowledge from fields or competing concepts. A learner accepts a new conception in place of his/her prior conception if it can be seen as an improvement over his/her prior conception and it is compatible with his/her conceptual ecology. Metaphysical beliefs are a critical aspect of conceptual ecology, they makeup the cultural lens from which a learner views and handles new knowledge.

Views of Intellectual, Ethical, and Moral Development

Intellectual and ethical development

William Perry and his staff interviewed mostly male undergraduates at Harvard and other elite universities in the 1950's and 1960's. Through an analysis of these interviews Perry developed a scheme of intellectual and moral development presented in *Forms of Intellectual Development in the College Years* (Perry, 1999). Perry claimed that college students journey through a progression or evolution of intellectual development marked by four major changes with variations, laid in out in nine positions. The positions

and transitions of Perry's theory are based on the student's attitude or stance with respect to knowledge and the process whereby meaning is made through lived experiences. Data were obtained by seeking evidences of current positions and inferences or reflections of previous transitions. Being less like stages and more like developmental transitions, the scheme reflects a dynamic nature of growth in interpreting the world, the self in reference to knowledge, themselves, and their role in the world.

Simple Dualism. Perry's initial major category is divided into Position 1- Basic Duality and Position 2- Multiplicity Pre-Legitimate. In Position 1- Basic Duality answers are right or wrong, known to authorities, and problems are solvable through conformity or seeking what is wanted. Answers are either derived from authorities undifferentiated from absolutes or derived from authorities that obtain answers through absolutes. A freshman male describes attending his first lecture, "what the man said was just like God's word, you know. I believed everything he said, because he was a professor, and he's a Harvard professor, and this was, this was a respected position" (Perry, 1999, p. 68). Knowledge is truth, viewed in polarities, conveyed by way of transmission from important authorities. Position 2- Multiplicity Pre-Legitimate is the second position of the initial category Simple Dualism, where multiplicity is unreal or alien. Some authorities have conflicting answers to problems, answers are unknown such that "inner voices" are trusted over authorities. A sophomore expresses his resentment in having to take required courses,

> Nobody in the world is less interested in natural sciences than I am. I don't
> want to know a thing about it…Well, for some people I suppose it does,
> somebody who has a sort of better-rounded mind than I do, and less

centered. They can't make me learn it. It's going to do me no good!

(Perry, 1999, p. 83)

The student is making meaning of diversity that is alien to him by taking a stance

of opposition.

Complex Dualism. Perry's second major category Complex Dualism marks the

appearance of Position 3- Multiplicity Subordinate and Position 4- Multiplicity Correlate

or Relativism Subordinate. The students separate into two groups with each developing a

discrete destructuring of the world. The alternative views are seen as a balance of

Oppositional and Adherence. The paradox of opposition and adherence is maintained to

accommodate a dualistic structure.

Position 3 produces problems that may have known solutions or may have

solutions still unknown. The task is to learn how to find solutions. Methods of reasoning

are used such as connected knowing through empathizing, as well as separated knowing

through objective analysis employing technique. A sophomore describes his discomfort

with a lack of answers and a preference for physics,

> I'd feel rather insecure thinking about these philosophical things all the
>
> time and not coming up with any definite answers are, well, they, they're
>
> sort of my foundation point. In physics you get definite answers to a point.
>
> Beyond that point you know there are definite answers, but you can't
>
> reach them. (Perry, 1999, p. 99)

In Position 4 problems are mostly with solutions that are unknown and some are

unsolvable such that all opinions are valid. A sophomore student describes reading Moby

Dick in a literature course. "I mean if you read them [critics], that's the great thing about

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a book like *Moby Dick*. (*Laughs*) *Nobody* understands it!" The student did not entertain the idea that some understandings may be preferable to others.

Relativism. Perry's third major category, Relativism is divided into two positions Position 5- Relativism Correlate, Competing, or Diffuse and Position 6- Commitment Foreseen. Position 5 is the last position whereby the student integrates knowledge from outside sources, joins these with his/ her own experiences, and internal reflections. Learning becomes a journey or commitment to an evolution. A student gives evidence of Position 5, "you find yourself thinking in complex terms: weighing more than one factor in trying to develop your own opinion" (Perry, 1999, p. 125). In Position 5 solutions can be supported with reasons and must be viewed in context and supported. The movement that begins in Position 5 is toward a "vision of generalized contextual Relativism- the revolutionary restructuring in which the students unite in Position 5" (Perry, 1999, p. 105). Evaluating solutions is the task in Position 5.

Position 6- Commitment Foreseen is marked by acceptance of relativism when perceived as necessary in a relativistic world. A senior discusses writing papers in college to support multiple points of view, the necessity of taking sides and supporting all sides.

It seems that so much of what I've been forced to do her is to taking of

two sides at once, just spends my judgment. There is a value in it; of

course there's a value in, in seeing any perspective, or any one particular

facet of, of a problem. But there's also a value in, in being able to

articulate one side more than another. (Perry, 1999, p. 157)

The task is to make choices and commit to a solution, yet some students in college may feel as if by learning the tools to do so they are in fact holding back.

Commitment in Relativism. The fourth and final major category is Commitment in Relativism, which includes three positions Position 7- Initial Commitment, Position 8- Orientation and Implications, and Position 9- Developing Commitment. Students in Position 7 begin to accept life as a series of choices made, and affirm that choices have consequences.

> I've always had a lot of doctors in my family, and my father meant to be a doctor and then, ah, quite during the depression. And he'd always wanted me to be a doctor, at which I had rebelled. And well, I had a board and room job this year, taking care of kids and, well, it just came slowly to me that this is really what I want, and for the first time I had a little direction. Right now I'd like to go into pediatrics; I'm really set on this deal (Perry, 1999, p. 174).

Initial commitments may come from a student's past, developing interests, and an urgency to make meaning out of life.

> Position 8 is marked by tentativeness to relativism with feelings of an expanding of narrowness.

> Well "tentative" Implies…perhaps uncertainty and, and, I mean readiness to change to anything, and- ah, it's not that. It's openness to change but, but not looking for change, you know. Ah…At the same time- ah, believing pretty strongly in what you do believe, and so it's not, you know, it's not tentative….So it's a commitment. It's a real, definite commitment, with a possibility of (laughs) of withdrawing from the

commitment, which I think is the only realistic kind of commitment I can

make, because there is a possibility of change here. (Perry, 1999, p. 178)

Students displaying tentativeness with wholeheartedness are in the process of

finding balance, as are trust with risk, and contemplation with action.

In Position 9- balances are developing as a process of growth from

polarities with the changes now accepted as a part of self-identity. "Complexity,

especially the conflict between value systems, demands a capacity to tolerate

paradox in the midst of responsible action." A senior describes hearing a group of

freshman students discuss objective morality. While he agrees the question is basic

to humanity, like questions of free will or determination, he now sees some

questions more as unsolvable mental exercises than practical or useful reality.

Well you can argue that forever, and I've tried. And you just exhaust

yourself on that topic, and then you go on to another topic, and then you'll

exhaust yourself on that topic, and go on and on, until you reach some

topic that you can discuss and, and reach some sort of accord on. And

when you get to that level it seems to me you've had a more profitable

educational experience, not because you solved all the problems that lie

beneath it, necessarily. You've discussed them, of course, but you haven't

solved anything. It's just that you've reached a certain level, using a

certain amount of language that allows you to come to a conclusion, to

reach agreement on something. And it's important to reach this level of

agreement, if you see what I mean. (Perry, 1999, p. 185)

Commitment and acceptance of balance is tolerance to the many paradoxes of reality.

Students find balance in uniquely individual ways such that career defined cultural norms

play a large role in self-identity, but within parameters of balanced self-expression.

Perry's scheme is one of intellectual and moral growth. Position 1 is changed

through assimilation of learning experiences from a dualistic view toward a more

relativistic view first evidenced in Position 6 and developing through to commitment in

Position 9. In Perry's scheme the individual is varied, moving, seeking to accommodate

the tensions of uncertainty and complexity through either opposing new visions or

adhering to a previously held vision. Then accepting the complexity of questions and

answers. For over thirty years this scheme was presumed to be the norm and applied to

all adults, both male and female of various classes, cultures, and ages.

Moral development

Similar to and founded on the work of Piaget, Lawrence Kohlberg extended moral

development understanding to form a stage theory where cognitive abilities are the basis

for moral reasoning (Crain, 1985). A series of moral dilemmas were posed to individuals

to understand the reasoning behind each moral choice. Each dilemma focused on one of

thirty-two aspects of morality. The most cited of these moral dilemmas is Heinz's

dilemma: Heinz's wife is sick with a special cancer that could be treated using a recently

discovered drug. While expensive, the druggist was charging clients ten times for the

drug than what it cost to make. Heinz could not raise enough money and the druggist

would not negotiate. Heinz broke into the druggist laboratory and stole the drug. Should

Heinz have broken into the laboratory to steal the drug for his wife? Why or why not?

Cross-cultural studies of children and adults yielded three levels of moral development with each level encompassing two stages.

Level I. Pre-moral or Pre-conventional morality is characterized as having a basis for moral reasoning in the concrete consequences to the individual. The individual seeks to maximize pleasure and avoid pain. Within Level 1 are two stages, 1) Obedience and 2) Self-interest. The individual may act based on Obedience and avoidance of punishment, or act to seek reward or Self-interest. A child attributes what is right to what an authority says (Kohlberg, 1968). In the Heinz dilemma the individual acting in Level 1-1 Obedience would not steal the drug because it would mean prison. Tommy at 10 years of age responds to the question, "Why should the druggist give the drug to the dying woman when her husband couldn't pay for it?" by considering the consequences of disobedience. In Tommy's view the moral choice depends on the importance of the person dying, he reasons that causing harm to an important person may result in greater punishment.

> If someone important is in a plane and is allergic to heights and the
> stewardess won't give him medicine because she's only got enough for
> one and she's got a sick…friend in back, they'd probably put the
> stewardess in a lady's jail because she didn't help the important one.
> (Kohlberg, 1981, p. 118)

Tommy's response above shows an example of punishment as the reasoning basis rather than the action's moral value.

An individual deciding based on Level 1-2 Self interest may support Heinz's choice to steal the medicine because he would find more reward in saving his wife even if

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he will have to go to prison. Moral decisions are choices made in exchange for rewards from superiors. People are often valued based on their utility.

Level II. Conventional morality is marked by an individual's ability to reason as a member of society who acts to gain approval with moral reasoning based on duty, to avoid disapproval and guilt. Within Level II there are two stages, 3) Interpersonal Accord and Conformity, and 4) Authority and Social Order. Two boys respond in a manner consistent with Level II to a question about the worth of human life. In the dilemma a doctor grapples with the thought of "mercy-killing" a woman who has requested death because of her pain. Consistent with Level II- 3 Interpersonal Accord and Conformity, thirteen year-old Richard responds that it is similar to putting animals to death to put them out of pain. Richard sees his choice as conforming to an already established expectation. Making a choice consistent with Level II- 4 Authority and Social Order, Tommy at 16 years responds considering the point of view of the husband and that actions have social consequences. "It might be best for her, but her husband- it's a human life- not like an animal, it just doesn't have the same relationship that a human being does to a family" (Kohlberg, 1981, p. 119). Tommy makes the moral decision based on what he sees as the conventions of society, law and order, that actions have consequences that must be addressed.

Level III. A moral reasoning based in personal human rights and moral standards marks Level III- Post-conventional morality. In Level III- an individual bases moral reasoning on the logic of human rights. At age 22, Richard responds to worth of human life in a manner consistent with Level III- 5, "If it's her own choice, I think there are certain rights and privileges that go along with being a human being" (Kohlberg, 1981, p.

23

119). This basis for moral reason differs from Level III-6 which lies in a belief in universal principles of morality (Kohlberg, 1968). An individual in Level III-6 would respond to Heinz dilemma considering a universal human ethics, saving a human life is fundamental and has more value than property rights. A choice against stealing the medicine would consider who else may need the medicine and that one human life has the same worth as another.

Kohlberg saw the challenge of determining moral development as being distinct from socialization and enculturation but saw evidence of a universal morality. Based on cross-cultural studies Kohlberg agreed with Piaget that there is a "culturally universal age development of a sense of justice, involving progressive concern for the needs and feelings of others and elaborated conceptions of reciprocity and equality" (Kohlberg, 1968, p. 489). Morality is universal, based in objective, impersonal, or ideal grounds with the separation of action from intention more pronounced with age.

Kohlberg's stages of morality are not believed to develop due to genetics nor are they a product of social learning. Morality is the product of moral development, resulting from an individual actively thinking through moral dilemmas to determine a personal point of view, other points of view that should be considered, and the consequences. Moral development is a movement of an external application of morality toward an internalization as absolutes are disentangled when applied real-life situations (Kohlberg, 1968). Studies based on Kohlberg's stages assessed women as having lower scores than men, concluding women were less morally developed.

Views of Faith, Religiosity, and Spiritual Development

Spirituality and religiosity are closely related but distinguishable in function. Spirituality can be defined as "the self's existential search for ultimate meaning through the individualized understanding of the sacred" (Wink & Dillon, 2002, p. 79). The Sacred is an entity worthy of reverence, the divine, the transcendent, a higher power greater than the human self. Religion can then be defined as "a system of beliefs and practices observed by a community, supported by rituals that acknowledge, worship, communicate with, or approach the Sacred, the Divine, God (in Western cultures), or Ultimate Truth, Reality, or nirvana (in Eastern cultures)" (Koenig, 2008, p. 13). In distinguishing religion from spirituality, religion is "institutional, formal, outward, doctrinal, authoritarian, inhibiting expression, while spirituality is individual, subjective, emotional, inward, unsystematic, freeing expression" (Koenig, 2008, p. 14). Hill and Pargament (2003) argue against dividing religiousness and spirituality claiming both are social and personal. Spirituality in the United States has become disconnected from religion in that people identify as being spiritual but not religious, still, both religion and spirituality are social and personal.

As noted by Hufford (Koenig, 2008), the relationship between the words 'spirituality' and 'religion' is similar to the pair of words 'learning' and 'education'. Spirituality is the broader domain with religion being an institutional aspect of spirituality. Today individuals may come to a spiritual state through practicing religious rituals, personally relating with the divine, connecting to nature, connecting to music, connecting to the arts, scientific truth, or a set of principles and values. A practice-oriented spirituality would be the "performance of intentional activities aimed at relating to the sacred" (Wink & Dillon, 2002, p. 80) where religiosity would be a regular

connection and active participation in a religious community. The key difference in this perspective of Wink and Dillon (2002) is that in spirituality is the inner-self seeking to connect with the sacred in a manner that can be integrated with religious practice-oriented actions.

Stage model of faith development

James Fowler (1981/ 1995) outlined a stage model of faith development where faith is not religious, but…

> our way of finding coherence in and giving meaning to the multiple forces
> and relations that make up our lives. Faith is a person's way of seeing him
> or herself in relation with others against a background of shared meaning
> and purpose. (p. 4)

Founded on Kohlberg and Piaget's work on moral and cognitive development, Fowler interviewed over 350 participants from preschool to senior citizen. Fowler's six hierarchical stages of faith align with Kohlberg's stages of moral development, including familiar aspects of behavior, affective, and cognitive (Fowler, 1981/1995) but also address the role of imagination in knowing, symbolic processes, and unconscious structuring processes.

Stage 1 Intuitive- Projective faith. In this stage, faith is child-like, dynamic, based in imitation, occurring in children of two to six years of age. A boy of four, Freddy, discusses topics including death and the human spirit, feelings regarding church, the images of God, and God in spirit form.

Interviewer: So heaven is where people go when they die?

Freddy: Your spirit goes up.

Interviewer: Oh, your spirit. What is your spirit?

Freddy: It's something that helps you- helps you- helps you do everything.

Interviewer: Yeah, where is it?

Freddy: In your body (Fowler, 1981/1995, p. 126).

When speaking about God, Freddy is shown a picture of a church and asked about the feelings of those who attend church.

Freddy: They feel sad.

Interviewer: How come?

Freddy: 'Cause all the things about God.

Interviewer: What kinds of things about God make them sad?

Freddy: Well, God dies. God dies and then he comes back to life. That- coming back to life is good but-

Interviewer: But the other part is sad?

Freddy: Yeah 'cause when you stay dead. That's all I know about that.

Interviewer: All right. Can you tell me what God looks like?

Freddy: He has a light shirt on, had brown hair, he had brown eyelashes. (Fowler, 1981/1995, p. 127).

During the process of the interview Freddy showed the interviewer two small statues of Christ. When asked if everybody thinks God looks like the statue, Freddy replies, "Mmmm, not when he gets a haircut." The interviewer follows, asking Freddy how we find out about God.

Freddy: When you go up- when your spirit goes up to heaven.

Interviewer: Is there any way we can find out before that?

Freddy: I don't know, really…when you take off in space.

Interviewer: Well how do you know about God?

Freddy: My teacher tells me about him sometimes. Sometimes I see him

on cards and I see, uh- all those people up in heaven.

Interviewer: Do people ever talk to God?

Freddy: Yea.

Interviewer: How?

Freddy: Well, well God can hear them, but he's in signs. He doesn't talk.

Interviewer: [Mis-hearing him] He doesn't? What kind of songs does he

sing?

Freddy: He sings songs about- I don't know, really. But he's in signs.

Signs like stop signs.

Interviewer: Stop signs? Can you guess what kind of signs he might send?

Freddy: Like peace signs.

Interviewer: Peace signs?

Freddy: Yea. That's all I know about that. (Fowler, 1981/1995, p. 127)

Highly influenced by the stories and actions of adults, Freddy's responses are a mixture

of stories relayed to him by others intermixed with his own spontaneous constructions.

He relies on language and symbols to organize his experiences and make meaning.

An adult in Fowler's study recalled his mother reading the story of Daniel in the

lion's den describing how God had shut the lion's mouths to protect Daniel from harm.

The boy had imagined dental devices that locked the lion jaws together. For days he

relived the story of Daniel and thought to himself, "God, I'm brave like Daniel. Put some

lions in here in this room and I will show you that I am not afraid." After thinking such at thought, he was afraid that God would answer his prayers (Fowler, 1981/1995, p. 131). The adult recalls a world of "fantasy," or imagination, typical of Stage 1, uninhibited by logical thought.

      Stage 2 Mythic- Literal faith. In this stage, children insist on demonstrations of proof for facts as stories are taken to be reality, begin to see from the position of another, and compose a world of fairness and reciprocity. When asked why there are people in the world, Millie describes the purpose of other people in the world from role she plays in relationship to others. She is now able to characterize her experiences in light of other's experiences.

> Millie: People in the world? Let's see. If there weren't any people, there
>
> wouldn't really be any world. And if there wasn't a world then the world
>
> would be blank. I mean everything- that's a tough question. Let's see.
>
> Why would there be people?
>
> It would be the same only there'd be a different person without me in
>
> it…Well there wouldn't be a Millie T. Well, there might be somewhere.
>
> And Sue T. wouldn't have a person to share a room with. And there
>
> wouldn't be a little girl in the Willingham School who plays the viola.
>
> And there wouldn't be Millie T., Jacqueline's best friend…And it would
>
> be different, I think it probably would be. (Fowler, 1981/1995, p. 137)

Rather than a general description, Millie approaches her absence from the perspective of her sister, the school, and her friend as she begins to imagine how a world would be

different without her. In Stage 2 the individual takes on the moral rules, attitudes, beliefs, of the faith community where stories and symbols are interpreted literally.

Adults in Stage 2 may describe a relationship with the Christian God based in reciprocity, where attending church, prayer, or acts of praise store up God's favor. Through an increasingly accurate ability to take the perspective of others, reciprocal fairness and justice are the basis of stories. Meanings are contained in stories with the "central importance of reciprocity as the principle governing divine-human relations" (Fowler, 1981/1995, p. 149). Stories are not used to form reflective or conceptual meaning, as Stage 2 persons are narrative and literal.

The transition from Stage 2 to Stage 3 is marked by a tension or paradox between the meanings of stories, literalism, authority, and the seeking relational perspectives. "A factor initiating transition to Stage 3 is the implicit clash or contradiction in stories that leads to reflection on meanings" (Fowler, 1981/1995, p. 150). Literalism is broken down and followed by critical review. Individuals may become disillusioned with teachings based in the narrative and literal, and move toward a "mutual interpersonal prospective" and more personal relationship with the divine.

