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The Dual Paths to Innovation & Economic Revival

This article is engaged in the problem of educational system development to improve workforce skills to adapt and innovate. The Creative Combination Model is considered to depict the influence of creativity contribution on the results of cognitive processes. The difference between eminent and incremental creativity is considered. The possibility and the conditions of considered issues implication in educational system are described in the proposed balanced approach.

Keywords: creativity, creative innovations, educational system, divergent thinking techniques, domain.

A country's economic prosperity is dependent upon a highly skilled workforce. In turn, this workforce is reliant on a well informed educational policy. In an increasingly turbulent global environment a key component of this policy is the need to develop a workforce that is creative and able to adapt and innovate. Yet despite a renewed interest in the field of creativity, the discussion as to the role of creativity in national curriculums, and its importance to economic development, is still largely cursory.

One of the reasons for this limited discussion is that creativity as a field of research is still an area of debate, measurement uncertainty, and apparent contradictions. Central to these issues are problems of creativity measurement, and a lack of understanding of the processes that result in its occurrence. In addition, there is a growing acknowledgement that there may be dual paths to creative innovation, one path leading to incremental development, the other to paradigm shifting innovations. Path one is lower risk and in line with current trends in many national education policies. Path two is higher risk but can potentially result in much higher returns.

Workforce Development

The development of human capital is central to a nation's economic development and in the current uncertain global economic climate there is a need for new ways of thinking, and innovation. Old models are failing, not just in a financial sense, but also in terms of economic sustainability and from a moral perspective. Economies that were recently held up as the successful 'Tigers' of economic growth have dramatically failed. Government debt in many of the world's largest economies is reaching levels well in excess of national GDP. Add to this the environmental costs, as well as social failures caused by a burgeoning discrepancy between the rich and poor, and it is evident that new models of economic development and

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dramatic innovative solutions are needed. In terms of the factors of production, it is only the human resource that can provide these solutions.

The development of human capital is dependent upon a country's educational systems and there has long been criticism of the limitations of these educational systems in developing creative individuals. The modern father of creativity research Guilford, stated that mass education methods result in increases in pressures for students to memorize large amounts of facts and to conform, so as to satisfy prescribed standards [13]. These goals are the opposite of what is required to develop creative individuals. Despite these assertions, many educational systems have become more, not less, standardized [8, 11, 14, 15, 29].

As education has become a vast global business, the industry has seen the development of standardized curriculum and tests. These tests ensure conformity of achievement but promote education systems that stress specialization, memorization, and rote learning methods. This results in a paradoxical problem. In the drive for economies of scale and simple testing methods, educational institutions are limiting one of the key skills required for organizational and national economic success: creativity.

There is therefore a crucial, and immediate, need for a better understanding of how to nurture creative thinking. However, research into the creative process has remained a relatively minor field [6, 36]. One of the limits to the area of creativity research is that until recently consensus as to the definition of creativity has been lacking. Additionally, there is still not an accepted model of the creative thinking process. Without clarity in these areas it is difficult to properly define the creative thinking process, and subsequently how it can be nurtured.

In terms of what constitutes a creative idea, after over five decades of modern research into the subject, most researchers now accept two criteria – originality, or the novelty of an idea, and appropriateness, or the value of the idea [21, 23, 30, 31]. In developing policies to enhance creativity we need to first understand the creative thinking process.

Creative thinking is a matter of combining distant domains

It is widely accepted that creative thinking involves combination and reorganization processes [3, 24, 27]. There is also evidence that the ability to combine and reorganize memories is related to creative success [24, 27]. Subsequently, much of the research into the creative thinking process focuses on the formation, synthesis, or modification of ideas [5, 20]. Researchers have stated that the creative process involves the creation of new memory structures either through the combination of distinct concepts, or the new combination of elements of existing concepts [22, 34]. However, the combination of distinct concepts is a different process and achieves different outcomes than that achieved by combining existing elements of concepts. While all creative processes involve some type of combination process, not all creative ideas are created equal and the path to different types of creative ideas is based upon different cognitive strategies.

As far back as 1963, Ghiselin noted that the cognitive processes underlying the production of major contributions may differ from those underlying the production of minor contributions [10]. Other researchers have also acknowledged a difference [1, 9, 28, 40]. Mumford and Gustafson suggest that the difference between eminent big C contributions and minor small c contributions, may be that the former entailed the integration and reorganization of cognitive structures, while the latter is related more to the extension of existing structures [21].

