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Scientific Creativity in Light of Artistic Spirit:

A Preliminary Literature Review on the Concepts of Intuition and Beauty

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Abstract

The purpose of this paper is to investigate scientific creativity in light an artistic spirit. As such, history's eminent scientists reveal that indeed there is an artistic component to scientific creativity of high ability. In this paper, that component is considered in light of the concept of "extracognition" with particular reference to intuition and beauty. Through a systematic review of the literature, three shared themes of intuition and beauty are derived. These are: a) making connections beyond consciousness, b) holism, and c) emotional response. These themes are then explored in light of practice in science education. Israel Arts and Science Academy is touched on as a relevant example particularly in terms of holism, creativity, and moral goodness. Finally, some practical suggestions are made in the area of education for bringing to life an artistic spirit in the science classroom.

"As between science and art, the priority developmentally seems to rest with art, this being the more immediate and intuitive ground from which the rationalistic and generalizing scientific meanings subsequently develop" (Phenix quoted in Innamorato, 1998, p.5).

Introduction

Art and science have long been viewed as contrasting domains. Nonetheless, their unity is evident in the life and work of Leonardo da Vinci, our renaissance man of the times (Deckert, 2001). His work enlightens us on what it looks like to be an outstanding artist and an outstanding scientist. Furthermore, a number of other eminent scientists also speak to the importance of having an artistic spirit. What, however, is that artistic spirit we speak of? In search of illuminating the creative processes of gifted scientists in light of an artistic spirit, the notion of extracognition comes up (Shavinina & Ferrari, 2004). Shavinina and Ferrari (2004) reveal "extracognition" as a new concept in the development of high ability especially in the sciences. Many facets of extracognition indeed seem to have aesthetic qualities that resonate with art such as intuitive processes and feelings of beauty. The aim of this literature review then is to explore how extracognition can enable scientific giftedness in light of artistic character. The review will focus on only two of four aspects of extracognition, that being: a) intuition, and b) feelings of beauty. Implications will be discussed around gifted education. The Israel Arts and Science Academy will be touched on as an example (Donoghue, 1999; Erez, 2001; IASA, n.d.; & Passow, 1992), culminating in some practical suggestions for bringing an artistic spirit to the science classroom.

Historical Interplay of Science and Art in High Ability Scientists

Perhaps the most obvious historical figure who captures the interplay of science and art is Leonardo da Vinci (1452-1519). In his work, art and science supported one another harmoniously (Potter, 2006). He was not only a renowned artist of the Renaissance, but also a

scientist of many facets such as botany, civil engineering, hydrology (Potter, 2006), and anatomy (Nicholl, 2004; Zwijnenberg, 1999). Just as Leonardo da Vinci demonstrated both scientific and artistic spirit in his life's endeavours, a myriad of other eminent individuals expressed the same spirit. In particular, Root-Bernstein (1987) found 400 instances in which famous scientists also considered artistic careers and had high ability in art as adults. One example of many being Roger Guillemin (1924-present), Nobel laureate who isolated the first peptide hormones, is also a painter and professional computer artist (Root-Bernstein & Root-Bernstein, 2004).

In reflecting on eminent scientists, it appears as though the skills, abilities, and perspectives in the arts compliment those of discovery in the sciences. Root-Bernstein (1987) notes that an engagement with music, the arts, poetry, and literature shape our personalities and it is from our personality that grand ideas arise. While Root-Bernstein (1987) shows that the arts have shaped the kinds of personalities that meaningfully contribute to the biomedical arena, other scientific arenas such as engineering and physics are also shaped by artistic personalities, as exemplified in Leonardo da Vinci, for example.

