Convergence *in* Creativity Development *for* Mathematical Capacity

Ai-Girl Tan

Nanyang Technological University Singapore

Bharath Sriraman

University of Montana

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Abstract

In this chapter, we highlight the role of convergence in developing creativity and mathematical capacity. We renew our understanding of creativity from the relations of three creativity mechanisms: Convergence *in* divergence *for* emergence, and three principles of experience: Continuity, interaction and complementarity. Convergence in the context of creativity development is an incidence of learning for capacity building and knowledge construction. Examples of convergent processes in learning are: setting a plan, having a structure, and possessing coordinated capacity to complete a task. To elaborate, we refer to theories of development and creativity on how people develop their capacity in convergence (e.g., collaboration), through mathematical learning (e.g., with coherence, congruence), and for creativity (e.g., imagination). We make reference to convergent creativity of an eminent mathematician *Srinivasa Ramanujan* (1887-1920) for a reflection on developing creativity and building capacity for good life.

Keywords: *Convergence, mathematics, collaboration, creativity*.

Introduction

Scope of the Chapter

This chapter comprises three parts. In the first part we present our assumptions, mechanisms and principles of creativity and creativity development. In the second part we review briefly contemporary views on creativity development and knowledge construction. We reflect on the role of convergent creativity in developing capacity through learning a subject matter. In the third part we draw preliminary conclusions that convergent creativity is essential for knowledge construction and for good life. We make reference to the legend-like encounters of a mathematician *Srinivasa Ramanujan* (1887-1920) for some elaboration on convergent creativity, knowledge construction, and mathematical capacity. In addition we refer to the works of *Vadim Krutetskii* (1917- 1991) who developed a systematic means of promoting convergent thinking in highly able students. Even though our inquiry into convergent creativity in this chapter is preliminary, we consider reflecting on convergent creativity an important aspect of developing high ability in education.

Assumptions, Mechanisms, and Principles

Convergence in creativity is a basis of knowledge construction. It is necessary for creativity development. We propose four assumptions of convergent creativity in the context of creativity for capacity building and knowledge construction: (a) Convergence is a mechanism of creativity; complementing divergence and emergence, two other mechanisms of creativity. (b) Creativity is an incidence of learning (Guilford, 1950); and learning is a continual, interactive and developmental experience (Dewey, 1937/1997). (c) Our basic words are relational to the objects, people, and intelligent systems (Buber, 1937). (d) The world of knowledge and meanings is constructed through self-discovery (Sundararajan, & Raina, 2013) and in collaboration (Zittoun, Baucal, Cornish., & Gillespie, 2007). The first two assumptions are related to mechanisms and principles of creativity. The last two assumptions concern construction in the relational worlds of human wisdom, traditions and affordances (what the environment offers). To lead a balance life, convergent *in* creativity takes developing coordinated abilities (structure) and collaborative capacity as core activities in learning. In the world of mathematics, convergent thinking forms the basis of reasoning required to discover invariant principles or properties, as well as to formulate generalizations from seemingly different situations by focussing on structural properties during abstraction (Sriraman, 2003, 2004a,b,c).

As a mechanism, convergence complements divergence and emergence, the two other mechanisms of creativity. While convergence and divergence involves a positional change of a set of elements, emergence is about a change of the very set of a system of elements (Kastenhofer, 2007, p. 363). Tan (2014) uses a preposition "*in*" to represent complementarity of the mechanisms and their continuous and interactive experience. Briefly, we can consider divergence (e.g., variation and differentiation) as part of *multiplicity* and *variety* in natural and psychological life. Convergence is "getting ready" to transform *randomness* to create patterns in the spirit of upholding the good (Nishitani, 1991). The transition of convergence *in* divergence can be *spontaneous* or *goal-directed* which involves *open* acceptance of realities as they are, as well as *effortful* preparation, selection, and cross-checking what is in the mind with what is acceptable. From a mathematical viewpoint, convergent thinking is a vital aspect of moving the field forward, when patterns from seemingly different sets of examples suggest abstractions that reveal structural invariances- when this occurs, seemingly random ideas cohere to form the basis of deep theorems. It is common amongst mathematicians to use the term "beauty" in an aesthetic sense when a result coheres properties from different areas (Brinkmann & Sriraman, 2009), and this can be viewed in terms of convergent thinking . Although classical examples abound (e.g., Sriraman, 2005), a modern example is the Modularity theorem established by Andrew Wiles, that connects the areas of elliptic curves with modular forms.