Cognitive networking research by Schilling provides a basis for understanding these differences in eminent big C and incremental little c creativity [32]. Schilling proposes that

creative insight occurs when an atypical association is made through random associations. Schilling notes that insights can help people to solve both everyday problems, as well as potentially leading to major scientific breakthroughs. This network model provides a basis by which connections of category elements result in different outcomes. Ideas that are the result of more distant, or atypical, connections will result in more novel ideas than those that are the result of more typical, or related, connections.

Combining the conclusions reached by [1, 9, 10, 21, 28, 40] with the research [32, 17] posited the creative combination model. This model posits that the degree of creative contribution of an idea is based upon the extent to which new ideas involve the combination of highly dissimilar, versus similar, domains.

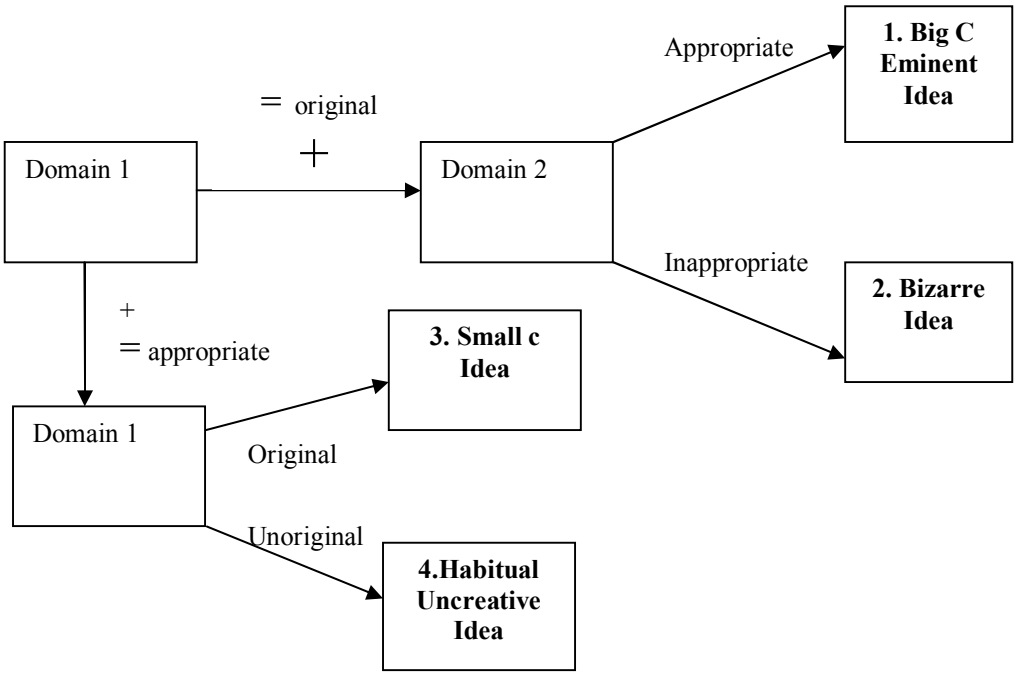

Fig. 1. The Creative Combinations Model: Big C versus little c Creative Ideas

This model posits that ideas that involve combinations of ideas from within a domain will be viewed as appropriate. If those combinations are also original then they are small c incremental creative ideas. Alternatively, ideas that combine different, or unusual domains, and are also made appropriate, will be viewed as big C, or eminent, creative combinations. Although the concept of domain is simplified in the above model, it is best described as a continuum. The proximity of knowledge domains to each other is based on the extent to which society currently associates those domains. This continuum is constantly changing as new creative ideas are developed and domains not previously associated with each other become related. For example Alexander Fleming's discovery of penicillin linked micro biology and medicine in a new way, and those domains became a lot closer.

While this model is useful for conceptualizing different creative thinking processes, it leads to further questions that need to be addressed before curriculum can be developed. A

growing body of researchers has noted that the requirements for big C and little c creativity are in many respects contradictory to one another. These researchers have shown that incremental creativity may actually work to retard the development of highly breakthrough creative ideas [33, 37]. So a central question is: "what do we need to teach to nurture creative thinking?" Much of the debate in this area has focused on the effect of knowledge on individual creativity.