To further illustrate the point that scientists find the integration of an artistic spirit important, consider their inspiring quotes. Physicist and Nobel laureate, Allan Cormack, says "The abstractions [I do in mathematics] are just as beautiful [as in art] and I find them more satisfactory" (quoted in Shavinina & Seeratan, 2004, p. 85). Furthermore, Max Planck, father of quantum theory, proposed that pioneering scientists "must have a vivid intuitive imagination, for new ideas are not generated by deduction, but by an artistically creative imagination" (quoted in Shavinina & Seeratan, 2004, p. 90). Einstein furthermore sums up the interplay of science and art by saying, "After a certain high level of technical skill is achieved, science and art tend to coalesce in esthetics, plasticity, and form. The greatest scientists are always artists as well"

(Thinkexist, 2006). Finally, and to repeat the beginning quote, Phenix, author of *Realms of Meaning*, states that "as between science and art, the priority developmentally seems to rest with art, this being the more immediate and intuitive ground from which the rationalistic and generalizing scientific meanings subsequently develop" (quoted in Innamorato, 1998, p. 58). It is clear that great minds of our times have considered the interplay between the arts and the sciences to be of great importance.

Extracognition

While the aforementioned eminent scientists speak to high ability in science in light of an artistic spirit, what exactly is that artistic spirit? The above quotes allude to the concept of *extracognition*. Extracognition seems to be a relatively new concept and area in the study of high ability (Shavinina & Ferrari, 2004). A review of the literature on PsycINFO reveals that not many articles use this terminology other than those used in Shavinina and Ferrari's (2004) book entitled *Beyond Knowledge: Extracognitive Aspects of Developing High Ability*.

What then does extracognition mean? According to Shavinina (2004), extracognition, particularly in Nobel laureates, includes the following aspects that contribute to high ability: a) intuitive processes; b) specific feelings of direction, harmony, beauty, and style; c) specific preferences and values in terms of a chosen field; and d) specific beliefs. Overall, extracognition refers to all things that are not cognitive and all contributions that do not come from basic cognitive influences (Runco, 2004).

What role does extracognition play in the creativity of high ability scientists? Shavinina and Seeratan (2004) have done a comprehensive study looking at autobiographical and biographical findings on scientific geniuses and also qualitative interviews with gifted 15 and 16-year-old students of physics and mathematics. Findings were similar in that between both gifted

adults and adolescents, extracognitive aspects included a) feelings of direction; b) specific beliefs such as the feeling of truth and faith in the power of ideas; and c) specific preferences like an aspiration towards harmony and beauty to name a couple. Indeed, in highlighting Phenix's quote as stated by Innamorato (1998), we are enlightened to the idea that all these feelings may come from intuition whereby art is this intuitive ground from which science can spring.

Intuition and Beauty

Through a systematic review of the literature on the concepts of intuition and beauty, three shared themes were derived. These are: a) making connections beyond consciousness, b) holism, and c) emotional response.

Making Connections Beyond Consciousness

This theme may be the most difficult to understand and also may be somewhat of a stretch in likening it to both intuition and beauty. To clarify, intuition involves making unconscious connections between ideas and patterns. Beauty, on the other hand involves making spontaneous connections between oneself and the world. Both, however, speak to a transforming experience whereby intuition forms new ideas and beauty forms new perspectives on the world on a larger level.

Intuition. In their extensive literature review, Sinclair and Ashkanasy (2005) found that one running theme of intuition is that it is derived from somewhere beyond consciousness. As such, intuition occurs as a gut feeling or an unknown realization that might be described as: a) pattern recognition (Anderson, 2003; Frantz, 2003; Sinclair & Ashkanasy, 2005; Volz & von Cramon, 2006; Welling, 2005) or b) flat activation (Gabora, 2002). In particular, pattern recognition is an unconscious process whereby we recognize pieces of missing information that should be there and make connections as such (Welling, 2003). In turn, the notion of non-

verbalism is related. Welling (2003) cites Schooler and Melcher stating that insight in innovative tasks follows more of a nonverbal trajectory because verbalization interferes with achieving insight. For example, a painting holds a thousand words all of which can be understood at the same time as opposed to the linear understanding a novel. As such, connections between patterns can be made, transforming the given ideas to an enlightened perception of new ideas.