Knowing (the present, tacit) and knowledge (the past, domain-relevant) guides emergence of new experiences (Cropley, 2006). Tan (2014) recommends the proposition "*for*" to represent the direction to which "convergence *in* divergence" heads, adhering to the continual, interactive, and complementary principles (Bohr, 1950; Dewey, 1937/1997). Creative learning can be spontaneous and goal-directed. In experiencing creative learning the principle of interaction intercepts and unites with the principle of continuity (Dewey, 1937/1997). Interaction precedes and mediates development of knowledge and capacity of creativity (Ponomerav, 2008a). Interception is an example of convergence in divergence for emergence of any novel experience. With reference to the principle of complementarity, perception and emotion which are qualitatively different from logical thinking enrich our creativity experiences. Generating novel ideas (Sternberg & Lubart, 1999) is in coordination with recognizing the best idea (Amabile, 1983), getting ready for construction of meanings. In capacity building (emergence) following the principle of interaction (Dewey, 1937/1997) convergence serves as a pulling force of cross-domain influences in learning. Spontaneous learning complements goal-directed learning. Actions and activities are in coherence with the affordances, and in congruence with the minds of the actor and the audience (Glaveanu, 2011). In everyday life, we undertake multiple complementary roles (e.g., the actor and the audience) and maintain congruence in these role-identities. The actor in action sets up the plan, coordinates his(her) abilities, transforms him(her)self and the environment when s/he encounters the activity with the audience to which s/he is part. S/he emerges with joy, contentment, and inspiration to bring his(her) audience to witness the beauty of his(her) creative (inter)action.

Emergence is about becoming (Rogers, 1961), and bringing something into existence (Frankl, 1984). In creative production, the motivated person identifies a theme of interest (*convergent thinking*). S/he proceeds to ideation (*divergent thinking*) and applying domain-relevant knowledge to select the best idea (*convergent thinking*). New ideas or variabilities are refined with reference to domain-relevant knowledge (Amabile, 1983). Creative products that are acceptable emerge after a series of iterative convergent processes such as seeing limits, zeroing on the potential, and drawing on the "correct" conclusions (Cropley, 2006). As stated earlier mathematics as a field provides astonishing examples of this process. Teaching experiments with high school students indicate that this is not limited to professional mathematicians given the right pedagogical conditions in the classroom (Sriraman, 2005).

Creativity Development

Developing Capacity

In the field of psychology, after the Second World War there have been conscious efforts to remove the "*fear*" of conducting scientific investigations on human creativity (see Guilford, 1950). A call to restore the "*faith*" in humanism renewed dialogues on sciences for the good. Spaces were created for interdisciplinary sharing of conceptions of creativity. During this period, some psychologists presented their views of creativity (e.g., Carl Rogers and Joy Guilford) and designed tests to identify creative talent (see Guilford, 1957). Subsequent efforts were observed in constructing measurements (e.g., Torrance Tests of Creative Thinking, see Torrance, 1966), and proposing models (e.g., a componential model of creativity, e.g., Amabile, 1983) and theories of creativity (e.g., a three-systems theory, Csikszentmihalyi**,** 1988). Decades later, these unassumingly "small" efforts received attention and have since served as a preliminary knowledge base that have supported continuous efforts to create possibilities in developing people's creative potential.

Towards the end of the twentieth century, there were social movements to develop potentials of all people under the policies of “the no child left behind” and “every child matters” and the like in different parts of the world. Creativity as a potential of every person has been a widely accepted belief. Movements of nurturing creativity and developing talents rallied supports. Consequently, the number of policies for creative education and creative industries grew sporadically. Some societies set up collaborative plans and rolled out programs to nurture all including the vulnerable (e.g., in 2004 Singapore declared herself as an inclusive society) and the talented regardless of their backgrounds. In the United Kingdom efforts to encourage imagination and nurture creativity were observed in the classroom (Craft, 1999). Creativity was acknowledged as a key to innovation and social-economic transformation in Asia such as China, Hong Kong, Korea, Japan, Singapore, and Taiwan. In these societies, one saw an exponential rate of people investing in the capacity to use creative digital devices in their everyday communication compatible to the rate of marketing electronic devices and smart-phone technologies. The adjective of “creative” has been accepted as an everyday vocabulary. More often than not investing in creativity has been linked to economic development sometimes leading to negative consequences for society, e.g., Korea (Sriraman & Lee, 2016).