Stage 3 Synthetic- Conventional faith. In this stage the individual's perspective holds a reliance on an external authority that extends from the personal outward to family and world. Through relationships, a person becomes known and accepted by others outside his/her family. God is "re-imaged as having inexhaustible depths and as being capable of knowing personally those mysterious depths of self and others we know that we ourselves will never know" (Fowler, 1981/1995, p. 153). The adolescent hungers to

be known, accepted, to have confirmation of the self. Faith becomes the foundations of identity development and worldview.

An example cited by Fowler is seen in Linda. At fifteen years of age, Linda has been challenged by the fourteen times her family has moved as her father sought work. Now settled in Florida, Linda has found a group of friends yet feels somewhat apart from them due to her moral beliefs.

> Linda: Well, I feel like I am not afraid of anything now because I know what I believe in and I know what I want to do in life, and nothing could really set me off course. We're not going to move any place now. Before, if we moved I got into people, different people, and I sort of changed as the people went. But I've learned that the best thing is just to be yourself.
>
> Interviewer: Linda, when you say you know what you believe in…can you try to trace how you came to know what you believe in?
>
> Linda: I guess religion, I've always gone to church and everything. And my parents, they always guided me…They've always taught me that God's always there and, you know, he'd the only way that you can really make it. You depend on him and I really believe in him and, you know how they say God talks in many mysterious ways? Well, in a sense he's told me lots of times…I really think that he's led me to where I am today. 'Cause lots of times I've just thought the world is just, you know, I just don't feel anything. But then, that morning I'll just have a feeling that...I guess there is Somebody, you know? (Fowler, 1981/1995, p. 155)

As Linda describes her challenges with peers and a sense of standing alone from her peers with her family of believers, she comes back to God as a unifying and dependable personal companion based on what she has been taught, and what she feels.

Critics of religion often assume that to be religious is to be Synthetic-Conventional, which Fowler posits may accurately describe much of American religious life. In Stage 3 a balance can be maintained, a person remains in a unifying, universal place of tradition, and authority of relationship. Mrs. M. exhibits the conformist nature of Stage 3, without the autonomy to construct an independent perspective. The interview with Mrs. M moves to the topic of the end of the world.

Interviewer: Do you think that life on earth will continue for some time in the future, or do you think we're coming near the end of the world?

Mrs. M.: The Scripture tells of many things that will happen in the last days and these very things are happening now. I think that we are very near the end of time. A very learned Bible teacher that I hear each week tells us that according to Scripture, the end will come before the year 2000.

Interviewer: Would you agree with her?

Mrs. M.: I feel very sad and ashamed for the way I have wasted my life. I do know that God has forgiven me for every wrong that I've done, and that He loves me. I feel very close to God most of the time, now that I am active in the world of the church again. Of course there are times that I don't feel close to Him as I'd like to, but I know that I am the one who

moves away, not He. I've learned that we all have so much to be thankful

for, if we only stop and count our blessings. (Fowler, 1981/1995, p. 172)

Not based on a process of reflection, or introspection, Stage 3 individuals hold a non-analytical faith. This synthetic faith of Mrs. M. is conventional in that she describes herself as one with a community, a perception based in her commonality with others. To the individual in Stage 3, the symbols of faith are not mere representations; they are actually the sacred things they symbolize. From this basis religious authorities are more than representatives of the divine, they are divine. Clashes between the authorities, experiences of separation from authorities, or experiences beyond the community may lead a Stage 3 individual into critical self-examination. The transition from Stage 3 to Stage 4 is marked by the contradiction between what seemed universal, followed by a movement through reflection toward a relative perspective.

Stage 4 Individuative- Reflective faith. Typical of young adults, Individuative-Reflective faith is marked by a differentiation from a group to develop the self and an ideology that is the product of reflection, critical review, and a questioning of the absolute. Meanings previously held as tacit become explicit and symbols are demystified and detached from the sacred. Life changing events that expose the ideology of a group, such as college attendance, encourage the individual to develop beyond the group. Fowler uses the story of Jack to illustrate Stage 4. The son of an abusive alcoholic, Jack began faithfully attending Catholic school in seventh grade, and singled out by male peers and bullied for two years. At nineteen, he joined the army and frequented bars with black soldiers to listen to music by black artists. Friendships with black soldiers made Jack see the role of politics and his own prejudice differently.

When I grew up politics meant speeches, hoopla, voting payoffs. I thought

I knew about politics, but now I began to see politics differently. I began

to see that the prejudice against blacks that I had been taught and that

everybody in the projects where I grew up in was wrong. I began to see

that us poor whites being pitted against the blacks worked only to the

advantage of the wealthy and powerful. For the first time I began to think

politically. I began to have a kind of philosophy. (Fowler, 1981/1995, p.

175)

When Jack returned from the military, his new friends, language, and political views

made him an alien in his old neighborhood. Jack's exposure outside the group caused him

to critically review his value system and understand systems and ideologies that grow out

of experiences and conditions. After marrying a middleclass woman, Jack became the

leader of a tenants' rights group that gave a political voice to the lower class. A mark of

Stage 4, Jack's life experiences forced a critical review of a tacit system and ideology.

Through critical review, questioning, and reflection the ideology of Jack's neighborhood

ideology was replaced by a new and explicit system.

Stage 5 Conjunctive faith. The transition from the faith of Stage 4 to that of

Stage 5 lies in complexity. In a Conjunctive faith, conceptual meaning and symbolism are

integrated by way of deep reflection and critical review. Logic and dichotomy is replaced

by an ability to see multiple sides simultaneously; an interrelatedness through a dialogue

of openness regarding the manner of fit. Stage 5 is a dialogue without categories, a

speaking and hearing with an openness that accommodates the knowing process to the

structure being known. Stage 5 requires the individual to listen regardless of impact, and

dialogue as a reverence for wisdom based in mutual trust. A scholar studying a sacred text approaches the text from the standpoint of Stage 5 if instead of reading, analyzing, and extracting meaning, the scholar allows himself to be read by the text. Stage 5 is going beyond the explicit ideology of boundaries of Stage 4 to a multidimensional, interdependent, and organic account of truth. In Stage 5, the symbols and rituals of religion are appreciated for the power of tradition to unite to group meanings while understanding their relative nature as representations.

Fowler describes Miss T. to illustrate Stage 5. At seventy-eight, Miss T. is writing her second book, a book of life truths. Miss T. has found grounding in hope and life courage, she does not live in a world of illusion. A graduate of Radcliffe and student of the Quakers, Indian philosophy, Rudolph Steiner, and Carl Jung, Miss T. has forever sought a deeper understanding. Miss T. talks of obtaining wisdom through Indian philosophy, a Krishnamurti who helped her see that spirituality lies in all persons.

> It doesn't matter what you call it. Whether you call it God or Jesus or
> Cosmic Flow or Reality or Love, it doesn't matter what you call it. It is
> there. And what you learn directly from that source it will not tie you up in
> creeds…that separate you from your fellow man. (Fowler, 1981/1995, p.
> 192)

After critically review, study in philosophy, and varied life experiences, Miss T. moved toward an inclusive spirituality where faith and religion are universal. "nobody can tell another about it. It has to come from within the individual" (Fowler, 1981/1995, p. 195). Miss T. illustrates the Individualization- Reflective faith of Stage 4. Her critical review of Christianity, study and reflection spawned an individualized faith. Miss T.'s return to the

traditions of Christianity marks Stage 5 whereby the symbols, religion, and ritual are demystified and relative yet they retain value, and purpose that is universal to humanity.

Stage 6 Universalizing faith. Fowler claims to have had Stage 6 Universalizing faith in mind before determining the five preparatory stages. Stage 6 is an exceedingly rare faith, one of inclusion of all beings, universality of a faith to transform, a faith of justice. For persons in Stage 6, all are united such that significance, security, and unconditional love is deserving of all others from any stage or faith tradition. This faith leads to committed "love and selfless passion for a transformed world, a world not made over in their image, but in accordance with an intentionality both divine and transcendent" (Fowler, 1981/1995, p. 201). Persons of Stage 6 can be unorthodox and unpredictable in being subversive to structures and are "contagious in the sense that they create zones of liberation from the social, political, economic, and ideological shackles we place and endure on human futurity" (Fowler, 1981/1995, p. 200). Representatives of a Stage 6 faith listed by Fowler include Martin Luther King, Gandhi, and Mother Teresa of Calcutta. These individuals have "committed their total beings" to visions that are radical but not abstract, as they identify with the oppressed whose future is "being crushed, blocked or exploited" (Fowler, 1981/1995, p. 202). Those with a Stage 6 Universal faith would claim that if we dare to look, and fully see the oppressed, only then would we know what is missing, and truly know what life is supposed to be for all.

Spiritual development across the adult life

Wink & Dillon studied the spiritual development of adults in two coed cohorts born in 1928/29 and 1920/21. Individuals were obtained an Institutes of Human Development longitudinal study following participants from the elementary years with

the first interview occurring in adulthood in 1958. In 2007 the IHD study "is composed of close to two hundred women and men who have been tracked their entire lives, from early adolescence through late adulthood" (Dillon & Wink, 2007). Data from participants and their parents has been used by various researchers, including Erik Erikson, "who drew on his involvement in the study to derive his influential theory of identity" (Dillon & Wink, 2007, p. 17). Study of these participants by Dillon and Wink addresses an area missed by other researchers, religion belief, religious practice, and religious change over a lifetime.

Age was found to correlate with spiritual development. Spirituality developed at a high level in the later half of the sixth decade of life and into the seventh decade of life. Gender correlated with spiritual development, with women being generally more spiritual than men. A life commitment to the cognitive correlated with spiritual development such that highly spiritual women were described as "valuing intellect and independence, verbally fluent, introspective, and having wide interests as early as young adulthood" (Wink & Dillon, 2002, p. 88). For the first half of adult life there seems to be a relationship between negative life events and increased spiritual development for women, with no similar relationship found in men. This relationship was strongest for women in older age when the negative life event involved conflict with a spouse. The same study did not show a correlation between spiritual development and religious denomination or intelligence as measured by IQ tests. Older age spirituality was significantly predictable by looking at early adulthood religiosity, spirituality, negative life experiences, and degree of commitment to the cognitive.

Women's Moral Development and Ways of Knowing

Women's moral development

Carol Gilligan presented a stage theory of women's moral development in response and counter to Kohlberg's stage theory of moral development (Gilligan, 1993). Gilligan makes the claim that Kohlberg set his work with men as the moral norm such that responses by women to questions of moral choice did not fit the norm. Kohlberg classified adult women the same way he classified children, implying women were morally inferior to men. Women are not morally inferior to men, women develop and make moral choices differently. Gilligan posited Kohlberg's stage theory was incomplete in that he had missed another mode of thinking. This other mode of thinking could be heard in the responses of women.

In order to study morality in women Gilligan interviewed women using the hypothetical moral dilemmas used by Kohlberg and the actual dilemma of abortion. By using the dilemma of abortion women were asked to address adult questions of responsibility and choice uniquely relevant to women. The different views and ethic of care emerged from an analysis of the way women used moral language, shifted moral language, and judged their own prior use of moral language. Unlike the boys and men studied by Kohlberg, women make moral decisions based on near relationships rather than distant rules of separation and justice. The stages of moral development emerging from Gilligan's work progressed from self to social, to principled morality. The moral development of women focuses not on objective rules of justice, but on a connectedness to others within an ethic of care. A woman moving from one stage to the next does not simply undergoing changes in cognitive development as asserted by Kohlberg.

Transitions between the three major stages of Gilligan's theory are marked by changes in the concept of self, goodness, responsibility, and the self in relation to others.

Stage 1 Pre-conventional. Gilligan identified an initial stage where the goal is self-survival. This stage focuses on what is viewed as selfishness, as seen in the response by Betty to Heinz's dilemma.

> I think survival is the first thing in life that people fight for, it is the most important thing, more important than stealing. Stealing may be wrong but if you have to steal to survive yourself or kill, than you do it, that is what you should do… Preservation of oneself, I think, is the most important thing. It comes before anything else in life. (Gilligan, 1993, p. 76)

Following Pre-conventional is a transition or movement from self-focus to include a responsibility to others. The wish to consider the self remains but the manner in which the need is met has changed. Self-worth is enhanced as is the need for social inclusion, Anne struggles with the paradox of selfishness and responsibility and fails to resolve the conflict.

> I think you have to think about the people who are involved, including yourself. You have responsibilities to yourself. And to make a right-whatever that is- decision in this depends on your knowledge and awareness of the responsibilities that you have and whether you can survive with a child and what it will do to your relationship with the father or how it will affect him emotionally. (Gilligan, 1993, p. 78)

Ruth is also challenged by the choice to have an abortion. She struggles with maintaining an unwanted pregnancy that could hinder her ability to complete her education meet her

responsibilities to care for her existing family. Ruth wants to protect self and others, but realizes that in this decision hurt is inevitable. She is aware that the moral choice involves the connection between the self and others.

> Morality is doing what is appropriate and what is just within your circumstances, but ideally it is not going to affect- I was going to say, "ideally it wouldn't negatively affect another person," but that is ridiculous, because decisions are always going to affect another person. But what I am trying to say is that it is the person that is the center of the decision-making about what's right and what's wrong. (Gilligan, 1993, p. 96)

Ruth first denies and then acknowledges the conflict between her own needs and her various responsibilities to others.

Stage 2 Conventional. The second stage identified by Gilligan is marked by a belief that goodness is responsibility to others and may include self-sacrifice. Cathy fears the consequences of having a second abortion. Her lover and her family support the abortion, yet Cathy would like to continue the pregnancy.

> I don't know what choices are open to me. It is either to have it or the abortion; these are the choices open to me. I think what confuses me is it is a choice of either hurting myself or hurting other people around me. What is more important? If there could be a happy medium, it would be fine, but there isn't. it is either hurting someone on this side or hurting myself. (Gilligan, 1993, p. 80)

The choice of Cathy, and others, was not a choice with respect to the pregnancy but a choice with respect to relationships. To hurt the relationship between her lover and her family could not be considered moral, yet personal sacrifice in the name of responsibility was moral. The failure to acknowledge her own needs would result in harm, the dilemma came down to choosing the victim. Choosing her own needs equated to selfishness, yet self-sacrifice harming the self while avoiding harm to others was goodness.

A transition follows Conventional stage, one marked by a change in the self from accepting the exclusion of self in an ethic of care to realization that goodness cannot be defined by self-sacrifice. Responsibility is reexamined, to consider the possibility of caring for the self and also caring for others. This movement from goodness to truth demands that the needs of self be uncovered and considered. Jane considers her choice to have an abortion and faces a conflict between selfishness and what this means to her sense of goodness. She addresses the need to be honest and truthful while considering not only the needs of others, but her own needs.

> I think in a way I am selfish, and very emotional, and I think that I am a
> very real person and an understanding person, and I can handle life
> situations fairly well, so I am basing a lot of it on my ability to do the
> things that I feel are right and best for me and whomever I am involved
> with. I think I was very fair to myself about the decision, and I really think
> that I have been truthful, not hiding anything, bringing out all the feelings
> involved. I feel it is a good decision and an honest one, a real decision.
> (Gilligan, 1993, p. 84)

Jane seeks to consider the needs of the self with the needs of others and to be honest and real. The moral obligation is a responsibility to not only care for others, but to care for the self.

Stage 3 Post-conventional. The last stage is marked by a principled morality, one of nonviolence, to avoid hurting the self and others. The moral judgment of Kohlberg is replaced with an awareness of human behavior, pain, and suffering. Responses indicate an understanding of the wrongness of ignoring the needs of the self as well as the needs of others.

> I have a real thing about hurting people and always have, and that gets a
>
> little complicated at times, because, for example, you don't want to hurt
>
> your child. I don't want to hurt my child, but if I don't hurt her sometimes,
>
> then that's hurting her more, you see, so that was a terrible dilemma for
>
> me. (Gilligan, 1993, p. 103)

Gilligan described additional stages to moral development involving self-evolution, and a thinking mode based in an ethic of care. Moral reasoning with a basis in care is a dimension not found in Kohlberg's stages based in justice, individual rights, and rules. Instead, the ethic of care dimension of moral reasoning is based in responsibility, connectedness, and relationships.

Women's ways of knowing

The researchers of *Women's Ways of Knowing* (1997) worked with a variety of young women and were curious and concerned about issues female students had about learning experiences. Together they purposed to connect work on student development with work on women's issues. Based on an analysis of interviews of 135 women, Mary

Belenky, Blythe Clinchy, Nancy Goldberger, and Jill Tarule developed a series of five positions for women that are comparable to the nine positions of William Perry's scheme of moral development (Gilligan, 1993, p. 103). The study included adult women from a variety of social classes and educational levels. Life experiences and reflection allow women to develop five perspectives. The initial stage is Silence whereby women have a perspective that is voiceless and mindless. The second is Received knowledge- a perspective capable of receiving and reproducing knowledge but not creating knowledge. Third is Subjective knowledge- a perspective of knowing as intuited and personal. Fourth is Procedural knowledge- a perspective of learning to apply objective means of gaining knowledge with elements of Connected knowing and Separate knowing. Fifth is Constructed knowledge- a perspective of knowledge as created, and an awareness that knowledge is contextualized such that value is found in both objective and subjective knowing.

Position 1 Silence. Few of the women interviewed are in the position of Silence but many others recalled a period in their own lives where they describe themselves as being voiceless. Women in Silence are the most "socially, economically, and educationally deprived" of all the women studied. Many women speak of a time of dependence when they held little trust in their own minds. A woman describes why she stayed with a physically abusive boyfriend for a decade,

> You know, I used to only hear his words, and his words kept coming out
>
> of my mouth. He had me thinking that I didn't know anything. But now,
>
> you know, I realize I'm not so dumb…And my own words are coming out
>
> of my mouth now. (Belenky, et al., 1997, p. 30)

Oftentimes seen as impulsive or immature, these women lack thought regulation and "find no vantage point from outside the self that enables them to look backward, bringing the whole self into view" (Belenky, et al., 1997, p. 32). Silent women are often blindly dependent on external authorities for knowledge, and view words as weapons. For this reason, these women are without an inner voice.

Position 2 Received knowledge. In contrast to women in a position of Silence, women in the position of Received knowledge obtain knowledge externally, reproduce knowledge, find ambiguity challenging and describe listening as an intensely demanding process. A female student describes a time in her first year of college as she takes in knowledge by listening, "I enjoy listening to discussions. I find I am doing ok just through listening" (Belenky et al., 1997, p. 37). Another woman describes listening in class, "You get a real taste, putting your mind to work… concentrating- listening and really getting something from it. Unless you're taking something in, it isn't worth it" (Belenky, et al., 1997, p. 37). Received knowers are open to the thoughts and ideas of others and may still their own voices due to a lack of confidence in their own thoughts and ideas. They do not see the knowledge of authorities as a human construction; in contrast, knowledge is viewed as being somewhere out there.

Position 3 Subjective knowledge. Women in the third position of Subjective knowledge trust intuitive knowledge over logic and rational knowing and move from silence to an assertive protesting inner voice. A woman describes the questioning that comes with caring for a newborn, "there wasn't anybody that really had the right knowledge, the right answers…but it's changed a lot in the last year…I'm all right. And sometimes now I think of something before somebody else thinks of it" (Belenky et al.,

1997, p. 61). In avoiding words, many express themselves nonverbally or artistically as a means to avoid categorization or hide their own thinking and thus still their public voice. A junior physics major was working out a scientific thesis that represented an unorthodox scientific view but was reluctant to share it with male faculty, "men don't think women have any place in science," (Belenky, et al., 1997, p. 67). Women in the position of Subjective knowledge are passing through a process of discovering an "inner power…subjective self" (p. 57), acting from gut rather than logic.

Position 4 Procedural knowledge. From the fourth perspective the world as more complex than can be addressed with either Received knowledge or Subjective knowledge. Knowledge is apart from the self and noted in the complex and various ways of looking at a situation. In an introductory art class Naomi questioned the right of an instructor to judge students' opinions. The instructor insisted Naomi not only write about her feelings and reactions, but justify them. Naomi wanted to judge the paintings by comparing them to her own feelings, moods, background, but the instructor wanted her to use a list of objective criteria including color, lighting, composition, and texture and "all that garbage" (Belenky, et al., 1997, p. 89). To Naomi this required a stifling of her own thoughts for the language and opinions of experts. Not knowing what to do but determined to be successful Naomi fell into a pattern of obedience and gave the instructor what she thought he wanted.