In a review of this debate on creativity and knowledge [40], discusses the issues in relation to two views, the foundation view – that domain specific knowledge provides the basis for creativity to occur, and the tension view – that there is a U shaped effect whereby knowledge provides the building blocks for creativity, but over a certain level that knowledge can lead to habitual behavior and limit creativity. This U shaped effect of knowledge can be expanded to account for the different knowledge requirements of big and small c creativity.

Small c creativity requires an extensive process of learning, evaluation, and re-evaluation of the existing information within a domain. A focus on past information as the basis for idea development suits situations that require solutions that will be accepted, and where immediate implementation is a priority. This is the situation faced by many organizations and academic researchers [24]. High domain specific knowledge assists small c idea generation.

In contrast generating big C creative ideas necessitates that a person integrates domains of knowledge that were previously unrelated. In this case high levels of specialist domain specific knowledge may actually decrease the likelihood of big C idea generation. An expert's strong knowledge of a particular domain means that memory categories from that domain are likely to be the anchor points for any new combination. These anchor points are so strongly developed that it is difficult for alternative domain concepts to link in with all the related memories structures. These anchor point's act as limiting nodes from which ideas will be generated, in what is called mental set fixation [38, 39].

Mental set fixation is where strong domain knowledge constrains search behavior by confining the search to a limited area. One related theoretical construct, 'structured imagination', proposes that when faced with a situation that requires a creative solution, a person might take a path of least resistance. This means they retrieve an internal solution, and then adapt that old construct in some novel way [38]. For example, an expert with many well-developed, memory structures relating to the existing product, will find they limit their creative search processes i.e. a new fry pan – it has to be round, it has to be made of metal, it has to have a handle. Moreover, research indicated that when engaged in generative tasks individuals do not consider the source of the components of their novel productions [19].

Another issue in relation to domain specific knowledge and creative idea generation, is that a minimum level of knowledge is required in order to generate ideas. While too much specialized knowledge may result in habitual responses and stringent problem definition, too little means that the person does not have any basis for developing new combinations. In summary a minimum level of knowledge is required before creativity can occur, while specialist knowledge beyond a certain point leads to a drop off in creativity – the U shaped effect.

This review of the literature provides a number of incremental insights. Specialist knowledge will foster small c, incremental creativity. In contrast, being a generalist will allow for more bases for big C, creative leaps. As noted in [19] if a person has a large amount of 'unconstrained' prior knowledge with boundaries of knowledge that overlap, then they should be able to develop better quality solutions. Subsequently, too much knowledge in one particular area may in fact be what limits big C creativity, rather than too much knowledge. As

noted by [32], if creative combinations are required between distant domains, the extent of a person's knowledge of both of the domains will influence the extent of the node connections that are made. This is given support by research in [4] that discusses the importance of teaching with an interdisciplinary approach. This approach provides both the necessary knowledge for creativity, while at the same time not narrowing down the focus of each discipline as standalone and unrelated.

Subsequently, it may be that [13] was correct when he proposed that it is not too much knowledge that limits creativity, but how that information is stored. Focused expertise in an area may limit big C creative thinking due to automated processing, limiting anchor points, and a lack of alternative domains as combination points. A diverse range of knowledge of different fields will allow opportunities for the cross fertilization of ideas and distant domain links to occur. This diverse knowledge will also allow for these links to be developed in a way that is understood within at least one of the domains.

So, on the one hand researchers' state that knowledge is an antecedent to creativity, and on the other that knowledge can limit creative thinking due to an expert's highly structured memory categories. But can expert knowledge limitations be overcome?

In studies of eminent creative individualsfound that notable scientists: read widely in areas outside their discipline, benefit from random chance events, and/or work on multiple projects at one time [35]. Each of these factors would allow a person's anchor points to be expanded; essentially allowing them to step away from their limited and limiting search model. Other researcher found that people who move from field to field tend to be viewed as more creative than those that focus on one field throughout their careers [16]. Additionally, it is well recognized that many major discoveries have been accidental. These accidental discoveries result from chance information which is used in the idea generation process.

Researchers have noted another way we can open ourselves up to alternative domains; we can learn divergent thinking techniques. These techniques force us to think across to unusual domains to assist in our creative combination processes. Many researchers have looked at the extent to which divergent thinking skills can be enhanced. Researchers investigating the mental processes involved in the creative thinking process have identified a range of cognitive processes and structures that enable more creative outcomes to be generated [2, 7, 12, 25, 26]. Moreover research has shown that these cognitive processes can be enhanced [2]. Hence, it appears that the cognitive processes underlying the idea generation stage of the creativity process can be taught, and structured techniques that allow divergent thoughts to occur may be crucial in individual creative development.