For nearly fifteen years, efforts have been seen in converging knowledge of creativity in the field of psychology. Within the first six years of the twenty-first century, two annual reviews on creativity were released. The first annual review by Runco (2004) used the four-Ps framework (Rhodes, 1961, person, process, product and press or environment) to organize the contents of the past creativity research. The second annual review by Hennessey and Amabile (2010) followed the line of thought of a systems approach and constructed a model to orientate the continuously increase number of studies on creativity which had blurred the disciplinary and cultural boundaries of the field of psychology of creativity. The renaissance of the studies of creativity overshadowed the previously negative sentiments of uncovering the truth of the humans' potentials. Instead, there have been efforts to outline flourishing conditions for and concise understanding of nurturing creativity. In Kaufman and Beghetto's (2009) four-c framework, there emerged familiar terms such as Big-creativity (or historical creativity), professional creativity (or domain-relevant creativity), little or everyday creativity, and transformational creativity or mini-creativity. Their framework suggested that mini-c and little-c are within all persons. Not all people will persist in pursuing professional c. Rarely, a person has the golden opportunity to experience his(her) own Big-c. The factors and conditions that influence the unfolding of professional c and Big c are complex, and are beyond one person's control. Glaveanu (2011) based on the knowledge of cultural psychology rewrote the language of the four Ps to the five 5As (action, activity, artefact, audience, and affordance). In essence, the person in his(her) social-cultural realm is an actor and an audience, whose action and activity are influenced by the affordance (or what the environment offers). With reference to positive and humanistic psychologies and Zen Buddhist philosophy, Tan (2012) advocates nurturing creativity for constructive growth, ethical practices, and the good.

Creativity is about generating novel and useful ideas (Sternberg & Lubart, 1999), bringing something to being (May, 1975) and flourishing humanness (Frankl, 1984). In the literature, the genre of *novel* best represents life. Novel is constructed in "the zone of direct contact with the inconclusive present day reality" (Bakthin, 1981, p. 39). In life, humans continuously interact with the others, share their knowledge, and experience novelties. Collaboration that generates conceptual conflicts creates ruptures in the existing knowledge systems and opportunities for knowledge innovation. Conceptual convergence in iteration accommodates conflicts and transforms them to shared knowledge. Accommodation is a form of adapting by modifying cognitive structures to fit the otherness. As an incident of learning, developing capacity is converging broad-based sensing, perceiving and feeling of the world and the "correct", systematic, logical and goal-directed processes of representing the world (Ponomerav, 2008a).

According to Ponomerav (2008b), throughout our life, we experience development of multiple forms of knowledge. *Contemplative-explanatory* knowledge emerges from the curiosity and philosophical needs of society. It grows out of practice, common-sense, life experience, work of literature and art, and so on. The person contemplates and records everyday knowledge; and describes it with reference to some existing theory. *Empirical knowledge* relates directly with concrete objects and integral events. It assists in solving practical problems. *Active-transformative* knowledge takes empirical models and transforms into abstract-analytical knowledge. It builds systems of modelling. We never cease to grow our coordinated abilities to react, represent (plan), recall, and reproduce meanings and knowledge. The world of knowledge we construct "mirrors" the diversity, order, and creativity of the world in which we live. Creative cultural divergence is based on internal persuasive discourse, which "is freely developed and allows for new voices to join in and participate." (Hsu, 2012, p. 108) Creative persons possess creative qualities, abilities or characteristics (see Guilford, 1950) which include but are not exclusive to sensitivity to problems, ideational fluency, flexibility of set, ideational novelty, synthesizing ability, reorganizing or redefining ability. Knowledge construction and innovation is a mean and an end of creativity development. In creating, we are motivated to generate and explore (Ward, Smith, & Finke, 1999) and coordinate abilities which include motivating, domain- relevant processing (knowledge, techniques) and creativity-relevant processing (ideation, breaking sets) (Amabile, 1983). In each phase of creating, there exists a "*continuum*" of sub-processes (Lubart, 2001).