One woman in the position of Procedural knowledge described herself, "I think everything out, and I want to make sure I understand exactly what's going on before I do anything" (Belenky et al., 1997, p. 99). Women in Procedural knowledge handle the multiplicity of objective and subjecting knowing by clinging to Separate knowing from

45

formal instruction allowing for various objective lenses, or moving to a Connected knowing rooted in relationships, empathy, and caring. Separate knowing is knowledge of "separation from the object, mastery over it" while Connected knowing is understanding which "involves intimacy and equality between self and object" (Belenky, et al., 1997, p. 101). One woman exemplifies the process of shifting lenses from Separate knowing to Connected knowing as she wrote. She saw this process as a game with the self while standing in two different places. First, the drafts were produced from the position of a Connected knower learning to believe in and become the words gained from the inner voice and voices of others. As the final draft approached, the drafts were critiqued from the position of Separate knower, reading with an objective, doubtful, and skeptical eye.

Position 5 Constructed knowledge. In the final position, Constructed knowledge, the voices are integrated, knowledge is contextual with objective and subjective strategies both employed while categories are avoided. She becomes adept at constructing and reconstructing frames of reference.

> I have come to see things in my own way. I feel that everyone has something unique to say, but some people know how to develop it. Some people can go even further- they can go outside the given frames of reference. Most people have something to say inside the given frames of reference. But then you take someone like Freud or Darwin- they are able to jump outside of the given to create a whole new frame of reference. That doesn't happen too often. They stay with it. They create their whole life around it. They change everything for everyone. (Belenky, et al., 1997, p. 133)

Women in the position of Constructed knowledge feel responsible for examining, questioning, and developing the systems that they will use for constructing knowledge. As described by Belenky, et al. (Belenky, et al., 1997, p. 37), the constructed knower assumes the general relativity of knowledge and sees that the context or frame of reference matters.

Before the work of Belenky et al. (1997) and Gilligan (1993), the male psychological and developmental experience explained by Perry (1999) and Kohlberg (1968) were often interpreted as the human experience. Thinking was defined as impersonal, objective, distant but not emotional, or relational. It was assumed that intellectual development in women would impair their emotional capacities, just as emotional development in men would impair their intellectual capacities (Belenky et al., 1997). Developmental psychology was based on a limited view of knowledge that was rooted in dualistic either/or thinking with women and men representing two sides of a human coin. Belenky et al., (1997) shows how the self-concepts of women are intertwined with their ways of knowing. As women work in the context of family and school, they actively seek power over their thoughts and develop a sense of voice. Using an integrated voice, they learn to communicate their thoughts and critically evaluate knowledge sources as they construct knowledge.

Women's Diverse Paths to Science

Various quantitative and qualitative studies have attempted to answer questions about the ways females become interested in science and prefer to learn science with hopes of connecting interest to learning to a science career. Females at the elementary school level carefully followed directions, maintained relationships, and preferred group

work. Males, on the other hand, explored and tinkered and were more competitive (Jones et al., 2000). One study found that when given access to books on science, elementary females preferred narratives about animals, and parents underestimated their female child's level of interest in science books (Jones, et al., 2000). In middle school 64% of the 198 female students studied described learning best through active learning strategies such as experiments, hands-on projects, and observations (Harwell, 2000). A quarter of the female students preferred passive learning environments such as observing activities or watching science being done. The remaining female students preferred to learn in cooperative groups through communication, working with partners, and doing activities with friends.

Gilbert and Calvert (2003) studied five women scientists to understand the internal constructions of a group of women who acted in effect as both the subjects of the study and also creators of new science knowledge. Rather than consider women attracted to science as outliers, they considered them valuable data sources to examine issues of gender and science. Using an unconventional methodology, a combination of qualitative narrative-based research with psychoanalytic techniques, stories developed by the group of five women were read at two levels. First, the stories were read at a surface 'cognitive' level to understand what the women said about themselves, and how they said it. Second, the stories were read at a deeper level to identify points where "cognitions, feelings, and behaviors seemed most intensely linked, paying particular attention to the points at which these links appear to be outside the speaker's conscious narrative" (Gilbert & Calvert, 2003, p. 867). To these women science met a need that at this point is less clear. Earlier, in the teen years they saw science as powerful, a system that discovered answers to

questions and uncovered the unknown. Some viewed science as predictable, orderly, a way to achieve control and holding promises of certainty. Others saw science has exciting, exotic, interesting, challenging, and "offering possibilities for action in the outside [that is, non-domestic) world" (Gilbert & Calvert, 2003, p. 870). All saw a place for themselves within science but had strongly ambivalent feelings about that place. It was clear that they saw their access to this position as having strong links to their fathers (or, more properly, their internal constructions of their fathers, and of masculinity in general), and that this association was, for many of them uncomfortable and/or disturbing. It is clear that each of these women has experienced a certain amount of internal conflict between their understanding (and identification) of themselves as a woman and their attraction to, and attunement with, certain elements of what is seen as being the masculine.

Many women studied by Gilbert and Calvert (2003) showed high levels of conflict, they held the belief that science requires certain aspects of scientists' lives to be suppressed. Feeling divided, many kept personal lives distinctly separate from their professional lives. Others expressed a sense of isolation in the workplace and remained dissatisfied with the lack of connection with coworkers. Several argued that they served an invisible purpose, feeling they supported the important work of others yet were 'marginalized' from the 'main action'.

An informal program to encourage urban disadvantaged female high school students toward careers in the sciences resulted in over 90% enrolling in college and over 40% pursuing a healthy-related field of study. The female students cited relationships

with staff, having a safe place to go, and learning career skills as reasons for their career decisions (Fadigan & Hammrich, 2004).

High school females choosing science courses do so for a career in biology, medicine, veterinary medicine, or physical therapy. They move away from the physical sciences and toward the life sciences to seek relevant people-oriented or health-related fields such as pharmacy, psychology, pediatrics, psychiatry, and veterinary medicine (Miller, et al., 2006, p. 365). It seems females come to science class valuing relationships and working with others as they learn, and continue a relational view with science careers involving understanding, investing in, and helping others.

Gender studies show differences between the ways female and male high school students view science. A survey of 80 college bound 10-12 graders in a science course, with the sample representing 50% male/ 50% female reveals a significant difference between preferred courses (Miller, et al., 2006). Of English, Spanish, Chemistry, Geometry, and Algebra II, females surveyed chose Chemistry as the course they liked the most followed by Spanish then Geometry. Males surveyed chose Spanish as their first choice followed by Chemistry then English. Females surveyed anticipated a people oriented major (14/40) in the most numbers with science earning second (13/40), while males surveyed anticipated a science major most (22/40) with Miscellaneous earning second (6/40). When expressing reasons for choosing a career in science, nine females explained using statements that convey caring for people or animals.

> I like to help people, and I want to be in some kind of medicine. I want to
> work with kids in physical therapy. I love kids. [Plans a physical therapy
> major]

When I was young I got really sick. Ever since then I've been determined

to help other children not have to deal with that. [Pharmacy]

I loved animals since I was a little girl. [Veterinary medicine] (Miller, et

al., 2006, p. 372)

Other females stated they needed to major in science to meet their professional goal that

they did not consider to be science. They were asked to compete the statement, "I am

considering a science major because…"

I don't really want science as a major. I want medicine. I'll have to take

science classes though. [Physical therapy major]

I need to know it to be an engineer. [Engineering major] (Miller, et al.,

2006, p. 373)

Females not choosing to major in a science revealed a perception of science and

scientists as uncaring, unfeeling, distant, or unemotional.

It's [science] not something that I can be dedicated to, the way I need to be

if it becomes my profession. [Psychology]…

Females are more emotional. Therefore, they would more likely choose a

subject full of emotion, the arts for example- humanities, English,

drawing- those all take heart and talk about and deal with heart to create.

In science there is black and white, right and wrong. In English there is

none. [English] (Miller, et al., 2006, p. 374)

Miller also found that female students who rejected science as a career choice did not

do so because science was deemed too challenging of a subject or because science

study caused issues with female gender roles. To these female students science did not

appear to be relevant to their life goals. Female students differed from male students in the reasons given for an interest in biology; female students were drawn to biology as a path to help others through the psychological or health sciences. Male students were drawn to the physical sciences over biology, seeking to prepare themselves for applied sciences of engineering, computer science, and medicine.

Some women who chose science careers described taking things apart as children, asking lots of questions, and being captured by questions that did not have a definitive answer (Barrett & Fisher, 1984). Others came to science in college seeking a career to help people and were drawn by courses where aspects of nature were "awesome, scientifically challenging, and valuable to the community in a practical sense" (Barrett & Fisher, 1984, p. 61). Some women see in science a way to pursue their love for new knowledge or to experience the moment of understanding. A physical chemist in her eighties interviewed by Gornick (2009) was asked when and how she knew she would was going to be a scientist.

'I always knew I'd be a scientist. Always. There was never any question about it.'

What was it in science you couldn't do without? A surprised smile flashed across its composed features. 'Thought,' she replied quickly. The questioner looked into her eyes, to repay her by listening hard. The old woman threw back her head, her eyes narrowed, for an instant her mouth quivered. Her voice, when it came, was rich and clear with feeling, 'To take part in a free-reigning conversation,' she said. 'Those moments…those rare half-hours…when suddenly there is a synthesis of

the human intelligence…and to know every day that it may happen again today…What else is there in life? *That's* what science has given me.

That's why I had to be a scientist.' (Gornick, 2009, p. 52)

Whatever their interest and path to science, female children, middle school females, and women come to science from a variety of childhood and adult paths, and seek to be scientists for many different reasons. In science, women find personal and societal value, both in the process of scientific study, and in the scientific knowledge that may result.

Summary

The way science has been defined and described has changed with time. Early science knowing was based in observations and reasoning with empirical evidence foundational to the systematic study and incremental building of science knowledge. By the mid-1900's, science was defined as lacking a history of uniformity, instead science knowledge proceeds through periods of normal science within paradigms and revolutionary ideas that provoke paradigm shifts. Scientific revolutions represent shifts in thought, the abandoning of some possibilities and the opening up to new possibilities.

Intellectual, moral, and spiritual development takes place throughout life in the context of lived experience and knowledge stance. Development moves from a more dualistic view to a relativistic view as learner's lived experience and conceptual frameworks are reshaped by new experiences and thoughts. Individuals learn about the world through first defining themselves as distinct and permanent, then seeing the world through other points of view, to critically review and develop an understanding of a logic independent of truth followed by a relative view of knowledge and spirituality. Learning occurs through interactions with others using the tools of culture to develop social

communications and inner thought. Described as a process of handling new concepts from within a conceptual ecology of prior concepts, learning can be described as conceptual change. Aspects of conceptual ecology include epistemology and metaphysics. Culture, language, beliefs, and stance regarding knowledge are the lenses from which we view and construct new knowledge. Spirituality is one aspect of a learner's conceptual ecology.

Studies show women develop intellectually, morally, and spiritually following somewhat different patterns than those seen as typical to men. Spiritual advances during mid and later life occur most often in women with a higher level of cognitive commitment who have lived experiences involving a conflict with a spouse. Moral development occurs through the actively working out of dilemmas. Males tend to make moral decisions based on individual rights, justice, and rules of society. Moral patterns become engrained in the individual to avoid punishment, guilt, to follow society, and lastly as they are viewed as universal morality based on objective rules. Females base moral decisions on relationships and a sense of caring for others with less focus on rules and more focus on responsibility. The intellectual development of women is closely bound to the development of self-concept and an inner voice. Silence develops a questioning voice moving toward accepting knowledge from others bound with lived experiences, and then integrated voices form an individual voice that serves to construct knowledge. Female students seem to come to be interested in the natural world and science from various paths, value relationships with people and animals, most often choose relationship oriented fields, and choose careers that help, care for, and educate others.

Chapter 3: Research Paradigm and Methodology

This study explores women scientists who maintain a strong spiritual position as they pursue scientific answers to questions about the natural world. This chapter describes the research paradigm for this study, examining the philosophical, ontological, and epistemological framework supporting methodological choices. Methodological choices are examined with the rationale provided for each choice.

Research Paradigm

A constructivist research paradigm was chosen for this study. The study questions the focus of science education on the cognitive domain to the exclusion of the affective domain, as a seemingly artificial separation that may not accurately represent the knowledge constructions of spiritual women scientists who teach science. Situated within a constructivist paradigm, the researcher takes the position that knowledge is a result of perspective, constructed in the social and cultural context of lived experience. Exploring how women come to scientific and spiritual knowing involves understanding the lived experiences and constructed conceptions of scientific and spiritual knowing as influenced by social-cultural factors. Realities are as numerous and unique as lived experiences, therefore a single path to knowledge cannot exist. Scientific knowing may differ as a function of gender, spirituality, and the type of science studied. To the male atheistic bench scientist scientific knowing may be conceptualized differently as compared to the female Presbyterian field geologist. Spiritual knowing may be conceptualized and perceived differently due to faith traditions that differ in their view of the Divine, humanity's place in nature, religious doctrine, and sacred texts. Due to the complexities of socio-cultural factors, an exploratory study using naturalistic inquiry methods was

chosen. Consistent with the constructivist paradigm, naturalistic inquiry employs data collected in the context of lived experience, such as through semi-structured exploratory interviews (Lincoln & Guba, 1985). The semi-structured interview provides movement within the data collection process to explore topics relevant to the participant yet unforeseen as relevant to the researcher.

Case study was chosen as it allows for an "empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Denzin & Lincoln, 2008, p. 116). Each person serves as a case, meeting qualifying criteria for the study as a person whose point of view is relevant and has worth to inform others of the life experiences and conceptions of spiritual women of science. Participants were purposefully and theoretically sampled from a larger pool of possible participants to maximize the diversity of ways scientific and spiritual knowing may be related in women of science. By listening to women scientists and analyzing responses for emerging patterns using grounded theory (Glaser & Strauss, 1967) the researcher may gain access to understanding the scientific and spiritual knowing of women scientists.

Limited to women scientists whose work includes a formal or informal teaching component, the purpose of this study is three-fold. First, the study aims to understand how women scientists come to scientific ways of knowing. Next, the study aims to understand how women scientists relate scientific and spiritual knowing. Third, the study aims to understand how women scientists portray scientific knowing to others as they informally or formally teach science concepts to non-scientists, as instructors, nurses, presenters, and graduate student mentors.

Researcher

The researcher is a Caucasian female with European American and Native American ancestry whose upbringing included active participation in a Christian church and extensive experiences in the outdoors. While attending a state university and teaching, she earned a BS in biology and education, and a MS in biology with an emphasis in aquatic ecology. As a research assistant, she worked for the state collecting and identifying fish in Central Texas streams, and assisted with masters level research projects involving the roosting behaviors of Mexican free-tail bats, the blood homocysteine levels and aorta blockages of rats fed high cholesterol diets, and the dragonfly larvae diversity of a post-reclamation lake.

Her science teaching experiences are varied, including laboratory and field-based courses such as botany, zoology, general science, 8th grade Earth Science, high school Biology I & II, Honors Biology, and Anatomy Physiology, science majors biosciences, non-majors integrated sciences, non-majors biology, physical geology, human nutrition, environmental science, and science methods for pre-service elementary school teachers. At the time of the study, she is a wife and mother of a middle school son and daughter, a full-time PhD student, and part-time science instructor. She maintains a strong non-traditional spiritual life and adheres to, and teaches her children a Christian-based code of ethics.

Method

Recruitment

A pool of possible study participants was created in Spring of 2011 with all potential participants resulting from recommendations by Texas Christian University

faculty, faculty from other universities, and personal and professional acquaintances. Potential participants were contacted via email and asked to complete a qualifying questionnaire to determine fit and willingness (Appendix A). Criteria for inclusion is that all participants are women at least forty years of age with advanced degrees in the sciences, worked in the pure or applied sciences, are involved in communicating science to nonscientists, and self-identify as having a strong spiritual commitment. Women not meeting the above criteria would be excluded from the study, as would individuals who are non-English speaking. All respondents meeting the above inclusion criteria were placed in a pool of possible participants. Invitations to participate were sent via email and the first interview was scheduled. Before interview, each participant signed and returned a written consent and media release form. Theoretical sampling was employed to select women from a variety of science careers thus maximize similarities and differences of information (Yin, 2009). Following the interview/s each participant was asked to recommend a woman in science for consideration as a participant and to provide contact information.

Participants

Participants for this study include a purposeful and theoretical sample (Creswell, 2009) of six spiritual women with advanced degrees and careers in the applied health, biomedical research, or natural sciences who communicate science to nonscientists. The demographics of these women can be seen in Table 1 followed by descriptions and quotes from participant qualifying interview questionnaires. Original participant formatting of questionnaire responses is maintained in the quotes, including capitalization, quotations, or emphasis.

Table 1

Demographic information of participants

	Spirituality	Degree/ Career	Age	Ethnicity	Marital
Anna	Native Am	PhD Paleontology/ Professor of Env Science	60's	Native Am	Divorced
Beverly	Presbyterian	PhD Geology/ Professor of Geology	60's	Caucasian	Single
Donna	Baptist	PhD Science Education/ Biomed	40's	African Am	Single
Jill	Catholic	Nurse Practitioner/ Oncology	40's	Caucasian	Married
Sara	Roman Catholic	PhD Paediatric Nursing/ Nursing Ed/ Admin	60's	Caucasian	Single
Terri	Disciples of Christ	PhD Planetary Geology/ Researcher/ MDiv	60's	Caucasian	Single

Anna is a native of the southwest who earned a BS in geology, MS in biological

systematics, and ecology, and a PhD in paleontology from Tier 1 research universities.

Her large vertebrate biomechanics research allowed her to serve as a consultant to zoo

personnel regarding the care of large reptiles. Ongoing areas of interest include

evolutionary theory, and the epistemic practices of education. As founder of a non-profit

research and educational organization focused on researching the different ways people

come to know the natural world, Anna has received multiple National Science

Foundation (NSF) grants. Currently Anna is a professor of environmental studies at a

Tier 1 research university and continues to serve on NSF grant committees. She was

married and has an adult son. Raised a Native American Christian, Anna identifies herself spiritually as a mystic.

> I am told by theologians that I am both an 'animist' and a 'mystic,' but I find the definitions and pronouncement of people from other cultural traditions can be over-drawn and/or simplistic…I am an enrolled member of the Choctaw Nation of Oklahoma and find that my spirituality tracks fairly closely upon the spiritual world-view commonly found among Indigenous persons. (A, Q, 23)

> My doctorate is in vertebrate paleontology with an emphasis on biomechanics. I taught in biology departments at the college and university levels for many years. However, my work then moved into the area of science education as well as that of integrated science (including the "science and religion dialog"). After that, my work moved into the realm of Native or Indigenous science. Most recently it has moved into the area of public education about the natural world that uses what I consider Integrated Ways of Knowing and Learning. (A, Q, 9)

Beverly is a native of the southwest and was the primary caregiver during the last years of her mother's life. Earning a BS, MS and PhD in paleontology from Tier 1 research institutions her research focused on Cretaceous sediments and ancient reefs. Currently Beverly works as a full professor of geology at a Tier 1 research university, instructing courses in history of geology, paleo-ecology, oceanography, and field studies in marine biology and geology.

The research I do now basically still involves paleontology… most recent

projects were Cretaceous reefs and I still send students off to study

modern reefs... Um, my masters student who just graduated this summer

went off to the Bermuda biological station…I've got another student now,

a PhD candidate who is working…on some of the ancient reefs that I

worked on when I was in grad school… Basically the work that I do with

ancient rocks and ancient fossils are all things that live on mud substrates.

The reefs that I look at are mud reefs, so that is the unifying factor. (B, I1,

422)

Identifying herself as a practicing Presbyterian, Beverly is active in her attendance and

church participation, and is an elected church elder. Beverly describes her spirituality and

current work in the sciences.

Donna earned a BS and MS in the biomedical sciences and worked as a

biomedical "bench scientist" researching brain receptors, gene mapping, and colon

cancer. In her forties Donna earned a PhD in science education and currently teaches

biology courses to pre-health students at a community college. Donna identifies herself as

being committed to Christianity as a Baptist and is active in attending and participating in

a Baptist church community.