Another way of explaining the unconscious connectivity between ideas is through the cognitive perspective of flat activation (Gabora, 2002). Specifically, the human mind has a variety of memory locations that are filled with experiences and things we know (Gabora, 2002). When we brainstorm, we loosen up our usual neural connections from one idea to the next and we let new insights come. This happens through "flat activation" (Gabora, 2002). It is like defocused attention. It is as though every memory location is stimulated almost equally so that none takes precedence over the other. Gabora (2002) uses the example of "snowman." "Snow" and "man" are not usually connected in our minds, but during flat activation they are given almost equal attention and so have the opportunity of melting together and combining to form the creative new concept of "snowman." Flat activation alludes to the notion that a wide range of ideas might foster creative connections and new discoveries.

Beauty. In their theory of aesthetic understanding, which focuses on beauty, Girod, Rau, and Schepige (2003) find a similar notion in that aesthetic understanding involves making connections between the self and the world and in that respect is transforming. In other words, the way in which we understand our world by making connections to it will transform us to a new consciousness. In this sense, interaction with the world culminates in a unique ending perhaps similar to the transformative "aha" of pattern recognition as discussed in relation to

intuition. For example, in teaching 4th-graders about geology in an aesthetic way, one student transformed her perspective on rocks and how they are situated in the world by seeing them as each having a unique story. Furthermore, she changed her perspective on the world in seeing everything as having its own unique story, even in terms of concepts such as the number 2 (Girod et al, 2003). In comparison to intuition whereby pattern recognition and non-verbal reflection provokes a new way of knowing information, Girod et al. (2003) state that aesthetic understanding transforms the individual into a new way of seeing the world as a whole, and not just ideas in themselves.

Holism

While intuition and beauty can both be understood in light of holism, distinctions must nevertheless be made. Holism speaks to intuition on the grounds that information and ideas are processed holistically. It focuses on the way in which ideas are formed and unified. On the other hand, holism speaks to beauty on the grounds that the person is made whole with ideas and the universe. This theme is somewhat similar to the first theme's aspect of making connections.

Intuition. During intuition, information is processed in a holistic way (Sinclair & Ashkanasy, 2005). In other words, information is processed in a non-sequential way. A current way to understand this non-sequential processing is in light of what Mintzberg would describe as synthesizing disconnected memory fragments into a new structure of information (Sinclair & Ashkanasy, 2005). This perspective plays on the idea that ideas in and of themselves are unified. An older way, however, of looking at information as processed non-sequentially, is in placing it in line with the big picture where ideas are unified with historical and cultural contexts. This idea comes from Jung and certainly depth psychology might best speak to it. Reynolds and Piirto (2005) recognize depth psychology as an important arena to the field of gifted education

and talent development and it centres on Jung's notion of the collective unconscious and archetypes (Reynolds & Piirto, 2005). As such, ideas might resonate with the historical and cultural patterns. Whether ideas are connected amongst themselves or to the larger picture, the common denominator is that they are formed based on non-sequential information processing.

Beauty. A similar theme that Girod et al. (2003) find in aesthetic understanding is that beauty is unifying. Here, unity somewhat reflects the feelings of connection between the self and the universe as exemplified in depth psychology (Reynolds & Piirto, 2005). Rather than simply focussing on the unity of ideas, however, beauty aspires to building connections with others, with the earth, and also then with valuable ideas (Girod et al., 2003). Girod et al. (2003) go on further to explain that aesthetic understanding unifies the past with the future and unifies parts, ideas, and concepts that result in a beautiful whole. For example, upon understanding each part of the periodic table, one can see the unified beauty in the structure of chemistry. While intuition speaks more specifically to the holistic processing of information, beauty complementarily speaks broadly to the holistic integration of the self with information, other people, and the world as a whole.