However, divergent thinking skills, while an important process in creative thinking are redundant unless a person has knowledge of alternative domains with which to make new connections. Hence, while these skills may have been overlooked in most educational systems, they in themselves are not enough to ensure creative outcomes. Research [18] showed that the application of such techniques can assist individuals to develop more original ideas as long as they possess a certain level of knowledge of the problem domain. However, for domain novices these techniques have a negative effect on the overall quality of creative outcomes.

Implications

In summary these findings contribute a number of insights that can assist in the development of a nation's human capital. In relation to the emphasis on knowledge development, given the U shaped creativity knowledge curve, a balanced approach is needed. If we want creative individuals capable of producing big C ideas, our education systems need

to be broad based and encompass both standard academic and other so called 'non curricula' activities, such as the arts. Additionally, we should specifically teach divergent thinking techniques. Most important however, is the need to recognize that the current drive to mass standardized education and early specialization in a discipline may not lead to a population that is able to think outside the current box that we have put ourselves in.

Alternatively, if a society wants to promote incremental creativity it should emphasize specialist in-depth systems of learning. Despite all of these discussions about the limitation of knowledge on eminent creativity, this is not to say specialist knowledge and incremental creativity cannot be as far reaching as eminent big C creativity. Specialist expertise will increase the propensity for small c solutions, and numerous small c additions will still move the field out significantly, as the edges of the domain expand. If these small c incremental changes occur fast enough then the overall result may be as significant as eminent changes. The other advantage of incremental ideas is that, given they are extensions of the existing domain, it is easy for experts within the domain to see their relevance. It is therefore easier to achieve acceptance of small c ideas. Incremental creativity is lower risk. However, this gradual development will not be recognized as significantly creative, as observers will not view those ideas as highly original. Incremental ideas will also not provide paradigm shifting solutions to problems.

This leads to a quandary. Should we encourage the process of specialist systems of knowledge, or alternatively, educational systems that encourage more broad interdisciplinary learning to occur? Of course the answer lies in our objectives. If we want a workforce that is highly efficient and able to make advances within certain prescribed areas, then we should encourage in-depth specialist knowledge systems. This will result in gradual improvements in the current systems, incremental creativity, but a lack of paradigm shifting breakthroughs.

Alternatively if we want to encourage a highly adaptive workforce that is able to integrate ideas across disciplines and think divergently, then a broader interdisciplinary education system should be encouraged. This method will encourage lateral thinking, but the creative ideas generated will be higher risk and a lack of implementation may lead to resentment. Additionally, while interdisciplinary knowledge and divergent thinking is useful for creative idea generation, extensive knowledge of the combination domains will still be needed to refine those divergent ideas and make them appropriate and workable.

Which is the best approach? There are no easy solutions, but currently, one of the most critical aspects of a country's national policy and long term prosperity is being driven not by educated discussion about what is best for our societies, but by financial and business imperatives. Some may argue that a lack of broad systems based thinking has led the world to its current state of economic and environmental decline. Whatever the view, in deciding upon our path to future social and economic revival, the debate around the expertise we require to move our economies, and the world forward, needs to be an informed one.

Summary: The Dual Paths to Innovation & Economic Revival

Economic and social prosperity is dependent upon a workforce that is able to innovate in times of change. This paper discusses the dual paths to developing a creative workforce. Both of these paths have different educational requirements. These requirements are discussed in order to better inform the workforce development debate.

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Двойной путь к инновациям и экономическому возрождению

Статья посвящена проблемам развития системы образования, направленного на усовершенствование у трудовых факторов способностей к адаптации и инновационной деятельности. Рассмотрена комбинированная творческая модель, которая позволяет продемонстрировать влияние творческого (креативного) вклада на результаты процесса познания. Показана разница между значительным и инкрементным творчеством. В предложенном сбалансированном подходе рассмотрены возможности и условия внедрения исследованных концепций в систему образования.

Ключевые слова: творчество, инновации, система образования, дивергентная техника мышления, область знаний.