I was involved in two different projects at medical center [name

omitted]. The first project involved mapping and sequencing chromosome

11 as part of the Human Genome Project funded by NIH. The second was

with the Center of Basic Neuroscience research. With this group I worked

on nerve receptor experiments and colon cancer. I supposed that I am

more closely related to biology. That was over 10 years ago. Currently, I

teach pre-health professions students anatomy & physiology and

microbiology classes. Occasionally I teach non-science majors general

biology. (D, Q, 715)

Jill is a native of the southeast, one of the youngest of 12 children, and recently

married in her forties. After earning a BS and MS in nursing Jill took a position as a

nurse practitioner in oncology and has continued to work with oncology patients.

I am a nurse practitioner working with stem cell transplant patients, but in

the clinical setting not in research…I work in a clinical setting that

involves providers and patients. (J, Q, 916)

Patients under Jill's care have been diagnosed with terminal cancer and are in the process

of being screened, and experimentally treated using stem cells. Identifying herself as a

practicing Catholic, Jill is active in attending church and practicing her faith through

ritual and prayer in daily life. Jill describes her daily work.

Sara served in the military as a nurse. She earned a BS, MS, and PhD in nursing,

and an MA in Christian Spirituality. Currently Sara works as Director of Nursing

Education for a tertiary pediatric hospital providing care and medical research protocols.

Sara described the multiple aspects of her daily work in healthcare.

I am immersed in explaining complex physiologic and pathologic

processes as well as rationale for medical therapy to lay people from

toddlers to adult family members, as well as supporting the development

of newly graduated nurses in their transition to providing holistic care in a

tertiary [pediatric] medical center where they see things they thought they

would only read about in school. (S, Q, 34)

Sara is a practicing Roman Catholic actively engaged in supporting nurse trainees in a

holistic care setting, and provides spiritual direction and pastoral counsel.

Terri is a native of the southwest and currently cares for her aging mother. She

earned a BS in geology, MS in planetary geology, and PhD in planetary geology from

Tier 1 research institutions. Terri's science research focused on vulcanism, interpreting

surface images of Mars, and serving as NASA mission director.

I used to work in the natural sciences research…I went from scientific

research to a science support role in operating and managing a planetary

exploration mission… I do interpret science for non-scientific audiences

within the context of talking about faith and religion. (T, Q, 3)

After serving as mission director Terri left the Jet Propulsion Laboratory, earned a

MS of divinity degree and became an ordained Disciples of Christ minister. An active

church member, Terri currently works in adult religious education at a Tier 1 research

university, and maintains a strong interest in the relationship between science and faith.

Data Collection

Data were collected in three ways for this study. A qualifying questionnaire was

used to obtain a pool of participants, in-depth ethnographic interviews were used to

collect the words and hear the voices of each woman, and a journal was maintained by

the researcher to capture field observations and analytical notes.

Interviews. Two forms of interviews were conducted between June 15, 2011 and

August 15, 2011 depending on the availability of interviewees. Two 45-60 min phone

interviews were conducted with some participants while a single 90-120 minute face to face or phone interview was conducted for other participants. During interviews, verbal and non-verbal communication was noted where available, and used to gain insight into the points of view and conceptions of participants as follow-up questions were crafted. All interviews were audio-recorded while field notes were recorded. Field notes were expanded within 30 minutes of each interview with initial thoughts recorded and follow-up questions crafted. Audio recordings of interviews were transcribed within five days of the interview with additional thoughts recorded during transcription.

Interview questions were semi-structured and sequenced to flow from one topic into another in order to explore paths to ways of knowing and conceptions of scientific and spiritual ways of knowing a) independently of one another, b) as they may relate, and c) how they may be portrayed to others. The first portion of the interview aimed to build rapport and trust and to cast the researcher as academic learner and listener (Creswell, 2009, p. 13). Interviews focused on lived experiences leading the participant to a career in the sciences. Beginning with the participant's early experiences this first interview section explored how each woman came to science, sources of interest in science, life experiences that drew her to science, how she currently views her place in science, and the ways science has been communicated to non-scientists. This first interview section ended with an exploration of the participants' conception of scientific knowing, asking the participant to define scientific knowing and to distinguish this way of knowing from other ways of knowing.

The second section of the interview focused on the path to spiritual knowing, the nature of the participant's spiritual life, spiritual life experiences. This second section

ended with an exploration of the participants' conception of spiritual knowing, asking the participant to define and distinguish spiritual knowing from other ways of knowing.

The final interview section explored the relatedness between the participant's scientific knowing and spiritual knowing. Within the context of their life and work, participants described issues, and experiences where science and scientific knowing intersect with religion or spiritual knowing. Demographic data were collected regarding parent occupations, schooling, marriage status, children, and age.

Journal. A research journal was maintained with several types of entries to aid in organization and analysis. Entries include meetings, diary, theory, writing ideas, readings, future studies, and questions modified from Glesne (2006). Meeting (pink) entries describe meetings with the dissertation chair and related directions, guidance, and thoughts. Diary (red) entries are inner thoughts, communications to self, personal concerns, and reflections. Readings (blue) entries are a record of thoughts on readings and how readings may relate to other readings, research in progress, themes, and data units. Future studies (orange) are a recording of ideas that could be future studies but are not part of the current study. In this section new questions and thoughts are captured, to address at a later time. Questions (yellow) are ideas that cannot be explained, thoughts to consider without clear resolution and study related concerns to revisit and change to another color. Theory (purple) entries are research ideas, thoughts, diagrams reflecting directional changes, and theoretical development to show how study ideas and themes are defined, relate to data units, and may relate to one another. Writing (green) entries pull from other colored entries and capture in diagram, outline, and text form how ideas could be tied together, possible bridges from one idea to the next.

Data Analysis

Ethnographic interview transcripts, qualifying questionnaires, and follow-up emails were coded to identify units and organized to note emerging themes using constant comparative method with the goal being to seek understanding and construct meaning (Lincoln & Guba, 1985). The constant comparison method proceeded as follows through steps of organization and analysis. Organization included formatting, transcription, and reduction to unit cards. First transcription documents were formatted with header (transcript type, data collection date, participant pseudonym and page numbers), margins, font, and line numbers. An interview audio-recording was then transcribed by the researcher on the formatted transcription documents and edited for misspellings, punctuation, and grammar. Other transcript types including qualifying questionnaire and email correspondence were formatted. Researcher comments regarding non-verbal data, tone, etc. were placed in brackets. A copy of the transcript was printed on colored paper unique to each participant.

Reduction of a text to data began by combining qualifying questionnaire, transcript, and follow-up emails into a single digital document. One of organization and reduction, this step involved the development of units of analysis and codes (Wiersma & Jurs, 2005). Sentences or short paragraphs that can stand on their own and represent a single line of thought, idea, or topic of interest were defined as a unit. Units were distinguished from the previous unit using a symbol at the beginning, and a line space at the end. Once a transcript was unitized, all data units with associated transcript line numbers and header information were printed on 4 x 6 index cards of a color specific to the participant. Card headers include participant pseudonym, date, data source

(questionnaire, transcript, email), card number and total cards for the participant. The first round of unitizing produced approximately 100-150 data unit cards per participant. Cards were determined to encompass multiple data units, and data sources were re-unitized by splitting paragraphs containing multiple ideas, as needed, into multiple data units. The second round of unitizing produced approximately 250-300 units of data for each participant. Of these data units approximately 200-250 units per each of six participants was deemed both relevant and significant to the research questions for this study. Total data units/cards for all six participants were approximately 1000 units.

Analysis took place when unit cards were sorted and resorted for comparison and re-comparison to maintain analysis and reanalysis throughout the length of the study. The process of analysis began with data unit cards from the first participant. All data cards for the participant were carefully read and sorted into piles representing preliminary themes relevant to research questions. During analysis those cards with two units were printed in duplicate so a card could be placed in the pile for each appropriate theme. Cards representing two pieces of a single unit were stapled together as one unit. Once all cards were sorted into piles a white label card was made with the name of the theme, phrases and sentences were added to define the theme. After all cards of a transcript were sorted into piles, piles were arranged with respect to other piles to represent a flow of thought, chronology of events, causal relationships, assertions, theoretical propositions, or other form of relatedness. A white memo card was used to record each pile and the associated emerging theme as defined from the nature of the language on the unit cards. Each card was reread to ensure fit to the defined theme then marked with a colored line symbol on the corner to indicate the pile in which it was placed for the sort. A second white memo

card was used to record themes arrangements resulting from the sort, and the theme card pile and memo cards were rubber-banded together. Long descriptions of each theme with an aim of fitting "the data well so they are recognizable descriptions of the item, activity, or discourse under consideration" (Richardson, 1996, p. 92) was written on the label card and in the research journal. A memo was made in the research journal recording the date, themes, theme definitions, and relatedness.

Analysis was constant comparative, thus after each interview, cards for the new transcript were sorted into theme piles with cards from prior participants. In this way, new themes emerged and old themes reoccurred to gain additional evidence and support the theme, modify the theme, or suggest a subtheme. Themes emerging from a sort informed future interviews, resulting in question modifications, additions, and deletions. The final interview protocol moved to further explore or focus more clearly on emerging themes as relevant to research questions. Using this constant comparative method, data analysis was a process of "continually sifting and comparing elements (such as basic data instances, cases, emergent themes and theoretical propositions) throughout the lifetime of the project" (Richardson, 1996, p. 92). Analysis served to identify similarities, differences, and support theoretical propositions.

An additional analysis of text applied learning from the broad analysis of all available transcripts seeking evidence in support of past themes and new themes. In addition, patterns emerging from interpreting units within each theme lead to the splitting of themes into subthemes. The memo cards and journal were used to record thoughts regarding subthemes with the rationales for splitting themes into subthemes. Journal entries were used to record possible links between themes. A larger context, big picture

view perspective was considered while examining specific cards for evidence of a theme. Some interview audio-recordings were listened to repeatedly to clarify context and tone, expression, emphasis and remind the researcher of non-verbal cues related to a response. Repeated cycles of analysis and organization served to become familiar with the data and then identify themes, subthemes, support assertions, and relationships between assertions to increase reliability. In this way themes were developed through an "active 'flip-flop' between the data and the researcher's developing conceptualizations demands a dynamic process of changing, re-changing and adjustment of the terms used until the fit can be improved" (Richardson, 1996, p. 92). Through multiple cycles of analysis negative data and discrepant data was identified. Negative data supported the rejection of a theme, pattern, assertion, theoretical proposition, subtheme, or suggested the development of an alternative or opposing theme. Discrepant data also provided another perspective, theme, or pattern (Ary, Jacobs, & Razavieh, 2002). Following the final analysis documents were created for each theme and quotes in theme card piles were copy and pasted from transcripts to theme documents and labeled with identifying citations (participant, source, line number).

Five major themes emerged from the constant comparative analysis of data sets of six participants. First, Passive knowing emerged as a major theme categorizing units describing attendance or exposure knowing without choice, commitment, or engagement in the knowing process. A second major theme, Mindful/Inner knowing includes private, quiet ways to know the Sacred and nature through observation, listening, being with and present, meditation, prayer, reflection, and seeking meaning in events. Engaged knowing emerged as the third major theme, categorizing those units describing an action to know

such as exploration through questioning, examination, or testing that is distant from what is being known. Relational knowing is the fourth major theme which categorizes units involving interactions with the Sacred that are experiential, dialogue and interactions with people, and involvements with groups that are cited as influential. Lastly, Integrated lifeworld knowing emerged as the fifth major theme. An over-arching theme, Integrated lifeworld knowing categorizes units of relatedness between scientific and spiritual knowing, connections to personal and professional lives of these spiritual women of science, and the consequences of a scientific and spiritual separation.

Interview protocol included asking participants to describe the relatedness between scientific knowing and spiritual knowing using a diagram where each way of knowing was represented by a sphere. Responses to this diagram representation yielded degrees of overlapping spheres with explanation. An early participant highlighted the limiting nature of the diagram question, providing her own mental image of relatedness. Later interviews moved toward a more open-ended question that resulted in a diagram or descriptive metaphorical representation based on words used by participants to describe the relatedness of scientific and spiritual knowing.

Verification

The final steps of data analysis involved member-check reporting of the analysis to study participants. Each participant was contacted and encouraged to respond to their case study to increase clarity and validity. Further data collected through these member checks served to verify the accuracy of interpretation and analysis. All participants responded stating they had been interpreted and depicted accurately, with a few minor alterations. Jill did not reply to requests for review and response.

Chapter 4: Results

Five major themes emerge from analyzing the interview transcripts of six spiritual women of science. Participant responses support that spiritual women of science come to a spiritual and scientific knowing through 1) Passive knowing, 2) Mindful/Inner knowing, 3) Engaged knowing, 4) Relational knowing, and 5) Integrated lifeworld knowing. Spiritual women of science come to know, interrelate, and portray science with spiritual knowing using these five ways of knowing.

Themes

Theme 1- Passive knowing

The first major theme emerging from analysis of participant interviews is Passive knowing. Participant responses support a way of knowing that takes place in contexts with little or no choice, engagement, or outer activity, and requires observing and listening. Responses of four participants reflect a tone of obedience to expectation, duty, and respect, while one response conveys a tone of resistance. Words commonly found in responses include 'attendance', 'expected', and 'going along with'. Because Passive

knowing is present in all six participants, seems understood as a typical or common way to come to spiritual, science, and nature knowing. While passive knowing experiences may be related to events of engagement, responses most often are missing descriptions of active engagement.

Passive knowing about religion. All six participants began attending church as children. When asked how they came to spiritual knowing, all participants stated they attended church with family. These responses, categorized as Passive knowing about religion are an exposure to the culture and traditions of religion. Responses have similar

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aspects that are present and similar aspects that are absent. Present in each response is attendance with family with the implication that attendance is expected. Responses most often use the word 'attendance' and the word 'expectation' is also frequently used. Absent from each response is choice and active engagement. Responses are a brief description of the context and do not include details of church-related events, personal reasons for attendance, a relationship with the Sacred, internal thoughts or feelings, or the presence of an inner spiritual practice such as prayer. Four of the participants describe Passive knowing about religion with a tone of acceptance of the expected, with one taking a tone of rejection of the expectation. Take for example this response by Jill to the question, How did life experiences bring you to your current spirituality?

> I think that I grew up in a family that is really religious. It was something
> that was expected when I was younger and I remember just going along
> with it because that is just how you were raised. You followed the
> Catholic tradition, you went to church, you went to confession, and that is
> what you did. I did that, but it wasn't until after college that I felt like I
> made a conscious effort to go to church. (J, I1, 189)

Jill's describes a Passive knowing about religion through attending church with family and then goes on to distinguish this early attendance from a later 'conscious effort'. When asked what drew her to her religion, Jill explains:

I think initially I didn't know, I just knew that it was something my family

practiced and this is what we did. And then what drew me after college is

the same thing that maintains me today; that sense of comfort, that sense

of peace. (J, I1, 222)

Jill's response distinguishes a Passive knowing about religion from a later

and more Engaged knowing of participation resulting from a choice and deeper

spiritual understanding related to a personal benefit. Her childhood church

experiences are a Passive knowing of religion, an attendance but without

engagement, choice, personal reasons, details of the church events, relationship

with the Sacred, or an inner religious practice of prayer.

When other participants were asked, 'How did you come to spiritual knowing?'

their responses also exhibit aspects of Passive knowing about religion, and are different

from responses about a later more engaged knowing. Beverly describes her church

attendance, and implies that what she gained from attending church was not enough to

allow her to decide about baptism.

My mother was very open with things, we would attend church together,

but I wasn't baptized until I was a teenager because she thought I really

needed to know what it was before I was actually baptized. (B, I1, 317)

Donna similarly follows her mother's lead in Passive knowing about religion.

Later she creates a knowing based in choice and relationship with God in her heart.

Well I was brought up going to church, that was the first thing but I can't say that my spirituality was there. I went with my mother to a Baptist church. (D, I1, 138)

I believed in God but I don't know if I could say he was sitting there in my heart the way he is now, to feel what I feel now, it was me who did that. (D, I1, 163)

Similarly, Terri attended church with family as a child through 5th grade, but 'floated free' from middle school until after graduate school.

I grew up in a Disciples of Christ church in Houston and so my family went to church pretty much every Sunday. We were very active in that church up through my baptism…I was kinda floating free for awhile...

floated free for a while, you know, [changes from distant telling voice to personal quoting voice] [I am] spiritual but I can do it on my own. I can be spiritual and not religious. (T, I1, 213)

Terri engaged in Passive knowing about religion by attending various churches from middle school until her twenties and describes this time as 'floating free'. She attended an agnostic New Age spirituality group with her parents, a southern Baptist church and youth group, and mass services at a Catholic student center with a college friend from Italy. Her descriptions do not focus on participation or an exploration of these faiths, but on a passive attendance of listening, and watching.

Not all examples of Passive knowing about religion are positively influential in spiritual development, but all participants describe an earlier time where knowing is

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passive and different from a later more active religious and spiritual knowing. While Jill, Beverly, Donna, and Terri support Passive knowing about religion through church attendance as expected, common, and beneficial, Sara and Anna emphasize the lack of fit. Anna and Sara support that Passive knowing about religion is distinctly different from an Engaged knowing where spirituality is created from lived experience. Anna was expected to attend church as a child as highlighted by her parental links to the church. Her great-grand-father was a Baptist circuit-riding preacher and that her grandmother founded the church where she was raised.

> My parents were very devout people, but most especially my father. My
> Choctaw family was Christianized long before coming to the Nations
> [Oklahoma]. (A, I1, 244)

However, she became resistant to the expectation to attend and found she could not blend her Native American spirituality with Christianity.

> I have had many experiences as a child and adult with churches, religious
> organizations of one kind or another…None of it turns out to work for me
> or really to help me get anywhere productive. (A, I1, 280)

Anna attended various Christian churches but did not commit or become engaged in them, nor did she develop a Christian-based religious practice.

Sara regularly attended Orthodox Catholic church and school. She expressed strong reactions to the expectation. Sara's reaction to Passive knowing of religion is strongly resistant.

And, from the time I was about ten, um, the whole context of a very

traditional Orthodox Roman Catholic context, I just a, I rebelled against it.

(S, I1, 51)

The first eight years were indoctrination, they weren't education. [Sara

later added that they were more indoctrination than education] (S, I1, 71)

…they [her parents, teachers, and pastors] were expected to know and

therefore you were expected to believe what they said. (S, I1, 925)

Sara's reasons for attending and resisting are one and the same; she was expected to come to know religion and spirituality through a Passive knowing about religion, and she was expected to not only accept what she was told but to believe it without question. Sara's reaction to Passive knowing about religion is strongly resistant.

Passive knowing about science. Responses from all six participants mention attending school, and most mention choosing science courses in high school. None of the participants list, mention, or describe school or other formal science education experiences before the sixth grade. Passive knowing about science is a theme emerging from the absence of engaging responses with school science K-6, and responses that indicate an expected shallow exposure to science as presented in school. When present, school science is described without emotional connection, lacking engagement, or a commitment to know. Two participants describe events about their high school science experiences that reveal a lack of engaging or influential memories, relatedness, or connection to science or nature. Donna describes coming to science by listing the courses that prepared her for college, and began an interest.

So I attended a parochial high school where you know I took chemistry

classes, biology classes, physics and things of that nature… I decided to

continue to take science classes, and I hate to admit this [laughs] but most

of the cute guys were in the science classes. So, I decided, hum, I'm going

over there with them. While I was sitting there with them I did become

interested in studying science further. (D, I1, 24)

Terri also describes a solid background of science courses in high school such that

choosing science for her was "natural all along, I had good teachers, good schools, and a

college prep high school" (T, I1, 189). Her experiences with science in high school

provided Terri with the expected foundation but are described without emotion and

lacking memorable experiences.

Two participants do not begin describing how they came to science using

experiences from middle or high school or by listing of college preparatory courses. Sara

and Anna skip K-12 and begin describing how they came to science with their science

experiences in college. In a college physics class Sara shares a memorable experiences of

Passive knowing about science. With an irritated tone Sara describes a college physics

course.