Emotional Response

Having an emotional response is an important theme in both intuition and beauty. While the literature reviewed on intuition focussed on the neurological connection between intuition and emotion, the literature reviewed on beauty spoke more to the personal emotion evoked from beauty resulting in motivation and moral goodness.

Intuition. The final running theme across definitions of intuition as reviewed by Sinclair and Ashkanasy (2005) is that intuitive perceptions often go hand in hand with emotion. Indeed, other authors agree (Greene & Haidt, 2002; Sadler & Zeidler, 2005; Volz & von Cramon, 2006).

Neuroscientific literature shows that indeed specific neurological structures and neurons involved in the emotional and affective behaviour are also involved in intuitive decision-making (Allman, Watson, Tetreault, & Hakeem, 2005; Volz & von Cramon, 2006). More specifically, Volz and von Cramon (2006) cite Bechara, Tranal, and Damasio's work showing that damage to the ventromedian prefrontal cortex results in poor decision-making that lacks emotional integration. Furthermore, Allman et al. (2005) hypothesize that Von Economo neurons play a role in both intuition and emotion whereby irregular development may contribute to autism and its characteristic social-emotional disabilities and resulting from faulty intuition. Finally, Greene and Haidt (2002) take a moral perspective on the role of intuition and emotion in decision-making. They note studies such as Anderson, Bechara, and Damasio's work whereby patients with damage to the ventral, medial, and polar aspects of the prefrontal cortex are immoral and lack emotionally intuitive decision-making capabilities. Overall, neuroscience tells us that intuition and emotion are indeed tied together at the micro-genetic level and result in socially appropriate and moral decision-making.

Beauty. Fittingly, the final theme in Girod et al.'s (2003) study similarly states that aesthetic understanding of beauty involves emotion in that understanding is compelling and dramatic. It was found that emotion from beauty could be tied to excitement and moral goodness. In their study of 4th-graders who were taught about geology in an aesthetic way, they found that for those students who gained aesthetic understanding, emotion was involved such that the object, rocks, took on a whole new meaning that actually got them excited. While beauty can evoke emotional excitement it can also evoke moral goodness (Hagman, 2002; Winston, 2006). Beauty itself can be expressed in terms of moral beauty. In other words, morality is a form of beauty on its own and the most important one for giving hope (Diessner,

Rust, Solom, Frost, & Parsons, 2006). In tying the emotional response of beauty with the other two themes of holism and making connections beyond consciousness, it seems evident that emotional responses of awe, interest, and excitement will transpire upon the realization of connectedness and unity.

Summary

Intuition and beauty are both facets of extracognition that play a role in high ability scientists, according to Shavinina and Seeratan (2004). From the literature, I have extracted some shared themes. Namely, a) connections or patterns are formed beyond what one was previously conscious of, b) holistic understanding is gained, and c) emotional responses result. For example, just as intuition relies on pattern recognition and making connections that are not visibly there, so too does beauty aspire to building connections in a broad sense to others, to the earth, and to valuable ideas (Girod et al., 2003). In this way, both intuition and beauty then aspire to holistic understanding (Girod et al., 2003; Sinclair & Ashkanasy, 2005). In other words, by bridging connections, be they at a micro-level or macro-level, joining ideas together and joining oneself with ideas, are all of a holistic nature. Finally, we cannot ignore that both intuition and beauty involve emotion. Emotion is found to be neurologically linked to the process of intuition and beauty evokes emotion in terms of excitement and moral goodness. In synthesizing these three themes between the role of intuition and beauty, we might better understand the grounds on which art and science can interact and evolve into a high state of creativity.

Practice in Education

"If we are to truly educate our children, we must develop both the scientist and the artist within them" (Girod et al., 2003, p. 577). How then can we develop both the scientist and artist

within? In light of intuition and beauty, are the aforementioned themes a part of the answer? A collection of articles speaks specifically to science education in light of these themes in an artistic spirit (Alexenberg, 2005; Battles & Rhoades Hudak, 2005; Charyton, 2006; Girod et al., 2003; Girod & Wong, 2002; Innamorato, 1998). This section is meant to specifically address science education.