Constructing the World of Knowledge

Knowledge construction is a social-historical, cultural, and over-generational endeavour. It is a convergence *in* divergence *for* emergence experience in the human world throughout our life span. In the field of psychology, convergent creativity in the context of knowledge construction has been elaborated by eminent psychologists, Jean Piaget (1896-1980), Lev Vygotsky (1896-1934), and John Dewey (1859-1952), to name but a few. A child prior to language acquisition constructs the world of knowledge by using his(her) senses, feeling, perception, and movement (Ponomerav, 2008a). Scaffolding is an example of social-cultural *convergence* when the adult enters into the zone of proximal development of the child and guides his(her) development (Vygotsky, 1978). Creative teaching is dependent upon *congruence* in teacher roles and a process of *coherence* in assessment, activity and instruction. Teachers adopt multiple roles in everyday classrooms. They possess multiple role-identities. *Congruence* as an instance of convergence in divergence in creative teaching (Tan, 2015a) is about relevant, multiple teacher role-identities that are combined as a co-ordinated competency and that guides the dissemination of knowledge and skills. *Coherence* is another instance of convergence *in* divergence of creative teaching (Tan, 2015a) taking the process of delivery of effective instruction as a mean and an end towards creative learning. The teachers design the lessons of the day according to the needs and styles of the learners.

Convergence signifies the readiness to transit to the capacity of constructing a structure, designing a plan, or coordinating abilities. According to Rich, Leatham and Wright (2013), convergent cognition refers to a *common underlying conceptual base* in which the relationship is unified, interconnected, and interdependent. Immediately after a baby is born, s/he is ready to *imitate* movement of gestures that s/he notices (Rizzolatti, & Craighero, 2004). S/he is curious to feel and touch any objects or people who appear before him(her). The new born is prepared to relate to the caregivers. S/he is motivated to fulfil his(her) needs. S/he has the potential to acquire knowledge in everyday life and in various domains. S/he is intuitively alert to learn about all things that come before him(her). *Imitation* is a significant *convergent* capacity that a child has since s/he is born. Through *imitation* s/he relates to the caregivers and people around him(her). Further, the child has the ability to organize information available and accessible to him(her). If the information fits into his(her) cognitive structures, s/he assimilates it; otherwise, s/he modifies his(her) cognitive structures to accommodate the new information. Organisation and adaptation (assimilation, accommodation) are *convergent* processes in constructing the world of knowledge, mental models, structures, coordinated abilities, or internal plans. "Operation" or structure is a reality referring to the child's deductive capability (Piaget, 1928).

Everyday Learning

The authors are in favour of a "*middle way*" (moderate) and a continuum approach to convergence in creativity (see Tan, 2014). Observing the practice of moderation in life we adhere to cultivating good conducts and avoiding dogmatism. We are contented with sufficient, optimal and balanced conditions in life. On becoming a person, we make appropriate effort to carry out what we deem as important for ourselves and for the people around us. With an understanding of continuum, we bridge the seemingly dichotomous discourses of divergence *versus* convergence such as a divergent task (list as many usages as possible for a "paper clip") versus a convergent task (At a cold and icy night a tired man reaching home had his dinner and switched off all the lights before he went to bed. The next morning he woke up and found himself walking through his residence full of dead bodies. What caused deaths of the residents in the man's home? (see e.g., Nielsen, Pickett, & Simonton, 2008). We postulate that the underlying creative process and action of generating and exploring likely common but the transformation of creative structures in interaction with accumulative, coordinated, and integrative information creates variations in forms creativeness and types of knowledge.

Learning in everyday life and classroom shall regard congruence in roles and coherence in contents and process of learning (Tan, 2015a). In a newspapers article released on August 24, 2015, a story of twin cubs which were born, with four hours apart in the Zoo of Washington attracted the attention of a home tutor. According to the article, the mother panda gave birth to the first cub in 2005, the second in 2012, which unfortunately died six days later, and the third in 2013. A decade after the first cub was born, twin cubs arrived after the mother panda successful went through the process of inseminated fertilization from frozen and lived sperms of two different male panda living in China and the United States of America.