One of the most memorable classes, not in a positive way, was a physics

class…we were in three different auditoriums with television sets. And

um, we were lectured to, and I was totally disinterested and I couldn't have

cared less. (S, I1, 22)

These women do not cite elementary science experiences as influential in their

path to science knowing. School science is described as providing a solid

preparation for college or graduate school not as active or influential. Influential

school science experiences begin after the sixth grade, take place outside of

school in informal settings, graduate school, or real-world experiences. All

descriptions cited as influential are active and therefore inconsistent with Passive

knowing but consistent with Engaged knowing.

Theme 2- Mindful/Inner knowing

The second major theme emerging from analysis of participant interview

responses is Mindful/Inner knowing. Participant responses support a private way of

knowing that is both thought and feeling. Mentally active and present, Mindful/Inner

knowing may be reflective and may link prayer to spiritual meaning in life events.

Although seemingly passive and quiet, this private inner knowing is based in an action of

prayer, meditation, silence, being present, observing, and listening. Mindful/Inner

knowing may relate to faith, feelings of wonder, connection, awe, gratitude, security,

grace, awareness, comfort, joy, or peace. Taking place in a formal or informal context

such as church, home, or the outdoors, Mindful/Inner knowing responses reflect tones of

intimacy, respect, and reverence. Words commonly used in responses include 'prayer',

'mindful', 'faith', 'comfort', and 'peace'. Mindful/Inner knowing is present in all six

participants as a way to spiritual knowing, and for two participants as a way to nature knowing.

Mindful/Inner spiritual knowing. A Mindful/Inner spiritual knowing theme involves a private spiritual life evidenced by belief in a higher power, faith in a higher power, regular meditation or prayer, and finding spiritual meaning in events. This is not a knowing through an examination of religious doctrines produced by others, but is a personally private interactive and experiential knowing. All six participants repeatedly reference an inner spiritual life that is integral to maintain personal spirituality, it is this private thinking and feeling life that is categorized as Mindful/Inner spiritual knowing.

Responses indicate participants prayed in various ways, including prayers of quiet meditation and awareness, thanks, meaning, sharing, and petition. Sara and Terri use different words to show mindfulness.

Sometimes it is silence, or a walk in the park, or sitting on a beach

watching the waves roll in. There are infinite possibilities. (S, I1, 719)

After taking a course called Pray Like a Mystic, Terri learned how to pray in nontraditional ways.

Then there was the experiential part and we started having some spiritual

growth groups where I first encountered…contemplative prayer and

centering prayer and being in the presence of God…It is being in

communion with God and feeling grace and so that started to happen

much more. (T, I1, 297)

I had what I would have to say was my first real and truly encounter with

Christ in an imaginative prayer and it was just life changing. (T, I1, 311)

It is experiential and also observational. It is dealing with what is beyond

the physical. It is a different layer of experience, maybe an internal

knowing rather than external knowing…it gives meaning. (T, I1, 479)

Donna's prayers also show mindfulness as conversations with God; she shares, seeks

guidance, and finds meaning.

I remember even when I was working in research I loved it…I felt a sense

of strong fulfillment there [in teaching], even stronger than with the

science discovery…I'm at the crossroads…And I'm sitting at work and I

get this call about a temporary full-time job. 'Ok, I've made a plan and

Lord are you trying to change my plan.' [talking to God] So I'm sitting

there at the microtome cutting some brains, ok and I'm feeling a strong

pull to go toward this world of uncertainty. (D, I1, 179)

Her prayers are coupled with feelings of security and peace, and give meaning to

life events.

And I did quit research and took the temporary job and along the way a

permanent one came open. I had no doubt in my mind even though I had

to go in competition or it against outsiders, I had no doubt that I would get

it. I had this strong feeling that this was where I was supposed to be, I was

pulled in that direction and that strengthened my belief in God. (D, I1,

196)

Donna believes that God has a plan for everyone and obtains spiritual meaning

from life events as confirmation, not requiring additional evidence.

For me it's believing God has a plan for me and everybody else and no

matter what is going on in my life I believe things are going to work out,

or that I have faith that it is going to work out…I guess it is the faith, it is

just going to happen and I don't have to go out seeking proof that the

shroud is real or anything like that. It is there, it is done [bold and

adamant]. (D, I1, 232)

An inner life with God is the basis for Donna's faith, with practice taking second.

One thing I don't sit on the fence about is my belief in God. So I just feel

like the practices may enhance that but really Him being in my heart and

me having a strong belief and a faith in Him overpowers any of the

practice. (D, I1, 251)

Anna's Mindful/ Inner spiritual knowing shows a strong feeling of Spirit's

presence, she seeks guidance, assurance and comfort from prayer. Her answer comes in

the form of a dream and song that spoke to her with spiritual meaning.

I work the job I work to make money for food, but it is THIS job instead

of another job because I prayed hard when I was looking for work. The

day they offered it to me, I woke up with a very particular song in my

mind as loud as if the music was on a radio, and it was music that has such

a certain significance to me that I knew it was saying, 'You will get that

job today and it is a good path to take.' (A, I1, 401)

Prayers may accompany practice. Take the response by Jill regarding praying the rosary. A lengthy practice requiring great focus and concentration, this is a mindful meditative prayer and of thanks and petition, based in faith, seeking spiritual meaning.

I maintain prayers every night before I go to sleep. (J, I1, 235)

The Blessed Mother is someone that I do include in my prayers because I

am always grateful for having given her only son…I always think of the

Blessed Mother and the patience she had to endure to give up her only son

to be sacrificed on behalf of us all. (J, I1, 270)

I've been in that particular situation where being diagnosed with a

particular form of cancer…maintaining my faith, my strength in God

knowing that I can handle, you know, what's in front of me…I think a

positive outlook is also the reason I was able to get up and go running

everyday despite going through radiation because I was keeping my mind

strong, my faith kept me pretty comforted and secure because of my belief

in God. And so I went to the treatment everyday but at the same time I

continued to do my running despite being fatigued. (J, I2, 744)

Jill practices a Mindful/Inner spiritual knowing that provides assurance, strength, comfort, and security from her prayer to God in faith.

Sara also experiences a Mindful/Inner knowing, prayers of petition based in faith and spiritual meaning from life events. A teenage boy came to the hospital having seizures, nothing seemed to stop them and they continued for over twenty hours. Sara waited with the boy and his mother as arrangements were made for him to be airlifted to a neurology specialist.

> I was holding the young man's hand in silence and I began to simply pray
>
> for rest. I didn't care about a cure, didn't want a diagnosis, the only thing I
>
> was interested in obtaining for this child was rest, sleep. It had been
>
> twenty hours and he was cramping in pain. This kid turns to me, looks
>
> straight at me, and falls asleep [she smiles]. (S, I1, 522)

As a nurse practitioner Sara believes there is "another power beyond me" (S, I1, 475). From a Mindful/Inner knowing involving faith in God she finds spiritual meaning in life events.

Beverly maintains a Mindful/Inner spiritual knowing of awareness, providing spiritual meaning for life events. Abroad when her mother unexpectedly passed away, Beverly was on an island east of the Philippines and experienced her mother's presence.

> When my mother passed I was actually in the Pacific and it was a strange
>
> situation in that she was always interested in Indians and cliff dwellings
>
> and Pueblos and things like that, and I actually was on the Island of

Pohnpei and there is an eastern Asian religious site called Nan Madol and

I visited it on that day. And, it was really weird because I turned to the

people I was with and said, 'It is as though my mother is here because this

is the kind of place she would like to be.' (B, I1, 602)

With a Mindful/Inner spiritual knowing Beverly felt her mother's presence. When

she later found out her mother had passed away, she was comforted. This form of

inner spiritual knowing is evidenced by various types of prayer, meditations, or a

prayer linked to an event with spiritual meaning.

Mindful/Inner nature knowing. A Mindful/Inner nature knowing is a near and

quiet knowing being mentally involved, present and aware, and experiencing a

meaningful connection with nature. This Mindful/ Inner nature knowing is personally

created through spontaneous experiences, rather than expected, structured, or involving

knowledge created by others as in Passive knowing about science. Although experiences

differ, Terri and Anna describe vivid memories of being present in nature and feeling a

sense of connection to nature and its wholeness. Throughout childhood Terri spent time

each summer near Llano, Texas. She enjoyed observing, and experienced a feeling of

connection to nature with openness, awareness that produced a sense of peace. Terri cites

these experiences as most influential in her choice to study science.

I think I developed a love of the earth…in the summertime I used to go up

to Central Texas to visit my grandparents, this is the Llano area, [and]

there is granite and a really interesting landscape. I just loved the

topography...we would go out to Lake Buchanan, and…I would be sitting

out on the boat dock by myself, and just looking up at the stars, and the

immensity of the sky, and really feeling comfortable, and in awe, and

drawn to that sky. So I really appreciate the world. (T, I1, 28)

Terri also experienced Mindful/Inner nature knowing later in adulthood while

working on NASA missions. In both instances, she describes as having a sense of

connection to nature, and reflects about how she is related to the universe.

They had this spot on it and they had discovered this very active volcano

on Io, this moon of Jupiter. I can just remember the thrill that went

through me when I heard that…Just this joy of a dynamic universe that we

live in and I think up to that point, although I knew that there were these

processes going on outside the earth this was the first time that something

that I had worked on, volcanoes, were found on a different, essentially a

different planet... So, it was almost like my world essentially enlarged. (T,

I1, 96)

There was a sense of connection um, with other worlds, and so it gives me

this great appreciation, this dynamism that enlivens our world and our

universe…I think that is part of what also has drawn me to it [science].

There is something about this dynamic earth, these powers that are way

beyond our control, our sense of knowing but has always spoken to me of

something greater than I am. (T, I1, 495)

Terri's experience involves Mindful/Inner knowing nature connection through science

knowledge that allows her to feel part of nature as a whole. "Um, first of all the

experiences I'm remembering are those that help me and have given me a greater sense of

wonder and connection. Wonder and connection…" (T, I1, 113). These experiences she

shares are both scientific and spiritual and drew Terri toward geology.

Anna also came an interest in science through a Mindful/Inner knowing in nature

she describes as a Native American way she learned from her father.

He taught us how to relate to nature in…an Indian way…to pay attention

to our surroundings at all times – weather, sky, position of the sun,

animals, plants, insects, and to notice how all these things responded to us.

(A, I1, 58)

We would then begin to "stalk" the deer, seeing how close we could get to

them before they ran off. We would move very slowly, taking care not to

step on anything that made noise, and if a deer looked up we would freeze

absolutely still. We might stand that way for long minutes before the deer

relaxed and put its head down to graze again. (A, I1, 74)

Anna and her brother were quiet, and attentive from within nature, to see, hear, and be

aware of nature and its response. A Mindful/Inner knowing with nature is not an

investigation from outside, but from within nature. It is coming to know nature through

connecting with nature.

Theme 3- Engaged knowing

The third major theme emerging from analysis of participant interviews is Engaged knowing. Participant responses support ways of exploring and creating knowledge based in a choice and commitment followed by outward action. It is an examination of existing knowledge and the creation of knowledge by seeking resources, questioning, and testing through science processes or critical review. Engaged knowing most often reflects a tone of curiosity, drive, and an ownership of the knowing process or resulting knowledge. Words commonly used include 'explore', 'question', and 'examine'.

In some instances the process of seeking knowledge and resulting knowledge may find utility or application and move from private knowing to public knowing. In some participants the process may require public actions, but the knowledge is gained for personal use.

Engaged religious knowing. The early years of Passive religious knowing are different from later teen and young adult years of Engaged religious knowing. Actions described in Beverly's response help to define Engaged religious knowing. When asked how she came to know about her religion, Beverly shared her experiences in communion class. She wanted to know and understand the doctrines of the Presbyterian faith tradition and relate them to her own thinking and beliefs. Although this is a personal choice, the actions taken to seek understanding are public and involve a synthesis of personal knowing with knowing from other sources.

It [communion class] was a matter of my trying to make the decision on my own with guidance, but basically my family let me decide. Do I want

to be a part of the church? Do I want to accept God?...And I decided that

Yes [emphasized] there was a God and that god was my Lord and Savior.

(B, I1, 421)

Attending church with her mother was Passive religious knowing while

participating in communion classes would be an Engaged religious knowing. With

resources available to her, Beverly read, studied, questioned, and discussed the

doctrines of the Presbyterian faith tradition, related them to her own thoughts and

beliefs, and made an informed choice about church membership and baptism.

Donna, Terri, Sara, and Anna also made choices and commitments to be

intentional about spiritual knowing through exploration and study. Donna's exploration of

religion was encouraged by her father's own experiences. When his children were in their

teens Donna's father encouraged them to look into various Christian denominations

before making a choice. Donna learned about Baptist traditions from attending church

and Catholic traditions from attending Catholic school.   Over time, Donna created a

'blended' religious practice that fit.

I was baptized in a Baptist church but he [her father] told my mother that

he wanted me to discover the denomination and come into my spirituality

when I am [was] ready. (D, I1, 162)

My practice is strange because it is bordering on the Catholic and Baptist.

I'm not sure I haven't been picking and choosing what I want to do. (D, I1,

243)

Donna's religious practice was created in her lived experiences in the Baptist church and Catholic schools and her active seeking of understanding.

After attending various churches in the teen and college years Terri and Sara wanted to return to church but found it challenging to find a safe place to question and explore doctrines and the Bible. Both sought out numerous events and situations to help them understand religious doctrines, reject those that did not align with their own thinking, and develop a personal doctrinal system that fit with their own beliefs.

> I just could not get into their theology…I'm going to stay with a church,
>
> but I could not find a church that fit. I could no longer sit in a classroom
>
> and be told that the beginning of the universe was six thousand years old.
>
> (T, I1, 257)
>
> I just got tired of the hell and damnation preaching…I went to a Sunday
>
> school class that taught that the Pope is the anti-Christ and after a series of
>
> those events I just couldn't stay over there. (T, I1, 437)

Sara was driven to explore, question, find resources, and examine religion.

> I think the first thing was to get out of the box, ya know...well the problem
>
> is…things were pretty rigid…and I left for 15 years and explored a variety
>
> of things. (S, I1, 282)

I don't think you can [teach spirituality]. I think that is one of the things

I…have found…the most troubling about the traditional church. It is this

attempt to tell others what and how to believe. (S, I1, 453)

That [questioning] was from my core. Yeah, that [questioning] was

certainly not encouraged…I was interiorly driven to find what fit. (S, I1,

947)

Through an Engaged knowing with trusted resources Terri and Sara explored the Bible, examined beliefs, and questioned doctrines. Terri found a trusted resource in a biblical scholar.

I was fortunate that the New Testament scholar…gave us college or

seminary level understanding. We spent a year and a half on I Corinthians

but in that any reference to the Old Testament we went back there, we

went forward, we dug in, he knew the anthropology, the history, he put it

all together. (T, I1, 302)

Sara found a trusted resource in a priest.

And, then I ran into this Irish Catholic Priest and he asked me one day, So,

do you know why you left [the Catholic church]? And, I said,

'Absolutely!' and he said, 'Why's that?' and I said, 'That I am gifted with

intellect and I ask lots of questions and it isn't even ok to ask those

questions.' He said, 'Ask away.' And, so for a couple of years we did this

back and forth, about once a month and I thought, this is new for the

Catholic church. (S, I1, 332)

Sara also enrolled in a master's level program and studied the New Testament to

understand the teaching methods of Jesus.

So I think um, I explored scriptures in the same way that I explore science

with questions, with openness, with context, always. (S, I1, 393)

Anna was involved in Engaged knowing as related to her Native American system of

spirituality for many years. Through science and religion dialogues, readings, and

spiritual groups she studied many religions and came to understand why her Native

American-Christianity doesn't work for her. Native American system of spirituality is not

considered to be a religion, is not based in faith or belief, and does not have a Sacred text

or written doctrine. For this reason Anna consistently used spiritual, and spirituality in

her responses, rather than religion. She explains that it is a challenge to explain her

spirituality and how it relates to Christianity, Western culture, and Western science.

The box he [Ian Barbour] puts people in, who experience the world-

spiritual as well as material (and otherwise) the way I do- is really rather

misshapen…Some of the most wonderful conversations I've had were

with him. And he is brilliant…But I think those boxes are where you see

his Western worldview pretty entrenched. And he can't help that. I mean,

he is who he is, raised and educated where he was, and so on…But I also

feel that box is a procrustean bed, but in more like six dimensions than

two. (A, I1, 333)

Currently Anna's understanding of her own spirituality comes less from an exploration of the work of others and more from lived experience. She has found it difficult to live and work as a woman of science, in Western science systems, when her spirituality is intertwined with the natural world. Her journey is one of Engaged religious knowing, conscious and sought after, concluding that her Native American spirituality is often in conflict with traditional Western science.

Engaged nature knowing. Early years of school science were not represented in the responses about influences toward science knowing. Some participants did describe coming to know the natural world as children, but through an active, conscious process outside of school. Based in choice, curiosity, and drive to know nature by exploring nature and existing knowledge, an Engage nature knowing involves questioning, observing, and testing of ideas with the ideas of others. Jill's experience with stitches defines Engaged nature knowing. As a child observing stitches, she became curious about the human skin and healing, was filled with questions, and took actions to know.

> When I was younger, I was always intrigued by the human body and illnesses. Whenever I saw someone fall down or hurt their self or bleed, I always wanted to see and figure out the process of how to help them heal. I remember when I was six or seven when I first saw…someone getting stitches. I will always remember that. I was always curious as to how that would heal and the skin and what was going on. (J, I1, 17)

This observation led to questions. To answer her questions Jill found resources in books, pictures, and her sister.

I have to say most importantly my sister Jeanie because she was in the

nursing field; she is about eight years older than me. When she was in

nursing school I always wanted to look at her biology and anatomy books.

I remember...reading her books and we would talk about it. (J, I1, 33)

Anna's early explorations of dinosaurs began with books, pictures, and lots of questions.

…my favorite pictures in the book were a series showing … a well-known

Charles R. Knight reconstruction of what was then called *Brontosaurus*…I

began to look for it at the Tulsa zoo and when we were walking in the park

or driving in the country. (A, I1, 4)

In addition to books and pictures, Anna sought out others who could help her answer the

questions that were forming.

My father explained to me…that dinosaurs had lived long, long ago but

had all died out... There was this picture of what looked like a crocodile in

this Knight painting and that puzzled me. There were crocodiles at our

zoo, so why not a *Brontosaurus*?… I found these questions fascinating and

quite pestered my father with them. In response, he got out a cigar box of

fossils he had collected as a boy in Palo Duro Canyon…He had dinosaur

teeth and coprolites (fossilized dung), and many wonderful stories of

finding the fossils and talking to the paleontologist he met there as a child

... Before I began kindergarten, I had decided to become a paleontologist.

(A, I1, 4)

Anna and Jill are examples of Engaged nature knowing in childhood. Spontaneous interactions with the natural world spark an interest, questions, and a seeking to find resources to know. Anna was engaged in knowing dinosaurs with books, pictures, and questions before she could read.

As a graduate student Terri studied current geologic processes and historical evidences of these processes. She applied this experience to interpret core samples while doing fieldwork in groundwater study.

I went to Austin to work in groundwater engineering and one day we were

out. One of my jobs was to look at the cuttings that came out of the well,

to sit there and be holding sand that had not see the light of day in tens of

thousands of years. It was connection, real connection. (T, I1, 82)

Although Anna was already interested in dinosaurs, it was an experience in graduate school that Anna uses to describe how her science intertwines with her spirituality.

I wanted to understand how this one group of dinosaurs, walked- whether

they stood up "erect" or sprawled out or what. So I wanted to learn from

the bones themselves. My advisor wanted me to hook up alligators to a

treadmill and walk them so fast that they would go into a 'high walk' that

moves from sprawling to erect, and to insert electrodes in their muscles

during this. (A, I1, 371)

Anna believed following her advisor's suggestions would be meaningless, and she felt the process was disrespectful and cruel. To answer her questions using good science that aligned with her spirituality, Anna had to be creative and find additional resources.

> I wandered off on my own to find a way to listen to the bones…and wound up in the Mechanical Engineering department…I learned about stress analysis…After my initial analyses, I took some of the dinosaur bones to members of that community and asked them to approach them as if they were human clients. What they 'heard' matched what the bones had told me in stress analysis. (A, I1, 385)

To address questions without answers requires Engaged nature knowing using creative exploration and resources, especially when trying to live in a respectful and authentic spiritual relationship with nature.