Making Connections Beyond Consciousness

Making connections beyond consciousness is significant in two ways for fostering scientific discovery: a) pairing art and science as subjects enables creative connections, and b) the realization of creative connections transforms the individual. First, in pairing art and science together, unforeseen connections might be made as discussed from the cognitive perspective of flat activation (Gabora, 2002). This raises the question of whether or not an integrated curriculum of art and science would facilitate creative thinking. It certainly seems that if artistic and scientific experiences fill up our memory locations, brainstorming will yield fascinating combinations of concepts integrating both art and science. It is important to note, however, that human creativity is largely non-random (Hummel, 2002) and people need clear relationships between content for optimal learning (Geake & Cooper, 2003). As such, Battles and Rhoades Hudak (2005) describe an interdisciplinary course in art and geology whereby the disciplines are meaningfully paired. Class activities centre on topics that illustrate interconnections of geology and art. For instance, the medium of metalwork and jewellery might foster discussion around the properties of minerals, while the medium of sculpture might afford us the opportunity to investigate different rock types and consider how differing material will affect the characteristics of the sculpted piece. As such, creative connections and new discoveries might be made.

Secondly, the realization of these creative connections brings the student to a whole new level of consciousness which is important in seeing the world in a new way and making further connections. Girod et al. (2003) and Girod and Wong (2002) might say that creating these connections is a transforming process whereby the individual actually changes alongside the insightfully creative idea. For example, a student might stare at a flower for a while and suddenly realize its systematic patterns. Upon this realization she might see patterns in all forms of nature and so through her sudden realization of connections she sees the world differently and is also, herself, transformed. Another example stated by Girod et al. (2003) can be seen in how a student sees astronomy in a whole new way, talking about it on a deeper level upon the true realization that everything is moving. He is overcome with a new relationship to the universe. All in all, science can benefit from seeing concepts, things, and "facts" in a non-rational, sub-conscious, and artistic way in order to evoke new connections and transform the way in which we see the world.

Holism

Holism is probably the most obvious perspective to take in learning science with an artistic spirit. Holism provides the grounds on which: a) science can be seen in an artistic way, and b) students themselves can become whole, embracing the interaction of two different disciplines. First, while Girod et al. (2003) and Girod and Wong (2002) do not speak to the direct integration of art per se in the science classroom, they do speak to the importance of incorporating aesthetic understanding of unity in the science classroom in order simply to unify the elements of science. For example, once students see the relationships between individual elements on the periodic table, it becomes unified, beautiful, and whole.

Secondly, in considering science in light of art and aesthetic understanding, scientific subject matter becomes whole and so do the students. In particular, engaging less with the traditional linear approach of science and more with a holistic approach, students can see and appreciate ideas in a personally significant way, thus building on their own journey and self-fulfillment in life (Innamorato, 1998). For example, Galbraith found that science students resist knowledge if it has no means for personal fulfillment (Innamorato, 1998). Innamorato (1998) thus suggests the importance of integrated curriculum that focuses on personal meaning or artistic abilities. Furthermore, Eisner (2005), who advocates strongly for arts in education, recognizes that we need to pay attention to the whole child in educating them. In so doing, he notes that indeed the arts can promote this holistic development whereby artistic forms of cognition in a variety of activities, including science, represent the most complete form of integration (Eisner, 2005).

Emotional Response

Bridging connections between science and art and seeing things in holistic ways results in an emotional response of joy and wonder (Alexenberg, 2005). These emotional responses can be linked to: a) motivation, and b) moral goodness in the science classroom. First, it is natural that this excitement in seeing connections evokes motivation to engage the learner further (Charyton, 2006) and to foster further investigation in science (Girod et al., 2003; Girod & Wong, 2002). For example, in their study where the teacher combined the study of geology with an artistic sense of "telling rock stories," Girod et al. (2003) found that even a poorly behaved fourth-grade student engaged in the activity with energy and interest. Furthermore, students in general might respond excitedly by wanting to tell others about what they have learned and by wanting to learn more (Girod & Wong, 2002) thus enabling greater motivation in school and in science.