To understand the information reported in the article, the adult adopted a *convergen*t approach to posing questions related to factual knowledge, accuracy of information, and drawing "correct" conclusions (Cropley, 2006). The child displayed some traces of coordinated abilities in reading the text, relating his previous reading on the same theme months ago, and in imagining how life can be better for both the adult and cub pandas in the zoo of Washington and in his home country (Singapore). Variability in generating (Cropley, 2006) questions were used to assist the child to grasp accurately factual information of the article: (a) Who was the author of the article? (b) Where did the Panda cub deliver? (c) What were the names of the officials in the zoo who spoke to the reporter? (d) How many cubs have the panda delivered since 2005? (e) How many of her off-springs survived? (f) How far was apart from her first delivery to the present deliveries? Variability in exploring (Cropley, 2006) aimed to guide the child to conclude what he read. It went beyond the individual panda in the article and discussed about the endanger species in the world. As a matter of fact, according to the article, there are about 1600 of them in the wild life, and 300 in captivity. Those who live in captivity have a low rate of fertility. The child who read the newspapers article answered the questions and penned down three sentences summarizing the essence of the article. He experienced some disequilibrium especially in understanding the term “twin” and the word “survived”. Guided by the adult, he related the number “two” to the word “twin”, the operation of “subtraction” to the early dead of the six day old panda. Learning is a cycle of rhythm of life, relating abstract ideas (e.g., death, survive) to concrete experiences (e.g., panda in the Singapore zoo), and interests of the child (e.g., reproduction). The joy of discovery in the cycle of romance from free questioning guides the child to the next cycle of learning appreciating the need to learn the language of a discipline such as mathematics (Woodhouse, 2012). Improvisation is novel as new behaviour emerged in the in-between space and through collective interaction (Sawyer, 1999). The child summarized the essence of the article and improvised the life in the wildlife and in the zoo. He imagined how the cubs played with their mother, and how he observed them playing taking the role as a visitor of the zoo at home and in the bamboo forest far away.

Classroom (Mathematical) Learning

Convergent thinking plays an important role in mathematical learning. Many early learning processes such as sorting, counting, stacking, categorizing converge into the abstraction of ordinality and cardinality, and the basis for the generalization of number. As students progress through mathematics, the structures they encounter become increasingly abstract (sets, relations and so on) with generalization as a key feature of mathematical thinking. In a sense abstraction and generalization can be viewed as a convergence of thinking of different properties of mathematical objects and the ability to eliminate superficial similarities to focus on structural similarities. Vadim Krutetskii (1976) analyzed the generalization ability of both "normal" and gifted students in a series of experiments. Krutetskii viewed the ability to generalize as one manifestation of the creativity of the individual. He hypothesized that "students with different abilities are characterized by differences in degree of development of both the ability to generalize mathematical material and the ability to remember generalizations" (Krutetskii, 1976, p. 84). One of the attributes of students who were able to generalize mathematical ability was the ability to switch from a direct to a reverse train of thought (reversibility), which capable students performed with relative ease. The mathematical context in which this reversibility was observed was in transitions from usual proof to proof via contradiction (reductio ad absurdum), or when moving from a theorem to its converse.

Krutetskii studied 19 students with varying mathematical abilities. The problems used by Krutetskii in his experiments met the following criteria. (1) The problems were of graded difficulty; (2) The problem sets consisted of simple problems as well as some that required "mathematical creativity"; (3) Some problems were simply put to evaluate skill mastery. These problems were based on new material that students had encountered in their curriculum. Based on his experiments with the 19 students, Krutetskii concluded that more "capable" students were able to rapidly and broadly form mathematical generalizations. He noted that these "capable" students were able to discern the general structure of the problems before they solved them. The "average" students were not always able to perceive common elements in problems, and the "incapable" students faired poorly in this task. These results led Krutetskii to examine "gifted" students separately followed by an examination of incapable students. The final experiment was a study of 24 "gifted", 22 "average" and 8 "incapable" students. Based on these series of experiments Krutetskii identified four levels of generalization as a function of the ability of the students. The researcher will quote directly from Krutetskii's writings.

> Level 1: Cannot generalize mathematical material according to essential features even with help from the experimenter and after a number of intermediate single-type practice exercises.

Level 2: generalizes mathematical material according to the essential features with the experimenter's help and after a number of single-type practice exercises, with individual inaccuracies and errors.

Level 3: generalizes mathematical material according to essential features, independently, but after some single-type exercises and with insignificant errors. Proper faultless generalization comes with insignificant promptings and leading questions from experimenter.

Level 4: generalizes mathematical material correctly and immediately, "on the spot", without experiencing difficulties, without help from experimenter, and without special practice in solving problems of a single type (Krutetskii, 1976, pp.254-255).