Engaged science knowing. The middle school and high school years marked an Engaged science knowing, coming to know the processes and knowledge of science by doing science. This Engaged science knowing involves resources beyond books and pictures, and begins nature knowing through the processes of doing science. Beverly and Terri cite experiences doing science as integral to an interest in science, and for both these science-doing experiences take place in the formal structured settings of school. Beverly describes her interest in science beginning with the sixth grade science fair. After she abandoned a project with hamsters, she began reading her brother's geology book to find new ideas. Beverly's sixth grade science fair project sparked her interest in geology and is cited as the most influential experience leading her to choose science and geology.

Beverly continued to expand this original sixth grade science fair project throughout

middle and high school.

> I just think I was curious about science, I wasn't afraid of math… There
>
> wasn't any kind of taboo or anyone that said females shouldn't be geology
>
> majors. They said, 'You want to do geology, that's great!' And I went on to
>
> regional science fair every year, and to the state science fair every year,
>
> and got to go to the international science fair my senior year…[My project
>
> was] sediments in New Mexico and Central Texas in the Cretaceous
>
> period. (B, I1, 114)

In a high school oceanography class Terri began to do geological fieldwork, and cites this

experience of Engaged science knowing as one that drew her toward science and

geology.

> I took Chemistry…and Oceanography, a class that rivaled the one I took
>
> ultimately at the University of Texas. It was a great class and I could have
>
> gone in different directions but I liked history, and something in the
>
> physical sciences seemed to make more sense…Biology was ok but I
>
> really liked geology and so what drew me into the scientific field was the
>
> love of the earth and geology and that we could get out and do field-work,
>
> and it was not all in the lab and I just loved it. (T, I1, 33)

For Terri and Beverly doing the processes of science to answer questions about nature was instrumental in drawing them to science. When asked what these science processes were, Beverly used a puzzle metaphor.

I think it is…finding out new things and trying to make relationships

between modern and ancient. It is the discovery aspect… it is like a jigsaw

puzzle…trying to examine all the other possibilities. So its basically trying

to assemble all the pieces…make observations about the past and try to

use the present to figure those out. (B, I1, 286)

Terri explains her Engaged science knowing in a similar way, adding that science is not absolute, makes intellectual sense, and is used to inform decision-making.

Well, scientific knowing is what I experience…it is what I can experience,

measure, see, observe, it makes sense. It is intellectually cohesive, um.

There may be unknowns that you can push into that and they have to

either make sense with the rest of what you know, or not. In geology it is

more of a qualitative science…I used to drive the engineers crazy because

I could not totally define for them what an alluvial fan was. (T, I1, 465)

Uh, particularly on the mission we would come in [to work] in the

morning and there would be laid out the mosaics of the images they had

downloaded the night before and put together and we would see this new

terrain…Where are we going to put the lander? How do you decide which

surface is good? (T, I1, 73).

Jill also explains that she uses protocols resulting from Engaged science knowing, they are evidence-based research applied to health-care.

I guess a scientific way of knowing is looking at what my resources are, what has been done and researched, what has an evidence base? As far as looking at all of that data in the past and looking at the statistics…When it

comes to work you would only practice what you know may work…you

would try to put them on treatment plans that have evidence of success. (J, I1, 109)

Sara is involved in Engaged science knowing to answer questions about how to support nurse trainees. She explains that this science knowing is evidence-based, but involves holistic care, it is both physical and spiritual.

I don't think I am able to separate the two [science and spiritual knowing].

I am involved in research…nursing is accused of killing its young

depending on who you read at this point in our history, 18-42% of first year nurses change jobs. There has to be some reason, and in my setting, which is tertiary pediatric medical center there are lots of reasons that could happen. I know that for three years now we throw twenty-something year olds with a bachelors degree in a discipline into encounters of non-accidental trauma to children, life-changing or life threatening illness, the

death of people prematurely and we think that somehow they are supposed

to provide care and survive themselves. I think that is ludicrous. And so,

what we are observing is…they are capable…they can thrive…but they

have to have support for their whole person…I ask them, What are you

doing for exercise? Do you have a dentist, a primary care provider, a

church home? Are you meeting and caring for your whole person?

Because if you are not you will not have the source to be caring for

anybody else… (S, I1, 189)

Science knowing is evidence-based with regard to medical treatment of patients, but holistic healthcare addresses the whole patient, mind, body, and spirit.

The epilepsy monitoring is all about the science of neurological systems.

The PET scans and the CAT scans and video EEGs, and let's put all those

disciplines together…and see what we can do to help this kid not have 200

seizures a day or find a way to get this tumor out without taking away all

of his language and motor function…but at the same time there is an

approach to the entire family…the family system is cared for as a whole

and respected for whatever their beliefs or traditions are…that is the

context of care. (S, I1, 189)

Participants agree that Engaged science knowing involves processes of observing, asking questions, listening, finding resources, and seeking evidence that can be used to make decisions. Explanations of the processes of Engaged science knowing are very similar when sediments, bones, or volcanoes are studied but more complex for cancer patients, nurse trainees, and pediatric families. Questions, observing, testing, and listening is the beginning of science work with patients, but Sara and Jill support that healthcare works best when nurses and patients enter into relationships.

Theme 4- Relational knowing

Participants support a fourth theme of knowing by being in a relationship. Relational knowing involves interaction and dialogue to understand. Through Relational knowing participants come to spiritual knowing, science knowing, and knowing of others. Responses categorized as Relational knowing were defined by participants' common choice of words (relationship, personal experience, personal

connection), or language conveying a tone of closeness, connectedness, and interactive dialogue to know. Actions associated with Relational knowing include listening, paying attention, and conversations. Feelings associated with Relational knowing include closeness, nearness, caring, encouragement, and support.

Relational spiritual knowing. Participants described spiritual knowing of interaction in relationship. This knowing may involve coming to know the Sacred personally, interactions and experiences with the Sacred and others, or connecting the Sacred to traditions or religious practice or through nature. Anna speaks of spiritual knowing in relationship with the Sacred through nature. Derived from her

Native American culture and experiences, she is in relationship with Spirit in the natural world.

> I cannot remember not knowing the spirit [later changed to Spirit], not feeling its presence, not experiencing a deep sense of living within it as a fish lives in the sea- with water coming into it and flowing through its gills and its gut and its kidneys every moment. That is my experience of Spirit, the Spirit of All That Is. To me it is not necessary to "believe" in Spirit, any more than it is necessary for me to "believe" in my father or in my son. They exist and I have personal experience with that relationship. It is the same thing. (A, I1, 287)

Anna's knowing of Spirit is a Relational knowing that seems without beginning or choice where a relationship with the spiritual and nature are one and the same. Jill also describes feeling a connection to God through her religion, faith, and assurance.

> Whenever I came up through [to north east], I don't know if you know we were affected by the hurricane [hurricane Katrina in New Orleans]. I had my faith in God and I knew that everything would be ok…And then more recently I was diagnosed with lymphoma and had to go through radiation. It was the same thing, I had my faith in God and I knew that everything would be the way God wanted it to be. (J, I1, 192)

Donna also supports a Relational spiritual knowing with God that is based in choice and a feeling of God's presence.

> I believed in God but I don't know if I could say He was sitting there in my heart the way He is now… to feel what I feel now, it was me who did

that. As the years went on and I went to school and into work and things

of that nature I just felt that there was a divine intervention to pull me in

that direction and I think that locked me in. (D, I1, 163)

Participants also describe a Relational spiritual knowing involving individuals, groups, and communities. This Relational knowing takes place through interactions and conversations with family members, peers, colleagues, or clergy. Donna comes to spiritual knowing and knowing of her religion through the caring relationship and open conversations with her mother. Influential in her spiritual development, Donna and her mother talk questions of faith and share what they believe and think.

That [loss of faith] was actually a concern that my mother had when I told

her I was going to pursue the sciences and be a biology major. I think

some of the old time beliefs are still in her and she was thinking that I was

going to become an atheist because most scientists were atheists. Maybe

they were at one time. 'Excuse me!' and I just said, 'No, my believing that

there were dinosaurs out there, I don't think that is going to make me an

atheist.' (D, I1, 301)

A two-way knowing of Relationship, Donna has not taken on her mother's beliefs as her own, nor has Donna's mother taken on Donna's belief. Each has played a part in guiding the other to a personally created system of beliefs and thoughts that work within their own lifeworlds.

Beverly attests to the influence of Relational knowing with her mother, scientists, and ministers who were influential drawing her to science, and supporting spiritual development through community.

Well what we did was to interact with the scientists and talk to them about what they were doing and what their projects involved…It was church-related, yes we did talk about the importance of faith in science. (B, I1, 73)

A pastor and university faculty were influential to Beverly while she was in college.

Well I've had wonderful pastors…when I went off to college the pastor that I had in grade school would drive across town…he and his wife would take me to church and we would have lunch together and that was a big part of my freshman year…There were several people including the Chairman of the Geology Department who attended the church I attended. They were very involved in keeping me active in church, I think. So at a time when a lot of students do not have time to go to church I was encouraged to go. (B, I1, 341)

Terri also cites the importance of Relational knowing within a spiritual community.

A year after I started on the Galileo project, um, I went back to church. I became very active in a church in Pasadena and very intentional about my faith through that journey with the church. (T, I1, 178)

My life was out of balance and I felt the need to get back to church and actually I visited a church, a Disciples of Christ church…and became

active there. So, I've always had this thread or profound belief in God, it

has always been there, but not always appreciating the idea of community

or community support for ones' religion or faith. (T, I1, 254)

For Terri, involvement in a likeminded spiritual community helps support

individual and community spiritual growth.

> Can one be spiritual without being religious, well I don't know if I believe
>
> that. I think being part of a faith community supports one on the journey
>
> and keeps one working at it, engaged. Maybe engaged is a better word,
>
> and learn a lot from those around me, and that conversation, and trying to
>
> live that life. And, I think that faith does need to be internal…but I don't
>
> think that is the whole story. I think God calls us to also be active outward
>
> and I think if one is spiritual without religion it is very easy to be just
>
> turned inward, without the outreach part, without being engaged with the
>
> larger community. (T, I1, 362)

In addition to gaining support, Terri says a spiritual community encourages outward

interaction as spiritual practice. Sara describes Relational knowing that is outward with

patients and nurse trainees. For such relationships to work they must be based in respect,

care, and mutual learning and a Mindful/Inner knowing to be present.

> I think everyone [should] absolutely be respected for their own journey,
>
> whatever that is. (S, I1, 930)
>
> I pay close attention with being concerned about wanting to care for the
>
> whole person and well, how do you do that without violating people's own
>
> ideas about what their physical, emotional, spiritual care should be from
>
> their perspective. I think the way to do that is to simply be genuinely

present in the moment, um. And you have got to pay attention to what they

say [Added, as well as what they do not say]. (S, I1, 466)

When asked, "So they will teach you what needs to be done based on need?" Sara

answered, "Absolutely, if you are paying attention, they will" (S, I1, 473).

Through a Relational spiritual knowing participants came to understand the

Sacred, how their own spiritual beliefs relate to those of others, how communities

can support spiritual growth, and how to be spiritually outward with others.

     Relational science knowing. Participant responses support a knowing of science

through relationships. Conversations with teachers, family members, colleagues, and

research groups were influential in how some participants came to know science. When

Anna was four years of age her father became aware of her interests and supported it with

his time and attention as well as resources.

     Obviously, my father was a big influence. How many daddies have a cigar

     box of dinosaur bones handy, or let their little children pour through their

     college textbooks and answer their questions with such patience? (A, I1,

     56)

Donna enjoyed conversations with fellow biomedical researchers from other

countries, and how they worked to answer research questions.

     Designing some experiment to see whether or not I can answer my

     question and I realize I may or may not answer my question. I may have to

     redesign and collaborate with someone else. That is another thing I've

     always loved, the collaboration with other researchers from other

countries, from other areas was just wonderful to me. I got to hear what

their training was like maybe in Britain or where ever what their work

ethic is…Just putting your heads together and sitting together talking and

discovering together you know, or designing an experiment together to try

to answer the question and I always realize we may not be able to answer

with what we have now…You work, people come in and you go talk with

them, and they come talk to you. And in talking someone is trying to get

to know what you are doing and they may say they read an article

yesterday by blah blah blah and you may want it. There was quite a bit of

interaction, we were not locked in a room where you were working. (D,

I1, 92)

Terri shared Donna's thoughts about collaboration in research.

Some of it was the excitement of seeing new lands that nobody had ever

seen before. Uh, particularly on the mission we would come in [to work]

in the morning and there would be laid out the mosaics of the images they

had downloaded the night before and put together and we would see this

new terrain. Um, there was that excitement, and the combined excitement

of the group looking at it and solving problems that were practical…There

was a camaraderie, there was a unique feeling of being on that forefront.

And then there was the contributing, the fact that some of the maps that I

worked on ended up being used. It is just that being on a space mission has

an aura that you are working in, I don't know how else to describe it. (T,

I1, 68)

Relational knowing is supported by participant responses of coming to know the Sacred, their own beliefs with others, spiritual development in communities, and how to outwardly practice in relationships. Through Relational knowing participants also came to know science, by being encouraged, supported, provided resources, given time, and collaborating.

Theme 5- Integrated lifeworld knowing

The fifth and last major theme of knowing is a more complete knowing that is a blending of all types of knowing as they function in the lifeworld. Spiritual women of science come to know nature, science, religion, and spirituality through Passive knowing, Mindful/Inner knowing, Engaged knowing, and Relational knowing. These ways of knowing are not distinctly independent from one another but are integrated in the language of responses. It seems these ways of knowing have become even more integrated over time as they became applied to life. For these women, science and spirituality intersect daily. The tone of Integrated knowing responses was one of resistance to a separation of scientific and spiritual ways of knowing. Words used to describe the relatedness of scientific and spiritual knowing include compatible, blended, different levels, overlapping, intertwining, two eyes to fully see, and inseparable. Currently, Mindful/Inner, Engaged, and Relational ways of knowing religion, spiritual, science, and nature are integrated in the contexts of a personal lifeworld, and the context of a professional lifeworld. The Integrated knowing of the personal and professional lifeworlds works, such that a disconnection or separation of the scientific and spiritual would have consequences.

Integrated knowing in a personal lifeworld. Each participant describes an Integrated knowing where scientific and spiritual knowing are related for them personally. Consider Donna's description of allowing scientific and spiritual knowing to be integrated.

> I struggled probably in my upper teens and twenties with *allowing* [emphasized] them [science and religion] to overlap. [her tone questions the use of the word allow] I don't think I *allowed* them to. [allow is said with more certainty] I think I tried to keep the worlds separate except for when I had to have those discussions with my mother who thought I was going to be an atheist, you know. And then they've come together more and more. I think they began to blend even more as I've worked at the medical center and I've worked with people who have said I'm not coming in here Sunday because I have to go to services. Realizing that I'm not the only one…that had faith that is in science. I think that made it more compatible for me to allow them to blend and I think over the years it just happened. (D, I1, 408)

Donna created an Integrated lifeworld knowing as she examined reasons for separation and communicated in relationship with her mother and research colleagues.

> I think that my fear was that I would find conflict between science and religion. In order to prevent that conflict I would not think about science during religious times, such as church, and I would not think about religion when I was studying science. I actually remember that day that I felt comfortable letting the thoughts overlap. That was during a religion

class in high school when the priest discussed creation and how talking

about or thinking about creation did not necessarily exclude science. (D,

I1, 695)

Donna had believed the two should be kept separate; the priest gave her permission to

begin to pull them together. Beverly did not ever see science as needing to be kept from

religion; she uses the historical connection to explain the relatedness.

I think the history of science grew out of the church, I know geology did.

There would be no geology if there had not been a push in the

Enlightenment to understand nature as a work of God. So the first

geologists were actually trained in the church. And they were studying the

earth to understand God. (B, I1, 408)

From Terri's point of view the historical connection of religion and science are

present and meaningful. Understanding the universe helps Terri understand the

nature of God.

I think that the earth that we live in is in our very limited experiences for

most of humanity's history and how we are seeing now, I guess I'm less

earth centered, to me it is the whole dynamic history, the evolutionary

history, the Big Bang on, the immensity and beauty and all of these things

going on elsewhere um, speaks to me of God as creative and dynamic. (T,

I1, 647)

When a volcano was discovered on the moon of Jupiter it was more than scientific

knowing, it was spiritual knowing and connection to God.

…we have this whole history that has defined them [science and religion]

for us. But at the same time, when I learned about volcanism on Io, it

affected my appreciation, my awe for universality I guess, it wasn't a

purely scientific learning. It was also to me a spiritual learning because it

expanded my known, my total known. Um, and that is one of the

definitions of revelation, is a new insight, a new knowing type of thing

and so in a sense learning about volcanism on Io was a revelation to me

that also affected my spirituality, my spiritual knowing…(T, I1, 485)

To explain how she relates spiritual and scientific knowing Anna uses the analogy of eyes and sight.

I think they are partners [scientific and spiritual knowing]. We use both

eyes to see and depth perception emerges as a new phenomenon that is

more than the mere sum of those two [literal] viewpoints. (A, I1, 464)

For Anna, scientific and spiritual knowing are more complete together than either would be alone.

Integrated knowing portrayed in a professional lifeworld. Participants

explain how an Integrated science and spirituality relates in the context of

lifework with others. Donna portrays an integrated science and spirituality in her

science courses.

If they were not overlapping…my answer would be one sided, one-way or

the other just completely. I don't think that but I could see myself doing

something that another instructor did while I was a student.

Saying, 'We leave religion completely out of this class and we stick to the

science part in here.' (D, I1, 500)

They will think, 'That is interesting, that person tried to answer a question

I've had for a long time and nobody would address it.' I've been told,

'Nobody would address it before.' I think that builds a level of trust there,

and my students usually trust me. (D, I1, 449)

After student questions open the door to religion in her class she is comfortable talking

more openly with students in her office, so they understand that she cares and is a woman

of faith too.

I'll tell them to stick to whatever you believe in, if you have a true faith

you just have to keep working hard and keep that faith and things are

going to work out. (D, I1, 285)

When asked a question about how science and religion relate Donna addresses the

question with thoughtful honestly. She believes that doing so builds and maintains

student trust. Donna remembers her own struggle and conversations she has with her own

mother about scientists being atheists. She considers the importance of her actions, and

chooses to be supportive and respectful of student beliefs.

In a context of her daily life and experiences in planetary geology, Terri speaks of

a level of knowing where the spiritual and scientific intertwine. She experiences her

scientific study of nature as a knowing of the physical processes, a connection with the

cosmos, and a knowing of the God as creator.

This dynamic and great place that we are part of in some sense… how

limited our own knowing is but yet there is a God that is beyond all of

that. It is hard for us to imagine that. Yet, I do believe in a personal

relationship with this God …this God still cares and is engaged in every

one of our lives…not just this God of an immense universe but also a very

personal god. (T, I1, 664)

Terri speaks publically and makes presentations at churches about her work at NASA and

her beliefs. Using photos taken by the Hubble space telescope to convey the vastness of

the universe Terri describes her connection with the universe and a personal god.

Anna's Native American traditions do not separate the physical from the spiritual.

Her Integrated knowing of the natural world carries a relationship of respect, humility.

I understood from childhood that we don't just observe nature; nature also

observes us. And if we really want to understand it, we must realize this.

Otherwise we see only a vanishing tail tip, bounding away through the

trees. (A, I1, 86)

Anna applies her Integrated knowing to science, while maintaining a respectful

relationship.

Asking the thing you are studying to help you, to share its wisdom with

you. Yes, that means praying, asking for dreams (in an Indian sense),

things like that. And yes, the world does respond to such requests (in my

experience). (A, I1, 261)

Rather than imposing studying nature by imposing on it, she aims to learn from nature by asking, observing, and listening.