Motivation in science stemming from an artistic spirit also has implications for engaging more girls, a population less engaged with the sciences (Charyton, 2006; Innamorato, 1998).

Secondly, alongside the excitement to further investigate scientific concepts, it is hoped that moral goodness accompanies the investigation. Many scientific ideas require ethical considerations such as human genetic engineering (Sadler & Zeidler, 2005). While no research was found stating a direct relation between the arts fostering moral goodness in a science classroom, literature does show that beauty is often associated with an awareness of moral goodness (Diessner et al., 2006; Winston, 2006) and the arts themselves hold the quality of beauty (Winston, 2006). Perhaps investigations need to be done on the question of whether or not art integration in the science classroom might evoke moral goodness in scientific decision-making.

Summary

Educational practice can develop both the scientist and artist within in order to foster integrative and holistic minds. Based on the extracognitive aspects of intuition and beauty, three interrelated themes are derived from which science classrooms can integrate an artistic spirit. First, fostering a science classroom where connections can be made beyond consciousness allows: a) the combination of art and science to enable creative connections, and b) the realization of these creative connections transforms the individual's perspective on and connection with the world. Second, a holistic approach in science provides the grounds on which: a) science is seen in an artistic way and b) students themselves can become whole. Third, fostering emotional response in science promotes: a) motivation to learn more, and suggests b) moral goodness in decision-making. All themes considered, they are linked to the extracognitive facets of intuition and beauty, which seem to be inherent in eminent scientists of artistic spirit.

As such, it is hoped to be relevant into the current day of science education whereby subjects are taught in an interdisciplinary way.

Israel Arts and Science Academy

A concrete example of a school that integrates the arts and sciences in the spirit of creativity, holism, and moral goodness is the Israel Arts and Science Academy (IASA). IASA is a national, residential senior high school established in 1990 that incorporates creativity through arts, discipline through sciences, and values and ethics through community work. It is open to all high school students across the country but is ultimately limited to those of high ability (Donoghue, 1999; Erez, 2001; IASA, n.d.; & Passow, 1992).

Philosophy. Passow (1992) describes the program's design in terms of a circle of four rings. The first and innermost ring is the field of specialization. In the second ring around that, are general core studies and interdisciplinary studies. The third ring is the school/community relationship. Finally in the fourth and outermost ring are the broad values devoted to a humanistic orientation and commitment to the country and its people.

With a focus on the second ring of interdisciplinary studies, the overlap of science and art becomes evident. Science and art work together at IASA to complement one another's opposing dispositions. IASA follows the Greek ideal of "Truth, Beauty, and Goodness" where science seeks truth and art seeks beauty and perhaps truth, as well (Erez, 2001). Art and science further complement one another in the opposing mental processes of analysis and synthesis where art is primarily about synthesis and science about analysis (Erez, 2001). Furthermore, while high school science chiefly focuses on justification, art focuses on discovery. The philosophy behind IASA is to have art and science work together in complementary ways always in the context of values and morality (Erez, 2001).

Interplay of Art and Science. IASA is interesting for its interdisciplinary nature on two levels. On one level, students are exposed to a wide array of passions and interests simply by living with one another, it being a residential school (Erez, 2004). The hope is that science students who may not have an interest in art or vice versa might gain some interest or curiosity simply by living with someone who does (Erez, 2004). As such, the arts and sciences get to intermingle in an informal and friendly way.