Krutetskii came to the conclusion that in order for students to correctly formulate generalizations, they had to abstract from the specific content, and single out similarities, the structures and relationships. The ability to generalize consists of two aspects:
(1) subsuming a particular case under a known general concept; and (2) the ability to deduce the general from particular cases (in this instance the generality is unknown).The work of Krutetskii has subsequently been extended by Sriraman (2002; 2003; 2004 a,b,c) in the contexts of number theory and combinatories where high school students were able to distill convergent properties such as Steiner n-tuples, the Dirichlet principle and Diophantine n-tuples. In all these experiments the principle of “convergence *in* divergence *for* emergence” became exemplified and supports strong evidence to Tan’s (2015b) theory of convergent thinking for fostering creativity. Moreover the case study of Ramanujan presented in the concluding section of this chapter provides a compelling account of convergent creativity that unified the study of infinite series, continued fractions and geometric function theory into “convergent” formulae that still provide number theorists fodder a century later- even though

this may be construed as an extreme case, it nonetheless illustrates our argument for fostering convergence in creativity development.

Conclusion

This chapter elaborates the mechanisms of convergence *in* divergence for emergence with reference to *knowledge-induced* creativity which has its base in *effortful* creativity (Cropley, 2006; Tan, 2015b). Our assumptions for convergent creativity include learning is a way of life to develop capacity of mankind for the good, ethics, universal values, health, positivity, and possibility. Learning for life goes beyond effortful commitment, knowledge-induced engagement, and domain-relevant processes. Learning *in* practice takes convergence *in* divergence as a core basis for emergence. Throughout our life, we master meta-theoretical strategies (selection, optimization, and compensation, Baltes, 1987), meta-awareness (imagination, and imitation), meta-regulation (broaden-and-build theory, Fredrickson, 2001), and so on. We construct different types of knowledge (e.g., contemplative, explanatory, and empirical, Ponomerav, 2008b) and show varying forms of creativity (e.g., mini-, everday, and professional, Kaufman & Beghetto, 2009). Mathematical learning and creativity is a life engagement. It is about thinking and feeling the world through mathematical symbols, representations, and language. The ultimate aim of mathematical learning and creativity is good life, ethical relations, and healthy living. Our understanding of convergence *in* creativity in mathematical learning and creativity is a cultural and disciplinary boundary crossing endeavour. Table 1 outlines the main points of convergent creativity for capacity building.

Table 1

Convergent Creativity for Building Capacity

Mechanism	*Principle*	*Process*	*Structure*
Convergence	Continuity	Self-discovery	Imagination (Intuition)
Divergence	Interaction	Collaboration	Tradition Cross-domain knowledge and knowing
Emergence	Complementarity		Imitation

A Novel-like Legend

This chapter presents our preliminary thoughts on convergent thinking, creativity, and mathematical learning. The chapter regards creativity as an incidence of learning (Guilford, 1950), and learning as a way of life to build capacity to discover meanings in life. Learning is both personalized and collaborative in inquiring into the good (Tan, 2012) and in acquiring knowledge from the human society. Particularly, we wish to understand convergent creativity in light of capacity building and knowledge construction in the context of learning a subject matter (e.g., mathematics). Our reflections on convergent creativity orientate around a legend of the world renowned mathematician, *Srinivasa Ramanujan Iyengar* (1887-1920). We regard as fortunate to come across abundant narrations and analyses of Ramanujan's life and work freely accessible in the Internet including those from eminent people such as G. H. Hardy (1877-1947), Bruce C. Berndt (1939-), and George E. Andrews (1938-) (see Berndt, n.d.; Andrews, n.d.1 & n.d.2). In this chapter, we specifically make reference to a British mathematician, Hardy's (1937) inspirational account on Ramanujan's mathematical capacity, his unique method of inquiry, and convergent creativity in mathematics.

"It was his insight into algebraical formulae, transformation of infinite series, and so forth, that was most amazing. On this side most certainly I have never met his equal, and I can compare him only with Euler or Jacobi. He worked … by induction from numerical examples … (W)ith his memory, his patience, and his power of calculation he combined a power of generalization, a feeling for form, and a capacity for rapid modification of his hypotheses, that were often rally startling, and made him, in his own peculiar field, without a rival in his day. " (Hardy, 1937, 149)