> I kinda wonder if a lot of people get stuck with their elementary God and what they learn in early Sunday school and they don't go beyond that. Um, particularly in traditions where you are not really taught to question…in science that is what it is about, asking questions…To have something stuck over here in a box it does make that something a lot smaller than what is over here [not in a box]. (T, I1, 890)

> When I learned about the volcanism on Io it affected me, my appreciation, my awe for the universality I guess. It wasn't purely scientific learning. It was also to me a spiritual learning because it expanded my known, my total known. Um, and that is one of the definitions of revelation, it is a new insight, a new knowing type of thing and so in a sense learning about volcanism on Io was a revelation to me that also affected my spirituality, my spiritual knowing. (T, I1, 488)

> I think the earth is a very limited experience for most of humanity's history and now we are seeing how, the whole dynamic history, the evolutionary history, the Big Bang on, the immensity and beauty of all of these things going on elsewhere [in the universe] speaks to me of God that is creative and dynamic. (T, I1, 646)

Separation of scientific and spiritual knowing. In describing how scientific and spiritual knowing are related, participants consider what a

separation would mean to them personally and for others in their lifeworld. Anna considers the consequences of separating scientific and spiritual knowing.

It [a separated scientific and spiritual knowing] is nonsensical for me, personally. But it exists and it's all around us in practice, nonsensical as it may be. It is Western culture. (A, I1, 478)

When Anna considers one way of knowing without the other, what she is left with doesn't make sense. Jill explains that her nursing preparation expected patients to be treated holistically, failing to do so would be an injustice.

They [instructors in nursing school] did emphasize the need to incorporate all three and not just see the body, but understand that they [patients] do have a spirit, and that they do have a mind and that you need to incorporate all three whenever you are treating a patient. (J, I1, 403)

I think it would be hard, to have one and not the other (science or spirituality), I think you need to have both. I think you would be ignoring what can sometimes be quite obvious and that would be an injustice to the patient. (J, I1, 448)

Jill sees her purpose as the person who bridges between the distant science and the emotionally and spiritual person. She notices when a patient that is not doing well does not have a source of comfort and peace.

I remember seeing one patient…I will never forget her, because… she had made it known that she didn't believe in God and I mean that was something she had noted to everyone. I just remember…that when she was

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actively dying she was terrified, absolutely had a terrified look, and I just

remember thinking how sad, it doesn't seem like anything comforts

her…this particular patient didn't seem to have that type of awareness. She

had no religion or spirituality…it has almost been ten years ago but it was

that profound and unsettling. (J, I2, 612)

Sara goes further, seeing that the separation of science and spirituality would

change the way she is in the world with her nurse trainees and patients.

I would be willing to say that if I could not [maintain an inseparable

scientific and spiritual knowing] …if I had to revert back to ya know,

some of the professional preparation where you have to really separate

anything that had to do with spirituality or religion or faith, if I had to

revert back to that I would have to find something else to do… It would't

be real, I would be lying, that would have no integrity from me

whatsoever. (S, I1, 507)

Sara must be who she is, a spiritual woman who also happens to be a nurse

practitioner, nurse educator, and nursing administrator. Prayer and the comfort

she knows comes with it is part of who she is.

It is a gift to be given, not a gift to be horded…there is an expression of

spirituality, but I don't give up on my science. I am still doing the testing; I

still did every one of those exams in a way that is appropriate. I am not

praying over kids in the hopes that somehow they will magically get

better. (S, I1, 545)

For these six participants science and spirituality cannot be separated as in their lifework, as each of them is a spiritual woman of science.

Summary

An analysis of interview transcripts of six spiritual women of science support five major themes. Spiritual women of science come to a spiritual and scientific knowing through 1) Passive knowing, 2) Mindful/Inner knowing, 3) Engaged knowing, 4) Relational knowing, which relate to one another in the last theme 5) Integrated lifeworld knowing. These spiritual women of science come to know, relate, and portray science with spiritual knowing through strongly integrated ways of knowing such that a separation would have consequences.

Chapter 5: Discussion

This chapter discusses the relatedness between the five themes of knowing emerging from transcript analysis. Then it returns to the original research questions and pulls together relevant literature with the findings of this study. First, each research question is addressed; How do women scientists come to science? How do women scientists relate spiritual and scientific knowing? How do women scientists portray spiritual and scientific knowing to others? Finally, the implications for science education, limitations of the study, and recommendations for future research are discussed.

Relatedness of Themes of Knowing

The five themes of this study emerged chronologically in the lives of these spiritual women of science. The evidence of a Passive knowing theme emerged earliest of all five themes. Through Passive knowing each woman was exposed to culture, habits, and traditions of the family religion and school before they chose and took action toward spiritual and science knowing. Three other active ways of knowing emerged between childhood and post-college years. Each woman began an Engaged nature and science knowing due to choice and actions of exploration, questioning, and study. All participants continued intense studies in the sciences beginning in high school and throughout college and post-graduate education. During these college years science was the focus for most, with religious education and spiritual development either less of a focus or not a focus. All were active in a Relational knowing of others and science within science communities.

A Mindful/ Inner, Engaged, and Relational knowing of religion/ spirituality emerged or re-emerged following college. Two participants continued an intentional

commitment with the faith tradition of their childhood, four participants began an intentional and prolonged exploration into a variety of faith traditions. As each woman became settled into work she eventually sought out a Relational knowing within a like-minded spiritual community. During college and after college each woman participated to varying degrees in an Inner knowing of spiritual development by maintaining belief and faith, various degrees and frequencies of prayer, and seeking spiritual meaning.

Integrated knowing seems to have taken hold and matured through real-world situations where science and spirituality interact. In teaching science students, supporting patient families with varied beliefs, science research with living organisms, interactions with science colleagues interactions between science and spirituality in lived experience. Participants began to see science and religion not limited to coursework or church in the lives of people as artificially separated and/or compatibly related.

Integration to participants is more accurately an overlapping of the two ways of knowing such that both can be used. This overlapping amounts to the two being used together in a way that is compatible but separated in time, or simultaneous. In action, Integrated knowing appears as a quick switching of hats to acknowledge the subjective knowledge of human caring involved when a seemingly objective science is applied in the subjective human world.

How do women scientists come to science?

The six women of in this study came to science through diverse paths. All women share an early path that defines them as Passive knowers. From this similar starting point the paths of these women diverge to include Relational knowing, Engaged knowing, and a spiritual connection to nature through Mindful/Inner knowing.

Passive knowing and Silence

These women first came to religion and then science knowing through Passive exposure. Participants attended church and school not by choice, but as an expectation, due to obedience. Descriptions of church and school attendance are without vivid detail present in active knowing experiences. The major theme Passive knowing is a knowing of religion and nature that shares some similarities with the position of Silence described in *Women's Ways of Knowing* (Belenky et al., 1997). Women in Silence are described as "passive, subdued, and subordinate" (Belenky, 1997, p. 30), all words that also describe being child-like following adult expectations, due to obedience, and being without choice or voice. The theme of Silence speaks about adult women who are without choices and a voice, mostly uneducated without means and options. Women in this study moved from Passive knowing similar to Silence toward Engaged knowing, having experiences in school, church, and with others that encouraged questioning, and exploration.

Relational knowing path to science

Sara came to choose science later in her academic career. She was drawn to a Relational knowing or people-oriented careers involving children, and found that elementary education was not a good fit. As a swim instructor for disabled children she was exposed to evidence based care, a nursing approach based in science research. Sara was less focused on the science and more focused on the treatment success and patient care. While pursuing her degree in nursing she began to lead tutoring sessions, as she was excellent at conveying challenging science concepts to her peers. Sara connects her interests in children, teaching, and care in her work as a nurse practitioner, nursing

administrator directing nursing education, and researching nursing education at a pediatric hospital.

Engaged knowing paths to science

Beverly, Dawn, and Jill were drawn to Engaged knowing, curiosity, the intellectual challenge of science and a pursuit to find answers to questions. Descriptions of the process of science are tradition including the steps of the scientific method. While these are spiritual women of science there was no mention of spiritual language when describing being engaged in science knowing, while the affect is present in tone and attitude. The paths of these three are similar to the chemist described by Gornick (2009),

> The chemist, on the other hand, is a scientist who knows that one experiences oneself in the act of doing, that to experience oneself is everything, and that the real power of science for the scientist is that it delivers, on an extraordinarily high level, the significant pleasures of engagement. (Gornick, 2009, p. 52)

Women in this study were different from the chemist in that they all connected the pursuit of science to its applications in society such that the focus was less driven by personal goals and more driven by the possible contributions they could make to improve humanity.

Spiritual nature before science

Two spiritual women, Anna and Terri came to a Mindful/Inner knowing with nature before beginning an Engaged knowing of science. Both were drawn to the natural world and developed a love for, connection to, and curiosity about the natural world. Their experiences are similar to the 18-25 year olds of Csoli's study *Understanding the*

Spiritual Experiences of Young Women who describe "spiritual experiences in nature as spontaneous, and simply being in nature appeared to be enough to trigger an experience" (Csoli, 2008, p. 234). For Amelia it is a "feeling of awe created by the vastness of the space in the Rockies that creates this spiritual connection"(Csoli, 2008, p. 152). Women in this study were different from those of Csoli's study in that they held a high interest in nature, when coupled with their spiritual experiences seems a reverence for scientific knowledge as a way to know and connect the self to Spirit for Anna, and God the Creator for Terri.

How do women scientists relate spiritual and scientific knowing?

Spiritual women of science

The group label 'women scientists' is not a complete or accurate description of the six participants of this study. These six participants are spiritual women of science, they all have had prolonged 1) childhood experience attending church with family, 2) adult spiritual knowing in the form of a personal relationship with the Sacred, 3) commitment to personal spiritual development, and 4) involvement in a like-minded spiritual community. These women were selected for this study because they identified themselves as holding a strong spiritual commitment. For this reason, these women hold both a spiritual and scientific place in the world. The more appropriate question being addressed in this study is, How do spiritual women relate spiritual and scientific knowing?

How do spiritual/ science women relate spiritual/ scientific knowing?

Passive knowers to Engaged knowers

As participants move from Passive knowing to an Engaged knowing of science and religion they reflect Fowler's description of faith development from Stage 3-Synthetic/ Conventional Faith to Stage 4- Individuative/ Reflective Faith. During Stage 3 the authorities adolescents hold for religious and moral beliefs are external, mostly parents and religious leaders. Adolescents hold tight to the beliefs and standards of these authorities as if they are their own. Many have formed these beliefs and standards within environments that discourage questioning and critical review. While some adolescents find comfort in Stage 3 and commit to this tacit system that is unexamined, others move toward Stage 4. Anticipating a transition, these adolescents and adults create a new identity and system of values resulting from critical review. Knowledge beyond authority figures is explored, processes of questioning and critical examination are employed. One of the participants in Fowler's study is described as looking with "critical awareness at the assumptive system of values he and his family had shared" (Fowler, 1981/1995, p. 177). Over time a self-created explicit set of standards and values is created, one of Stage 4 that replaces the tacit values and meanings of Stage 3. Women in this study can be seen in Fowler's descriptions of Stage 3 as it is similar to descriptions of Passive knowing of both science and religion. The movement into active knowing through Mindful/ Inner knowing, Engaged knowing, and Relational knowing is similar to the movement from Stage 3 to Stage 4. External authorities are examined; the tacit system of Passive knowing becomes an explicit system of Mindful/ Inner knowing, Engaged knowing, and Relational knowing. The faith, spirituality, and practice of others learned through exposure and followed out of duty becomes personal, understood, realized, and carried

out by choice and with commitment. This new Stage 4 system is Integrated lifework knowing of spirituality created to work for spiritual women in science lifeworld contexts.

A Mindful/Inner, Relational, and Connected knowing science

The comparison with *Women's Way's of Knowing* (Belenky, 1997) does not end with similarities between how these women came to science through Passive knowing and the theme of Silence. Gender research supports differences with respect to science learning preferences, with female high school students sharing a stronger interest in empathy (Sommers, 2009). Those females with low interest in science perceive science to be without a human element (Belenky, et al., 1997) uncaring, without morality (Miller, et al., 2006). A conflict arises for female students who prefer cooperative connected knowing (Belenky, et al., 1997) and aim to be successful in science, which values separate knowing over connected knowing (Lundeberg & Moch, 1995). In this study the themes of Mindful/Inner, Engaged and Relational knowing emerged as choices, commitments, and actions taken toward knowing science.

The major themes of Mindful/Inner knowing and Relational knowing are consistent with the epistemological orientation Connected knowing as described by Gilligan (1993) and used by Belenky et al. (1997). Mindful/Inner knowing are ways to know the Sacred and spiritual self through inner prayer, meditation, and seeking spiritual meaning, and nature through quiet observation and listening. Relational knowing involves experiences and interactions with people through listening and the formation of shared experiences or conversations. These descriptions are similar to female science student's learning preferences toward connected learning, involving a spirit of cooperation where students are encouraged to discuss, ask questions, and dialogue to

learn (Lundeberg & Moch, 1995). In connected learning the spirit of cooperation is fostered as students share, feel safe from judgment, and value diverse opinions.

Engaged religious knowing and Separate knowing

Engaged knowing of religious doctrines or science knowledge through exploration and questioning is similar to the epistemological orientation termed Separate knowing described by Gilligan (1993) and used by Belenky (1997). Women in a position of Separate knowing are said to seek knowledge, implying "separation from the object and mastery over it" (Belenky, 1997, p. 110). An Engaged knowing is an investigation of the knowledge, rules, procedures, theories created by others, a seeking of alignment between personal knowledge and knowledge of others. Participants in this study describe exploring, questioning, and examining to create their own knowing of religious doctrines in communion class, Sunday school, and through dialogue with scholars. All six participants describe the process of science based in questioning, and evidence to test hypotheses, all consistent with separated knowing. In addition, Sara and Terri describe an Engaged knowing of the Bible and religious doctrines that is similar to the process used by scientists to create and modify scientific knowledge.

> I explored the scriptures in the same way that I explore science, with questions, with openness, with context, always. (S, I1, 393)
>
> They thought Galileo was a heretic and a nut, ya know. Well, they turned out to be wrong about that and they acknowledged that. And, I think it is a two thousand year old bureaucracy and it is sluggish and slow and eventually they catch on. It just takes a while…I think that doctrine can change with new knowledge, I think it can evolve. (S, I1, 440)

Separate knowing is a knowing shared by women of *Women's Ways of Knowing*

who "met the standards of academic achievement" and also "violated

conventional feminine stereotypes," (Belenky, et al., 1997, p. 103). Five of the six

women hold PhDs in the sciences, and at the onset of this study five of the six had

never married or had children. Three participants hold PhDs in geo-related, which

are mathematically intensive majors where women are underrepresented (Ceci,

Ginther, Shulamit, & Williams, 2014). In addition to a more separated Engaged

knowing, these spiritual women of science employ other ways of knowing that are

connected.

Constructed knowing and Integrated knowing, blending of science and spiritual

Participants in this study were able to integrated spiritual and scientific knowing

through a separate Engaged knowing of science knowledge and religious doctrines and a

connected knowing that is Relational, and Mindful/Inner knowing. This Integration is

similar to the Constructed Knowledge of Integrating voices described in *Women's Ways*

of Knowing (Belenky, et al., 1997). In the position of Constructed knowing, participants

"find a place for reason and intuition and the expertise of others…reported that her

understanding of how answers were generated had changed as she had changed." (p.

133). The women are described as articulate, reflective, noticing what is happening with

others, caring about the lives of people, aware of own thoughts, concerned with inclusion

and exclusion, separation and connection, struggling to find balance and take action to

make a difference. These descriptions are similar to the six participants of this study, who

integrate separate knowing and connected knowing as they integrate scientific knowing

and spiritual knowing. Take Sara's response when considering what a separation of

spirituality and science may look like in her work as a nursing administrator and nurse practitioner.

> I can remember the first time I ever prayed in the presence of a parent and there is not religiosity in that. Um, then or now. Um, it is a spiritual thing and I don't think you can…try to departmentalize [Sara later changed to compartmentalize] I don't think it is real. I think it is not an option…I think if you are not whole-present wherever you are and in whatever you are doing and allow others to be the same, I don't think that is possible. I don't think that can be done. You can try it or fake it, you can manipulate it, but I don't think it is real. (S, I1, 173)

If Sara has integrated her spiritual and scientific knowing, with the consequences being like separate knowers- "thinking and feeling are split asunder; they feel fraudulent and deadened to their inner experiences and inner selves" (Belenky, et al., 1997, p. 135). The process of integration is a "weaving together the strands of rational and emotive thought…rather than extricating the self in the acquisition of knowledge, these women used themselves in rising to a new way of thinking." (p. 135). The women in this study have moved beyond integration to portray an integrated spiritual and scientific knowing in meaningful work that gives them purpose, is spiritual practice, and supports the journey of others.

Postformal logical thought

Piaget's stage theory has adolescents in the formal operational stage as the topmost rung of cognitive development. Later studies showed "mature adults performed badly on Piagetian logical tasks, at least in terms of passing complex Piagetian formal

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operations; they performed significantly worse than younger respondents, worse than teenagers" (Sinnott, 2010, p. 3). The research flaw seemed to occur when choosing Piaget's formal problems in contexts of physics, mathematics, or chemistry to test adults, rather than developing logical problems more like daily life. Following a mental test, Sinnott imagined what may occur if elementary students were given logic tests meant for preschoolers. She imagined that they "would make errors on the easy tests, not because they lost the logical skill but because they were doing something else more sophisticated that did not allow the simplistic 'right' test answers to emerge" (Sinnott, 2010, p. 4). Sinnott knew that Piaget's testing methods handled structured problems and limited solutions to a single system. Based in her understanding of complexity as illustrated in the real world, problem solving is not limited to one logical system. The question for Sinnott became, Do mature adults use a higher logical thought that cannot emerge using a test for formal operations?

Sinnott's research included interviews with adults representing age, gender, class to find out what they believed constituted adult intelligence. Aspect of intelligence most cited by these adults are those not typically tested; creativity, interpersonal relationships, and adaptability. Sinnot proposed the use of ill-structured and open-ended real-world problems to understand logical thought of adults. She asked that the participants engaged in a verbal dialogue that revealed their thought processes. Below is an example of a real-world question used for the research protocol.

You are supervising the assembly of a magazine that comes out monthly.

Several workers are putting pages in order; others are binding the pages.

The binders finish 20 magazines every half-hour. Those putting pages in

order, however, finish 40 in two hours. Some of your workers are idle part

of the time. Equal numbers of workers are performing each task and there

are more than enough supplies in each area. All of the workers can handle

both jobs. What can you do to keep all of them equally busy? (Sinnott,

2010, p. 40)

Below is a section of verbal dialogue as a participant addresses the problem of the

magazines described above.

Ok I'm attempting to solve the problem and talk as I go…This says that all

workers can handle jobs. So, as there's a backlog, simply move employees

over…It is the binders that would be idle…I would move them

over…there are other solutions. Hire more people to put the pages

together, so you can actually match the amount produced by

binders…Another possibility would be to, of course, slow down the actual

work pace for the binders…Being in the clinical field I would also be

concerned about how happy they are and the type of work they do…So

you could have them doing additional work. You could even have a

recreation area for then that would keep them busy and happy…No I

haven't had open-ended [experience with problems like this]. Most of

what I have had to do is in connection with SAT, GRE, where you're

supposed to come up with the answer. (Sinnott, 2010, p. 40)

Using Sinnott's open-ended real world scenarios, mature adults were found to be more

sophisticated in their thinking as compared to adolescents. Adults are aware of multiple

logical systems and may approach a problem by employing one system after another and

evaluating the possible results. Once the participants realized the answer was not fixed, they moved toward employing multiple logical systems. These adults were able to connect cognitive systems, social systems, and spiritual systems and rather than being fragmented, they were whole. Over two decades of research culminated in the development of Sinnott's inclusive theory, Postformal Thought. The theory came to be "the cognitive underpinning for understanding how to balance the complexities of our many identity realities so that we can consciously try to live in balance as adults" (Sinnott, 2010, p. 9). This highest form of problem solving is required for the real world and may rely on a shifting of realities many times per day. As certain professions 'demand the expert use of multiple realities' the studies included psychotherapists, secondary teachers, college professors, undergraduate students, middle-aged couples, research administrators, and family members making health care decisions.

Through conflicts and relationships, realities are created by consensus. These realities are not created in theory but are created and tested to find those that they work in the real world. In addition, Sinnot describes these mature adults as having the capacity to match the thinking of others. In order to understand another person's point of view, these adults identify the lower level of thought and shift to this thought to allow mutual understanding and communication. Using these tactics adults in post-formal logic are considered to posses highly effective interpersonal and adaptive skills.