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Подвійний шлях до інновацій та економічного відродження

Стаття присвячена проблемам розвитку системи освіти, спрямованої на вдосконалення у трудових факторів здібностей до адаптації та інноваційної діяльності. Сучасна система освіти, на думку автора, набула форми індустрії з розвитку стандартизованих програм та тестів, спрямованої на глибоку спеціалізацію та машинне запам'ятовування значного обсягу навчальних матеріалів, що перешкоджає розвитку творчого інноваційного мислення. При цьому губиться один з ключових факторів розвитку – творчій підхід, що дозволяє продукувати інновації. Автор виділяє два основних шляхи створення інновацій: поступового (інкрементного)

розвитку, менш ризикований та заснований на продовженні існуючих тенденцій розвитку освіти, та рушійних (творчих) інновацій, більш ризиковий але потенційно більш ефективний. Але проблема визначення ефективності творчої діяльності до цього часу не вивчена через відсутність підходів до її чисельного вимірювання, чіткої моделі творчого мислення та низки протиріч, що досліджуються у статті.

Автор приходить до висновку, що творчість – це певна комбінація різних концепцій або елементів однієї концепції, але не всі творчі ідеї є однаковими за значущістю, оскільки вони є результатами різних стратегій пізнання. Автор приводить комбіновану творчу модель, яка показує, що рівень творчого внеску в результат процесу пізнання залежить від ступеня наближеності областей знання, елементи котрих формують нову ідею: якщо вони належать до віддалених областей, ідея визначається як значуща творча комбінація; якщо ж комбінація елементів утворюється в рамках однієї області знання, ідея визначається як інкрементна, менш значуща але теж оригінальна.

Автор відмічає, що надмірне поглиблення спеціалізації в певній області пізнання зменшує можливості творчого мислення та ймовірність продукування інновації. Даний U-подібний ефект залежності «знання–інновації» пов'язаний з ментальною фіксацією множини знань, у зв'язку з чим у спеціалістів певної предметної галузі формуються вузлові (якірні) точки, тобто неспроможність знаходження нових зв'язків в досліджуваній області знання через надмірне засвоювання її категорійного апарату. З іншого боку, основою творчого пізнання є оволодіння специфічними знаннями області знання хоча б в мінімально достатньому обсязі. Таким чином, формування значущих ідей шляхом комбінування елементів різних областей знань можливе лише за розширення границь власних мінімальних і не занадто поглиблених знань в різних предметних галузях. Даний висновок, до якого приходить автор підкреслює важливість застосування міждисциплінарного підходу в освіті, який, з одного боку, має запобігати формуванню якірних точок, а з іншого боку – диверсифікувати освіту через вивчення віддалених одна від одної концепцій, дисциплін, роботу над різними проектами тощо.

Окрім цього, важливим є освоєння так званої дивергентної техніки мислення, що дозволяє реалізовувати процес творчого мислення через побудову зв'язків поміж віддаленими і не властивими одна одній областями знань. Якщо зв'язок між віддаленими елементами знання продукує нове знання, значущу інновацію, відстань між ними слід відтепер вважати значно меншою ніж до побудови зв'язку.

Імплементація висновків, до яких прийшов автор, потребує розвитку запропонованого збалансованого підходу сутність якого полягає в наступному. Якщо головним напрямом розвитку обирати рушійний (творчий) інноваційний розвиток, необхідно розширювати межі системи освіти та до стандартних академічних дисциплін залучати «не програмні» види діяльності, такі як мистецтво. Поряд з цим необхідно навчати дивергентній техніці мислення. Це повинно створити необхідні умови створення значущих рушійних інновацій. Якщо ж обирати поступовий розвиток, його основою слід вважати подальше поглиблення спеціалізації в традиційній системі освіти. Це повинно створити сприятливий клімат для розвитку інкрементних інновацій. Якщо дані інновації будуть впроваджуватись в досить швидкому темпі, інтегральний ефект може біти порівнюваним з рушійним інноваційним розвитком. Дані інновації також ймовірно буде легше та з меншими ризиками впроваджувати. Слід відмітити, що другий напрямок розвитку скоріш за все не надасть можливості впровадити в життя парадигму рушійних інновацій та здійснити якісний прорив у розвитку. Вибір тієї або іншої стратегії врешті решт залежить від задач, які ставляться перед системою освіти в довгостроковому періоді.

Ключові слова: творчість, інновації, система освіти, дивергентна техніка мислення, область знань.

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