At the early years of development, Ramanujan encountered traditional wisdom (*divergence* in cultural traditions, see Hsu, 2012) and showed interests in numbers. According to Hardy (1937), Ramanujan grew up in a Brahmin family of a high caste. He adhered to all observations in his caste, and remained strictly a vegetarian practitioner until the end of his life. Ramanujan, who was once a clerk turned an extraordinary mathematician, showed at his early years (before ten) his exceptionality in mathematics. His talent in mathematics was recognized at the age of 12 and 13. Only at the age of 16 he was exposed to George Schoobridge Carr's volumes (*A synopsis of elementary results in pure and applied mathematics)*. Carr's volumes were an inspiration for Ramanujan to establish formulae. With no other resources, each solution was like a piece of research to him. Ramanujan credited his achievements in arriving at the formulae to the gifts he received from the goodness of Namakkal in his dreams. It was believed that Carr's volumes contributed to the unfolding of full powers in mathematics in Ramanujan. With some encouragement from people in his homeland, India, Ramanujan wrote and sent his voluminous work to great mathematicians in the United Kingdom. In his twenties, Ramanujan left for England and had since worked closely with Hardy. His talents in mathematics flourished further in the new environment in which he engaged in intensive and daily sharing of his discoveries with his mentor: "… he was showing me half a dozen new ones almost every day … ." (Hardy, 1937, p. 146)

Travelled to Cambridge and worked with colleagues in the Trinity College, Ramanujan and his mentor(s) combined their personal (imagination) and social resources (collaboration), funds of knowledge (including contemplative-explanatory, empirical, and active-transformative, Ponomerav, 2008b), and sources of creativity (e.g., professional and Big, Kaufman & Beghetto, 2009). Together they resolved conceptual conflicts and brought their knowledge in mathematics to convergent creativity. Ramanujan;s algebraic formulae and transformation of infinite series orientated the direction of his creations, and served as heuristics to design meanings (see Cropley, 2006). Ramanujan was a great master of hypergeometric series and continual fractions (Hardy, 1937); creating new series and patterns beautifully which was therapeutic, meaningful, and spiritual to him. Life was the beauty of mathematics (*emergence*). In Hardy's (1937) account, Ramanujan's was enthusiastic to generate and share with him novel theorems: "… he was a mathematician anxious to get on with the job … " (p. 146) Proofing his own theorems and inquiring into the process of creating novel theorems were not in his list of priory and interest. Hardy, the British mentor showed Ramanujan the importance to derive proofs to verify his own discoveries. Ramanujan's determination to overcome challenges and to maintain enthusiasm in mathematics served as an exemplified case of inquiry into *convergent creativity* (see Craft, 1999). To elaborate we cite Hardy's account on Ramanujan's convergent creativity: "It was his insight into algebraical formulae, transformation of infinite series, and so forth, that was most amazing. … He worked, …, by induction from numerical examples; all his congruence properties of partitions, for example, were discovered in this way. But with his memory, his patience, and his power of calculation he combined a power of generalization, a feeling for form, and a capacity for rapid modification of his hypotheses …" (Hardy, 1937, p. 149).

Hardy admitted that his discovery of Ramanujan was a romantic incident in his life time. He was able to understand Ramanujan's brilliance, and was ready to openly listen to Ramanujan's generative variabilities daily and to critically build up his capacity in finding proofs. Ramanujan's joy of imagination was substantiated by Hardy's persistence in searching for proofs. "A mathematician usually discovered a theorem by an effort of intuition; the conclusion strikes him as plausible, and he sets to work to manufacture a proof." (Hardy, 1937, p. 151) Coordinated abilities of generating theorems and of proving the theorems systematically are essential to remove any fallacy and to confirm accuracy of one's imagination.

Convergence in Creativity for Good Life

Inquiry into the good requires a continual renewal of *moderate attitudes* towards the external influences (*continuity*). It is about living *in* the tradition and contemporary knowledge, as well as living *with* self-discovery (Sundararajan & Raina, 2013) and openness in collaboration (Jarczak, 2011). We reflect on *convergence*, a mechanism of creativity and a core of *effortful* endeavour. Convergent thinking exists in *effortful* creativity (Cropley, 2006), which is knowledge-i*nduced*. Effort on a *continuum* of the action or process is likely a matter of the degree of intensiveness. Likewise, on a *continuum* of knowing and knowledge is likely the common underlying process and action of creating, while emergence of variations in terms of forms and functions is likely dependent on how accumulative, coordinated, and integrative information interacts with and makes senses to the persons who use it. Tacit knowledge (Polanyi, 1968), people's conceptions (Sternberg, 1985), what is in the person's mind or the like is a basic of scientific knowledge (see Polanyi, 1968). Creative thoughts share commonalities of *goal-directed* thoughts (*complementarity*), which occur during problem solving, planning, reasoning, and decision making, and *spontaneous* thoughts, which includes mind-wandering (Mok, 2014) and memory processing (Christoff, Gordon, & Smith, 2008). Collaboration in knowledge convergence involves the like-minded people with epistemic curiosity in resolving conceptual conflict and in committing to iterative refinement of shared knowledge (Jorczak, 2011).