Participants in this study consider and address the lifeworld scientific and spiritual interactions from the cognitive developmental level of Postformal thought. Integrated knowing is a way of knowing that considers the complexity of real-world situations. The real-world of these spiritual women of science is not singularly spiritual or scientific, but

an Integrated knowing of the spiritual and scientific internally through Mindful/ Inner knowing, outwardly through Engaged knowing, and in interactions with others through Relational knowing. From an Integrated knowing, each participant has become a teacher adept at adjusting how they teach and interact with students to support Mindful/Inner knowing, Engaged knowing, and Relational knowing in students. Interactions between participants and others may involve discussions of beliefs, faith, or prayer, an acknowledgement of Mindful/Inner spiritual knowing. Interactions also involve explanations of the processes of science, questioning, exploration, to understand religious doctrines, or research methods, supporting Engaged knowing. Interactions between participants and others are of a Relational knowing nature, supportive, caring, and open. These spiritual women of science live and work in contexts where science and spirituality intersect regularly, they approach these intersections from a cognitive level of Postformal thought, and their teaching and interactions with students serve to challenge and support students as they move from Piaget's formal operations to Postformal thought.

How do spiritual/ science women portray spiritual/ scientific knowing?
Integrated personal and professional lifeworld knowing as spiritual practice

The relatedness of scientific knowing and spiritual knowing is portrayed by these women scientists as compatible and Integrated lifeworld knowing, where all ways of knowing intersect in the context of daily lifework. These spiritual women of science have come to integrate science and spirituality for themselves personally, and as a part of their daily work with others professionally. The women in this study were selected because they self identified as holding a strong spiritual commitment. Each woman also describes an element of her spiritual practice as how she interacts with others, in the role of service,

through authenticity, by caring, and supporting others. Each portrays an integrated science/ spiritual knowing a necessary element of an outward spiritual practice of service.

Sara understands that separating scientific and spiritual knowing would have dire consequences. A deliberate separation of the two ways of knowing would result in a student-instructor or patient-nurse relationship that is distant, incomplete, inauthentic, or an artificial context, much like attempting to control experimental variables by pretending they are not present. For Sara, failing to acknowledge, consider, and treat the whole person is "ludicrous," and "nonsense," if pediatric medical treatment [Sara later changed to health care] did not consider the whole patient Sara explains that she would simply have to "find something else to do" (S, I1, 508).

In the role of teacher, mentor, and nurse these women acknowledge and deal with spirituality and science as ways of knowing that intersect for others. As university professors, Anna, Beverly, and Donna find ways to model and discuss how science and spirituality can be in conversation as compatible ways of knowing. Anna guides her graduate students toward research methodologies that are consistent with a respect and care for the natural world. She does not privilege the distant objective experimental sciences, but teaches her students to value the qualitative, naturalistic, and descriptive methodologies that allow an understanding of the natural world from her spiritual position of humility and respect that does not allow for manipulation. Beverly has experienced the consequences of students losing faith when religious doctrines that claim evolution dispels the Bible and the earth is 6000 years old come into conflict with modern geology. By creating geology courses that begin with the historical of science based in religion and a motivation to understand God, Beverly creates spaces where

science and religion are compatible. Donna also addresses student questions about the relationship between science and the Bible in her university science classes. She does not privilege science of the Bible but describes ways to integrate both sources of knowledge. When asked about Eve being made from the rib of Adam, Donna uses this question as an entrance to understand human genetics. Donna explains that taking the time to address questions builds and maintains trusting relationships with students, many of who have been told to keep their religion out of science class.

Jill approaches her work as a nursing practitioner with respect and care for patients. During treatment she comes into contact with a variety of belief systems, and support all belief systems and non-believers during the process of treatment and dying. In this way Jill portrays an integrated medical science with religion/ spirituality as necessary for patient well-being. From Jill's experiences, medical treatment and the process of dying is better accepted, tolerated, endured when supported by spiritual awareness and comfort.

These spiritual women of science are adept at moving between and straddling the artificial lines between Separate knowers and Connected knowers as described by (Belenky, et al., 1997). The science knowledge used by these women is a product of what most would consider separate knowing that is 'strictly impersonal' where 'personal beliefs are rigorously excluded.' Lines that distinguish separate knowledge are blurred when science is integrated with spirituality in connected knowing contexts surrounded with beliefs that cannot be excluded. Using Engaged knowing, a Mindful/Inner knowing, and Relational knowing, these women perform their daily work by standing in as Integrated lifeworld knowers in more than two places at once. Science knowing and

spiritual knowing must be Integrated ways of knowing as a necessary aspect of strong spiritual commitments to religious practice of care and service. For spiritual women of science, spiritual commitment is reflected outwardly through caring interactions with others.

> I believe practice is something that is in your heart and is everyday, it doesn't have four walls, and so I may not make it to church every Sunday but I do what I can and mainly I will try to show Christian love and understanding to all the people that I come in contact with, even when it is challenging. (B, I1, 431)

> God calls us not to just grow closer to God but to also be outward as well, to be engaged with those around us, and that can also drive us closer to God. It's a circle. (T, I1, 376)

> I go to church on the weekends, participate in that hour ritual with the community, and then also those things that you would not necessarily think of practice but how you treat others. I always treat everyone with kindness and respect because I know that is what God would expect of me. (J, I1, 236)

> I love the quote that is attributed to Frances of Assisi…Preach the Gospel always, and if necessary, use words. I think that the way people live with one another, I think that is the best expression of spirituality. I think that is the best expression of who we really are, spiritually, emotionally, [and] cognitively. (S, I1, 400)

For spiritual women of science there is a spiritual way to be involved in doing, teaching, and practicing science, where an Integrated lifeworld knowing is required. Science is portrayed by these spiritual women in a manner that can be received by students, patients, and nurse trainees, from an ethic of care. It is this religious practice motivated ethic of care that places these spiritual women of science in a meaningful position, between what could be a distant uncaring science in a human feeling world.

Consider Jill's work as a nurse practitioner educating and managing patients as they undergoing stem cell treatments for terminal cancer. In her daily work Jill educates patients about the qualifying, collection, and transplant process using Exploratory knowing of science knowledge. Second she is developing a Relational knowing of the patient as she collects patient physical data, assesses the patients' emotional and spiritual health, and the she incorporates her Inner knowing and may pray with and for patient awareness, peace, and comfort.

> I feel so much comfort in God that I feel to go through this type of therapy
>
> is not just physically overwhelming to the body but emotionally I can get a
>
> sense of comfort having the power to pray and the power to meditate and
>
> just to seek some sort of solace in knowing that God is with them and that
>
> they are not alone. (J, I2, 560)
>
> Jill has experience with treatments that are not successful.
>
> For example, knowing when a patient doesn't respond to any type of
>
> medications that we have, um, and knowing that they're refractory so to
>
> speak, and the science part is not working, you know, for them. Um,
>
> sometimes I leave with that thought that when the science is not working I

feel like there is no option for them and I think other people believe that

you need to put that in God's hands and whatever is supposed to happen it

is his decision and part of it is conflicted because I am Catholic and at the

same time when the science part is not working for the patient, it is not

going to work, period. (J, I2, 525)

Jill's role as a nurse practitioner is to aid patients in finding comfort and peace while

undergoing treatment; she does not expect God to intervene if treatments are not working.

Today, all six participants merge ways of knowing into an Integrated lifeworld knowing

of science applications and education in daily life. As earth scientists, science educators,

nurse practitioner, and nursing administrators, each of these spiritual women of science

portrays science that is compatible with human caring.

Pedagogical constructivists

These women understand that spiritual and scientific knowing is a process of

relating separate and connected ways of knowing. This knowledge and their own

experiences, coupled with a strong motivation to serve results in spiritual women who

actively model and integrate science/ spiritual knowing as mentors and teachers. They do

so in contexts where science and spirituality regularly intersect. Sara's response

encapsulates her teacher role as she works with nursing trainees. She understands the

process of constructing knowledge and integrating ways of knowing, from this position

teaching is not telling, teaching is guiding and supporting.

So they bring in ideas that serve them at age twenty-something. Those

things won't serve them when they are forty or sixty, but they serve them

now. I can't give them what I have now forty years later, that is not

possible. (S, I1, 543)

Donna understands that students gain support from instructors who can be trusted, open, and supportive of student learning.

…the buy-in needs to be on their part, about the science, or buy-in for

learning, or feeling that you are that trusted person who is teaching them

what they need to know about anatomy, in this case. You are going to lose

that, and it doesn't hurt you except if you are conscientious about those

kinds of things. Usually students need to feel like they can trust you up

there with whatever the discussion is, you are not going to be judgmental.

And so, if one were to ask me a question and I were to cut them off like

that and just left it on the scientific side I feel that would lose that trust…I

think that builds a level of trust there, and my students usually trust me,

even the failing ones, They trust me to tell them, Ok, let me tell you, this is

what you are lacking…What you can do is withdraw and try again, I'll

even let you continue to come to class so you can continue to pick up on

the new material. It is that trust. (D, I1, 433)

Beverly has adjusted her geology course to begin with the historical connection between science and religion. She made this decision to assist students who have conflicts between the geology and a literal interpretation of the Bible.

I know in one case I had a student who was a religion major who took my

1402 [geology] class and he decided that he couldn't accept the literal

interpretation of the Bible, which is the way he had been brought up. It

literally destroyed his faith. I would never want that to happen to another student, but he questioned his faith because of the science class. So I really do spend a lot of time relating the two and show how they need not be in conflict. (B, I1, 747)

These spiritual women of science adjust interactions to support the spiritual and scientific journeys of others. Rather than teaching from a telling or single- minded view, they allow and support the knowledge construction process of others and thus providing an openly supportive and caring learning environment.

Discussion

Boundary pioneers

Scientists at the top of their field who speak out about reconciling religion and science are termed boundary pioneers Ecklund (2010). While some religious stances (fundamentalism and evangelicalism) are tolerated and viewed in a negative light by elite scientists, boundary pioneers are received positively. It is not the reconciliation of religion and science that makes an elite scientist a boundary pioneer, but the fact that he/she has credibility within the scientific community, and "openly talk about such reconciliation" (p. 46). Boundary pioneers, such as Francis Collins, provide a model "to show future scientists that full commitment to science can be held alongside full commitment to Christianity" (p. 46).

Women represent 9% of the elite scientists studied by Ecklund for her book *Science and Religion: What Scientists Really Think* (Ecklund, 2010). Less open to speaking about their faith, Ecklund refers to these women as having a "closeted faith," explaining that much is at stake for women in elite science. Rather than engaging in open

discussions, women scientists refrain from discussions of spirituality in the science workplace. While women may not be highly represented in elite science, women with advanced degrees in science and engineering are well represented as science educators kindergarten through university (NSF, January 2009). The six women participants in this study may have portrayed a closeted faith early in their careers, but currently live a blended life as a formal or informal science educator in a context where science and spirituality intersect. While these women may not all be considered elite scientists, five serve as liaisons between science institutions and the people they formally or informally teach.

None of the participants mentioned engaging in regular spiritual conversations at work, but all mentioned being willing if prompted by questions from students, patients, or trainees. Each believes the way she interacts and treats people and the natural world says more about her spirituality than what she says. All six spiritual women scientists could be referred to as boundary pioneers of a relational kind. By living daily in a scientific/ spiritual context each remains approachable, willing to earn trust, and show caring that is informed by an internal scientific/ spiritual dialogue that respects and supports the journeys of others. Each reaches out personally in the context of her lifework; when a spiritual student struggles to reconcile science and faith, a patient's faith is challenged by terminal illness, a parent seeks comfort for a child's illness, or a demanding pediatric nursing career could take its toll on nurse trainees. All six women are boundary pioneers who model how a scientific/ spiritual life can relevantly connect scientific knowledge to the lifeworld of others, with an ethic of care.

Implications for Science Education

School science reflects a "narrowly conceived notion of knowledge and the role knowledge plays in an individual's life" (Cobern, 1996, p. 579). This study supports that spiritual women of science challenge the nature of science often reflected in reform documents. For spiritual women of science, knowing that is Passive, Mindful/Inner, Engaged, and Relational culminating into an Integrated lifeworld knowing where all ways of knowing interrelate. Science knowledge is created by these scientists and applied by these scientists who reject the clean boundaries between science and religion and embrace an Integrated lifeworld knowing where spirituality and science work together. Reform documents expect school science to allow students to learn about science, and also understand science. It seems school science is more of a Passive knowing about science while understanding science is a higher level of knowing, an Mindful/Inner, Engaged, Relational, and Integrated lifeworld knowing through lived experiences with science as it exists in society.

This study also supports that some women scientists conceptualize a natural physical world that is also spiritual. For these women a spiritual connection to nature may serve as a motivation toward scientific study. Connectedness between a scientist and the natural world may motivate scientists to understand, create science knowledge, apply knowledge to benefit humanity, and preserve the natural world. School science should portray a knowing of the natural world that can be founded in the richness of multiple ways of knowing and in this way connection to student lifeworlds.

Educators must be open to the many ways of knowing scientists may employ to experience the natural world, and invite discussions that allow students to blend their ways of knowing toward a more full Integrated lifeworld knowing. One avenue of

blending ways of knowing may be through stories of science-related fields where science intersects with human lives, and scientists work to care and meet the needs of others.

This study also supports that the cognitive focus in science education that devalues spiritual knowing or excludes other ways of knowing inaccurately represents the interrelatedness of scientific and spiritual knowing in at least six spiritual women of science. Science education must refrain from implying scientific knowing is incompatible with spiritual knowing and other ways of knowing. In devaluing the life-worlds of students, science educators may alienate spiritual students from engaging in school science. Students may believe that to engage in school science they must abandon their spiritual and other ways of knowing. Some students may believe that to engage in school science they must become less spiritually connected to the natural world.

Sara, a holistic health care nurse practitioner, administrator, and researcher asserts that young pediatric nurses survive and thrive in a challenging career when an organization supports nurse trainees as whole persons. Organizational support for these nurse trainees includes inquiring about each nurses' physical, spiritual, emotional, and relational health and needs. Public education has been accused of failing to adequately support its young teachers. Further studies exploring the nature of holistic health care support for young nurses may inform teacher education programs and mentor programs charged with supporting early career teachers.

Limitations of Research

One limitation of the study is the spiritual similarity of participants; all six women were raised in a home where some form of Christian church was attended. While one participant was Native American, other non-Christian spiritual traditions are not

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represented. It would be informative to interview women of science from the other major religions of the world; Islam, Confucianism, Hinduism, Buddhism, Judaism, Daoism (Prothero, 2010). A second limitation of the study lies in the limited science disciplines and careers represented; physics, engineering, and mathematics were not represented, nor were the social sciences. Future studies may address these limitations through access to women scientists of other spiritual traditions and scientific disciplines.

Recommendations for Future Research

Other spiritual women of science. As per this study, Donna, a Southern Baptist was most challenged by the prospect of allowing her spirituality to overlap her scientific knowing. Southern Baptists in Texas are historically evangelical Protestants. According to Ecklund, "while nearly 28 percent of the American population is part of an evangelical Protestant tradition, about 2 percent of natural and social scientists at elite universities identify themselves this way" (2010, p. 15). Why? Future studies exploring scientists from evangelical Christian traditions would be informative to science educators. Such studies may also inform science education of the science paths most often taken by evangelicals who choose to study science. Exploratory interview studies of the relatedness of scientific and spiritual knowing in evangelical college students with and without science-related majors may provide an understanding of the reasons for low evangelical representation in the sciences.

This study involved interviews of six participants. Three of these participants discussed the historical connection between science and religion during the Enlightenment. It would be interesting to explore historical accounts to find and

understand spiritual women scientists from different periods of history since the Enlightenment.

Life paths of spiritual women of science. This study has prompted further questions regarding the life paths of spiritual women of science. Three participants describe a time of distancing from religion during the college years, an exploration and study of science and religion, followed by a return to the religious foundations of childhood. Future studies exploring female science majors at the undergraduate, graduate, and early career stages may provide insight to understand the nature of this movement away from religious foundations. Is this movement more typical of some Christian denominations as compared to others? What does this movement away from religious foundations look like, during the college years?

This study focuses on women with degrees and experience in the applied health sciences or research sciences. Three of the six participants change careers in midlife, leaving research science for careers in teaching, or spiritual direction. These results have prompted further questions regarding the movement of spiritual women scientists out of natural science careers toward other careers. It may be informative for science and science education to understand the factors that influence women research scientists who change careers during mid-life.

This study selected for women with degrees and experience in the applied or research sciences, and resulted in five of six participants who were single with no children. These demographics have prompted further questions regarding women scientists. Does a career in research and/or applied sciences draw women who do not marry and have children? If so, what are the factors that influence such life choices?

This study represents a brief glimpse into the lives of women who are spiritual, work in science-related fields, and portray science to non-scientists. Research regarding images of scientists formed by children or pre-service teachers consistently focus on images of scientists at work. Exploring the images of scientists at home may help educators see the views children and pre-service teachers hold of scientists as people. By creating drawings, a list of describing words, and then a written or paragraph or conducting interviews with participants, science educators may more fully understand how children and pre-service teachers perceive scientists as people at work and at home.

Appendix A Qualifying Questionnaire

Women Scientists' Scientific and Spiritual Knowing Study

Are you a woman of science with a spiritual/ religious commitment willing to share your story? Please take a few moments to determine if you qualify and are willing to participate.

I am Angela Buffington, a science educator and PhD candidate at Texas Christian University. My research interest lies in the scientific-spiritual ways of knowing of women in science. I believe future science students, teachers, and scientists may benefit from the stories of women in science who maintain a spiritual/ religious commitment.

This study explores how women come to science, relate science and spiritual ways of knowing, and portray science to nonscientists. Data will be collected in the form of audio-taped interviews in person or over the phone. Study involvement is voluntary with confidentiality being carefully maintained.

Qualification Questionnaire: The aim is to interview diverse women such that a variety of sciences and spiritual/ religions combinations are represented.

1. Has your work involved research and/or applications in the health/ engineering or natural sciences? If so, with which of the sciences are you most closely associated?

2. Do you hold a spiritual and/or religious commitment? If so, describe the nature of your spirituality and/or religion.

3. Does your work include communicating science to non-scientists? If so, describe the context of such communications.

If you have answered in the affirmative to all three questions, I am hoping you will agree to be interviewed. Please indicate your willingness by sharing your responses.

I will then contact you to determine a time that works best for our discussion.

Thank you. Your time, and consideration are very much appreciated.

Appendix B Interview Protocol

Interview Protocol Part 1

I appreciate your taking the time to share your thoughts so that other may learn from them. I would like to understand your path to science and your science and spiritual ways of knowing. Please give your name and a brief description of yourself, your research, and your teaching.

How were you drawn to science?

Describe influences on your path to science.

What about science draws you to it today?

Describe your science way of knowing.

How were you drawn to spirituality?

Describe influences on your path to spirituality.

What about spirituality draws you to it today?

Describe your spiritual way of knowing.

Interview Protocol Part 2

Describe how your spiritual and science ways of knowing relate.

Describe how you arrived at this relationship.

Construct with me a visual or metaphorical representation of your scientific way of

knowing as related to your spiritual way of knowing. What thoughts guide your

construction?

Where would you place your science research? Describe using a scenario.

How do you portray science in your teaching? Describe using a scenario.

Where would you place your science teaching? Describe using a scenario.

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ABSTRACT

WOMEN SCIENTISTS' SCIENTIFIC AND SPIRITUAL WAYS OF
KNOWING

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While science education aims for literacy regarding scientific knowledge and the work of scientists, the separation of scientific knowing from other knowing may misrepresent the knowing of scientists. The majority of science educators K-university are women. Many of these women are spiritual and integrate their scientific and spiritual ways of knowing. Understanding spiritual women of science would inform science education and serve to advance the scientific reason and spirituality debate. Using interviews and grounded theory, this study explores scientific and spiritual ways of knowing in six women of science who hold strong spiritual commitments and portray science to non-scientists. From various lived experiences, each woman comes to know through a Passive knowing of exposure and attendance, an Engaged knowing of choice, commitment and action, an Mindful/Inner knowing of prayer and meaning, a Relational knowing with others, and an Integrated lifeworld knowing where scientific knowing, spiritual knowing, and other ways of knowing are integrated. Consequences of separating ways of knowing are discussed, as are connections to current research, implications to science education, and ideas for future research. Understanding women scientists' scientific/ spiritual ways of knowing may aid science educators in linking academic science to the life-worlds of students.

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