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DESIGNING ELEGANT PROBLEMS FOR CREATIVE THINKING

Creative thinkers seek elegance in their work. An aesthetic sensibility accompanies creative work from the original vision or motivation to its use in identifying what many creators describe as an 'elegant solution'. Examples of this characteristic can be identified in most, if not all fields. If one defines creative thought in developmental terms, as "a process in which the individual finds, defines, or discovers an idea or problem not predetermined by the situation or task" (Kay 1989, p.65), then the importance of guidance by an aesthetic sensibility becomes more visible.

We can see elegant solutions all around us. This chapter will look at what has been said about elegant solutions by a few creative producers and a few examples of elegant solutions that can affect our environment prior to introducing the concept of elegant problems. Elegant Problems address the what, not the how of creative teaching and learning.

Aesthetic Sensibility, Deep Problems and Elegant Solutions in the Sciences

The ability to appreciate the beauty of a solution has been noted by scientists, mathematicians, and artists. The term 'Elegant Solution" is used across disciplines and time to describe the result of creative thought. For example, Campbell (1960) cites its importance with the words of the mathematician Poincare:

> The useful combinations are precisely the most beautiful, I mean those best able to charm this special sensibility that all mathematicians know, but of which the profane are so ignorant as often to be tempted to smile at it....
>
> When a sudden illumination seizes upon the mind of the mathematician, it usually happens that it does not deceive him, but it also sometimes happens, as I have said, that it does not stand the test of verification; well, we almost always notice that this false idea, had it been true, would have gratified our natural feeling for mathematical elegance.
>
> Thus, it is this special esthetic sensibility which plays the role of the delicate sieve of which I spoke, and that sufficiently explains why the one lacking it will never be a real creator.
>
> (Campbell 1960, pp. 85-86)

Research on Nobel Laureates in science provides another example:
Like other departments of culture, science has its own esthetic. Among the elite scientists, the prime criteria of scientific taste are a sense for the "important" problem and an appreciation of stylish solutions. For them, deep problems and elegant solutions distinguish excellent science from the merely competent or commonplace. This requires good modeling and intuition and develops during interaction with masters.

(Zuckerman 1977, p.127)

Another example is found in an early interview with the Nobel laureate Frank Wilczek where the identification of an aesthetic quality to research questions was stated with elaboration:

S: Is it possible to teach that aesthetic to someone?
W: Oh, yes…the sort of teaching that goes on here at the Institute. This sort of post-graduate teaching I would say is mostly teaching in taste. And, it's done, of course, very informally. You get a sense of what excites people, what problems are regarded as too difficult, what problems are not ripe, what people express admiration for… which isn't the same, of course. Different people admire very different things, in fact. … But, I think actually the best way to get an idea of what the aesthetic is, is again, to read the masters. You get an idea of what the possibilities of achievement are. And, just as in art and music, the works aren't self-contained. Each work explicitly refers to other work, and you can't fully appreciate the beauty of it and where it fits in and what it means unless you know something about the whole culture.

(Subotnik 1992, p.374)

Aesthetic Sensibility, Deep Problems and Elegant Solutions in the Visual Arts

This same intellectual and intuitive process occurs in the arts. As individuals, artists have a highly developed personal aesthetic that guides more than their work (Kay 1989). In a study of problem solving and problem-finding behaviors, a task that was considered a very open-ended problem by others was described as a constrained problem to solve by the professional artists. Where the other participants were amazed (or overwhelmed) by the choices within the task, the majority of the professional artists commented on the predetermined nature of the game. One participant said "this isn't fair to artists because their own aesthetics gets in the way." Yet, despite their perceived limitations of the problem posed, all of the artists sought their own elegant solutions.

Artists define (although not always with words) the problems or issues they consider important and appreciate the solutions of others doing similar investigations. This may be a major impetus for the forming of 'schools of art' (e.g. Bau-

haus, Hudson River School). Traditionally, artists and scientists have collaborated to address issues regarding theories of perception (Kubovy 1982).

A closer look at elegant solutions

You know it when you see it. Elegant solutions have an aesthetic quality. In mathematical terms, it is qualitative – something is or isn't elegant. An example of an elegant solution can be recognized without precisely knowing the problem posed.

For a visual example, imagine if you will, the entrance door of an elementary school adorned with a sculpture in the shape of a Greek temple pediment that displays a collaged mosaic form that reads, "What do you need to Know?" Taking one of the major guiding questions built into all curriculum design (What do you need to know?) and transposing it to a visual greeting that exclaims the building's purpose is elegant. This particular piece also provides the visual paradox of converting the spontaneous or quick medium of collage into the ancient, meticulous art form of mosaic (new and old, past and present). Thanks to the Chicago Public Art Group, Lowell Elementary students, staff and administration are enjoying the visual and intellectual stimulation of this elegant solution (Gude 2007). One does not need to know the precise problem posed to this community arts group to appreciate the solution's architectural elegance.