On another level, IASA provides a range of courses to help students perceive connections amongst various fields while concentrating on their own (Donahue, 1999; Erez, 2004). It is as though the sciences and arts mix in a context whereby science students are allowed to engage in innovative art projects and art students are allowed to engage in innovative science projects. For example, one week, called the Gildor Project Week, gives students the space and time to experiment with new approaches in their own field or to explore a subject other than their own field of study (IASA, n.d.). IASA endorses creative excellence in its students, recognizing that scientific creativity is often difficult at the high school level while creativity in art is the name of the game (Erez, 2004). By pairing the arts and sciences in an interdisciplinary manner, it is hoped that the creative mentality of art will transfer to science where to dare is rewarding (Erez, 2004). By overlapping the discovery process of art with science in order to promote new ideas, the integration of art and science can be seen as credible (Erez, 2001).

Educational Implications

What then are some practical strategies for teaching science with an artistic spirit? Girod et al. (2003) make explicit suggestions as to how to foster students' aesthetic understanding particularly in science.

First, content must be crafted in a way that livens it up to the artful ideas that they are or were at one point. This involves creative planning on the part of the teacher. For example, in their study, the teacher taught geology in way that enlightened students to understanding rocks as each having a unique story to tell (Girod et al., 2003).

Second, teachers must encourage students to ask imaginative questions and wonder about the potential of ideas (Girod et al., 2003). For example, asking questions like "What if…". Certainly, the great scientists throughout history valued imagination. Einstein, for example, is quoted as saying "Imagination is more important than knowledge." As such, teachers are encouraged to support the inquisitive nature in asking creative questions by giving students time enough to explore and to let ideas grow to change the way students see the world.

Third, Girod et al. (2003) suggest encouraging artistic perception whereby we look at the world with an eye for detail. They call this "re-seeing" such that we must look at objects closely enough to discover things in them that we might not have seen before or that we might have simply generalized. For example, in looking at the moon and wondering why it looks the way it does, we can see it in greater detail and gain not only aesthetic understanding, but also the curiosity to investigate further.

Fourth, Girod et al. (2003) urge teachers to model aesthetic understanding by engaging with scientific ideas that invoke inspiration and appreciation for beauty. Furthermore, it must be evident to the students that teachers too are transformed by engaging with aesthetic understanding.

Finally, teachers must scaffold students' emotional engagement with science (Girod et al., 2003). It is suggested that emotional engagement be capitalized on in order to gain even a richer account of aesthetic understanding. For example, even if a student seems to be acting

immature in interpreting the stories of rocks, the emotional excitement must be nurtured in a receiving way.

Summary

The purpose of this paper was to investigate scientific creativity in light an artistic spirit. As such, a look at history's eminent scientists reveals that indeed there is an artistic component to scientific creativity of high ability. I have looked at that component as being extracognition with particular reference to intuition and beauty. Through a systematic review of the literature, three shared themes of intuition and beauty were derived. These are: a) making connections beyond consciousness, b) holism, and c) emotional response. These themes were then explored in light of practice in science education. Israel Arts and Science Academy was touched on as a relevant example particularly in terms of holism, creativity, and moral goodness. Finally, some practical suggestions are made in the area of education for bringing to life an artistic spirit in the science classroom.

Discussion

From the literature review, a number of questions were evoked and are up for discussion.

Self-Reflection Questions

1. What is your personal experience with intuitive processes or feelings of beauty in doing your own research?

2. Is research itself more of an art or a science? To what extent do we allow intuition and feelings of beauty into our practice of research?

Questions for Education

3. If the arts are indeed relevant, might it be important for scientists to be trained in the arts or simply educated to appreciate the arts?

4. Are there implications for arts-integration with the sciences?

5. Can extracognition (intuitive processes and feelings of beauty) be taught? How can they be ignited?

Final Question

6. What might be some important research questions and studies to further investigate scientific creativity in light of an artistic spirit?

Miscellaneous Questions of Curiosity

7. How can we foster the positive aspects of an artistic spirit while avoiding negative aspects like “madness” and/or emotional distress?

8. Can art integration in the science classroom alert students to moral goodness? On the other hand, can it breed the opposite?

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