For convergent creativity to emerge, it is essential for a person to possess the structure of creative agency. In learning, humans are agents of change (Bandura, 2001), actors innovators of knowledge-based activities. Humans as agents are reactive, pro-active, reflective, and creative. We are able to predict or think ahead of time and space (Bandura, 2001). We understand the social cultural world not only when we take conscious and effortful actions but also when we observe how *interactions* unfold when we are with other people or part of shared systems. Born into the living human world, we sense, observe, and model the others. We develop meta-strategies to optimize opportunities and compensate our shortcoming (Baltes, 1987). Humans are receivers of accumulative expertise, knowledge, and skills. We create our own world of knowledge. An essence of creativity development is to shape, orientate, and lead life to its fullest (Cropley, 2006). Our seeing and knowing orientates our direction to develop humanism within and without. We put in intensive *efforts* to develop coordinated abilities, collaborate with the others, synthesize resources, set up plans, and relate to the good and ethics.

In narrating the great Indian genius in mathematics, Hardy (1937) revealed his wisdom to recognize the invaluable gift of Ramanujan. Ramanujan built up his capacity in multiple aspects in mathematics mainly through self-absorption in and joy of doing mathematics. He enjoyed a prolonged duration in the romantic phase of learning (Woodhouse, 2012) and his absorbed mind was at all times engrossed in the stage generating novelties and exploring discoveries (Ward, Smith, & Finke, 1999). The pre-inventive structures of mathematics went through rounds of transformations and emerged as novel formulae and series. Hardy admitted the reservoir of Ramanujan's unprecedented imagination. In his narration, Hardy (1937) noted how Ramanujan instantly saw a pattern in a number (e.g., 1729) as "a sum of two cubes in two different ways" (p. 147). It was evident that Ramanujan possessed convergent capacity to generate varying types of *knowing-knowledge* (contemplative, explanatory, empirical, and active-transformative, Ponomerav, 2008b). He had the capacity to coordinate abilities (e.g., imagination) and to transform tacit knowledge (e.g., the number plate of a cab) instantly to scientific knowledge (e.g., the series patterns). As a critical contemporary and mentor, Hardy identified Ramanujan inadequate capacity to derive proofs for some of his imaginations particular in the analysis of number theory. Hardy attributed this Ramanujan's incapacity to the insufficient instructions and mentorship he received in his early years of education. Our inquiry into Ramanujan's creativity development seems to concur preliminary to the critical reflections of scientific creativity that formal education can be important to transform creatively some forms of knowledge (e.g., analysis). Freedom of imagination and transformation is essential for other forms of knowledge creation. It is imperative and immediate for educators and scientists to examine the good of schooling and a claim that formal education limits creativity capacity. Likewise it is essential to investigate the importance of freedom of thought that enhances creative imagination in varying incidents. Future reflections shall focus on imagination as a prerequisite of creativity (Vygotsky, 2004), its roles in convergent creativity, and its possibilities for knowledge construction.

Final Words

In generating theorems, functions, and series, Ramanujan attained the supreme joy compatible to the spiritual unity with Namakkal. He reached a high level of imagination, self-discovery, and spontaneous cognition. Convergence in creativity unfolds and consolidates after a series of iterations of imagination (divergence) and/or analysis (convergence). We are hopeful that under flourishing conditions knowledge-*induced* convergence in creativity not only a source of domain-relevant capacity but also a reservoir for self-care and wellness. Convergent creativity has its underlying processes in spontaneous and controlled cognition (Mok, 2014) as well as in creative imagination and creative collaborations (Hardy, 1937). The continuous appreciation of "the loss notebook of Ramanujan" and its subsequent renewals in knowledge of mathematics has remained amazing evidence of convergent creativity. Our next journey of reflections on convergent creativity shall focus on how to re-construct the conditions for imaginative creativity that Ramanujan enjoyed in India and those for analytical creativity that he experienced in England. Reflections on how flourishing conditions enhanced convergent creativity can be a key to support full development of human potentials in the presence of positive affordances (what the environments offer for ethical practices). Our views on convergent creativity can serve as a gentle reminder for a meaningful journey of creativity development not only in the world of mathematical abstractions but also in the relational and humanized world.

Remarks

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