In technology, the interface between early Internet technology and applications deemed safe for K-12 school systems was elegantly resolved by Bernie Dodge's creation of WebQuests. By designing a controlled yet creative environment, students' explorations were limited to pertinent and appropriate sites as determined by the teacher. This invention overcame the legal and moral obstacles that prevented so many schools from immediately embracing the new technology. Yet decades later, creative teachers and students continue to find this tool quite useful for designing safe environments for open-ended investigations.

Although these examples of elegant solutions are from creative experts in each field, these solutions may not receive the same degree of appreciation as the work of a Poincare or Nobel Laureate because they are not responses to problems surrounding big ideas (Whitehead 1929) or the powerful ideas that entertain a mind interested in redefining the field of computer technology (Kay A. 2009). Where Alan Kay's work may be categorized as 'Emergentive Creativity', the highest level of creativity (Taylor 1975), the technological example would likely be considered 'Innovative' whereas the architectural 'Inventive Creativity'. Reflecting on the relationship of aesthetic sensibilities and elegant solutions, I wondered if elegant solutions were only associated with expertise or was it possible for beginners to attain elegant solutions through aesthetic knowing?

As an educator I know learning occurs when you meet the learner where s/he is

to guide them to the next level— whether that level is a step or a leap. But what invites the leaps? Reviewing past experiences at the K-12, college, and staff development levels, yielded instances when an assignment consistently evoked elegant solutions from at least a few students. In a sudden realization, I knew that if I want my students to strive toward elegant solutions as they develop their creative thinking skills, then my role is to inspire with "Elegant Problems" (Kay 1995). The next question "What is an Elegant Problem?" has engaged my imagination, thoughts, research and teaching for some time.

Types of problems

How one solves a problem depends, among other conditions, on the type of problem at hand. The transition between closed and open-ended problems has been highlighted in much of the literature on problem solving. Closed problems (sometimes called 'well-defined') have one correct answer. On the other side of the continuum are open-ended problems (or 'ill-defined) where the process is as open-ended as the amount of satisfactory answers. In between these two extremes are degrees of open-endedness. An art question that asks the name and date of a particular painting is a closed problem. Typically, the artist working in the studio or scientist in the lab are the examples given of open-ended, problem finding. Yet the most open-ended directive I have seen is a desktop sign given to IBM employees long ago that simply stated: "Think". Without advanced creative thinking skills, this level of open-endedness might paralyze. The problems posed to students – even post-docs - can fall anywhere along the closed-open continuum depending on their prior preparation, their own and their mentor's perceptions. Each of these problem conditions (closed to open) invites Elegant Problems.

Characteristics of Elegant Problems

There are six characteristics of an Elegant Problem. Beyond the fact that an Elegant Problem provides the potential for elegant solutions, they are also quite clearly, creative problems. Guilford's (1964) four characteristic behaviors found in creative thinking: fluency, flexibility, originality, and elaboration characterize Elegant Problems. Elegant problems or challenges gain strength from their ability to render many different solutions (fluency of responses), appeal to a variety of problem solvers (flexibility of problem space), provide opportunities for unique (original) responses, and invite elaboration (or reduction of it) in details or concept. Perhaps most importantly, an Elegant Problem has a worthiness factor. Each of these characteristics requires some further explanation illustrated by the simplest concrete example:

1. The defining element of an Elegant Problem is its ability to elicit a multi-

tude of elegant solutions across time and place. However, one can only identify an Elegant Problem in hindsight by the amount of elegant solutions it evoked over time.

2. An elegant problem provides FLUENCY in responses. Fluency applies broadly—it has length, if you will. The question or problem statement accepts many answers. At best, each problem solver will find one's own answer(s). This doesn't mean there are no wrong answers. It also doesn't mean that all right answers are equally good. Much like brainstorming or sketching, the idea/solution selected for further development by the problem-solver is a different step for discussion elsewhere. Here we are looking at the purposeful design of the problem (issue/challenge/assignment) to make sure that the problem invites many responses.
3. FLEXIBILITY of problem space means that the way an elegant problem is defined must include an entry point for those uninterested or unable to go beyond developing basic skills yet also extend *wide enough* to encourage delightful surprises you did not see as possible. It reaches all levels of engagement, satisfying disinterest to passionate emersion. An Elegant Problem is also flexible in that it applies universally—appealing across age span, level of ability or expertise, culture, or conceptual sophistication.
4. An Elegant Problem provides room for ELABORATION—it applies expansively and/or deeply. At first glance, elaboration could simply mean adding complex or entertaining details to a solution is a welcome contribution. This is an especially useful stretch for learners talented in a particular domain who complete a challenge quickly. One might also elaborate on an idea by removing extraneous details. Elaboration can also mean communicating to others by providing the necessary details for others to follow one's path to the selected solution. For example, many scientists, mathematicians, artists and other thinkers, will develop an analogy or metaphor to help outsiders understand the new concept or idea by associating it with something familiar to the audience members. This is particularly important if the new idea is very creative so viewers require a safety line to comfortably reach the new summit. A metaphor elaborates with details needed for understanding.
5. An elegant problem encourages ORIGINALITY. Originality is the characteristic most often imagined when one uses the term creativity. (Yet least often measured in 'tests' of creative thinking.) An Elegant Problem must set an environment for novel, inventive explorations and solutions. It permits problem interpretation. It engages the imagination. It also invites personal aesthetic inquiry—an important area of development for creators and for audiences of appreciators. The problem invites possibilities that surprise.

6. The element of VALUE or WORTHINESS is key to distinguishing an Elegant Problem. An Elegant Problem is personally relevant and meaningful and\or addresses an issue fundamental to the field of inquiry (technical and/or intellectual importance). At best, it does both. An Elegant Problem may serve as a bridge between and across realms of meaning by making connections or encouraging the transfer of an idea to other knowledge domains/interdisciplinary issues. It may reveal conceptual similarities and contrasts. Most importantly, the problem fascinates**.** It stimulates curiosity and a sense of wonder. A well-constructed problem is one that can fascinate the beginner as well as the expert.

Describing an Elegant art Problem might solidify the abstract idea with an example of basic or 'expressive creativity'. Asking participants to "Draw *your* shoe" invites possibilities that range from learning scientific observation skills to creating metaphoric self-portraits. One could present this in an elementary class as easily as an advanced high school or college course. It can work as a staff development exercise as well. There are many shoe drawings by renowned artists, but the fact that one's shoe continues to inspire current *post* postmodern work strengthens the example (Shiota 2008). Let's look at the six characteristics through this exemplar:

Personally relevant and meaningful solutions from experts to novices are encouraged in this simple problem and have been across time. With regard to Guilford's creative behaviors: By definition, the problem requires *fluency* with individual responses. *Flexibility* is exhibited in the 'Draw *your* shoe" challenge as it appeals to elementary students to adults; beginners to the artistically talented, and novices who need help with a specific technique to experts such as Michelangelo who identify new techniques are intrigued. *Originality* has emerged often, but a favorite was drawn by a young man who drew his sneaker with absolute realism then depicted cartoon characters as a team of miniature workmen in hard hats using tools to repair holes with needles/thread or buffing out scuffs. Another who drew her shoe, capturing it before drawing her leg exiting the page on one side with detailed background covering the rest of the page, demonstrated *elaboration*. Understanding this drawing of a shoe as a visual metaphor for self-portrait invites elaborations of object and background from other problem solvers.

A three - word problem using simple tools has inspired endless possibilities across time, cultures, age levels, and expertise. Elegant problems yield elegant solutions in any field.

Creativity and Aesthetics

Creative thought encourages, perhaps requires, aesthetic sensibilities. Exposing problem solvers to different creative thinking strategies through Elegant Prob-

lems exercises and strengthens creative muscles. For example, there is an artist/educational consultant at an outdoor sculpture museum who introduces participants to the interactive creative processes needed to be an audience to the creative process of others. By helping multi-age audiences make a heart connection with art, he shares what and how to observe the clues left by the conversation the artist began then offers ways to engage one's own imagination to seek personal meaning. This "contricipation"—the contribution of the creator interacting with the participation of the viewer is required for the appreciation of any creative product produced (Stein 1984)—from the arts to new ideas to inventions. Appreciating the creative work of others may serve as a preamble to creative thinking, as it seems to also require the development of aesthetic knowing or personal taste (Kay 2012). As art informs science (Root-Bernstein 2000), aesthetic knowing may be required for creativity in all domains. Elegant Problems may be a useful framework for designing opportunities to develop aesthetic style and creative thought in every context.

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Author's brief bio

Sandra I. Kay has a Doctor of Education and Master of Education in Special Education from Teachers College, Columbia University and a Bachelor and Master of Science in Art Education from SUNY New Paltz. She has over 40 articles and chapters including: *School Arts, The Journal of Aesthetic Education, Design for Arts Education, Roeper Review, Creativity Research Journal, Gifted Child Quarterly, Teaching Exceptional Children,* M. A. Runco (Ed.) *Problem finding, problem solving, and creativity;* K. D. Arnold, et.al. (Eds.) *Remarkable women: Perspectives on female talent development,* the APA publication by R. Freeman & B. Shore (Eds.) *Talents unfolding: Cognition and development* and has coauthored an art education text *Creating Meaning in art: Teacher as choice maker.* Her research interests focus on developing talent/expertise and on the problem-finding aspects of creative thought, visual thinking, and other habits of mind that engage the imagination and promote self-directed inquiry in children and adults.

A founding faculty member of the Center for Teaching Critical Thinking and Creativity (CTCTC) at San Diego State University, she also provides workshops or courses on a developmental model of creative thinking when she is not writing or spearheading the production of a not-for-profit educational documentary on crea-

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