



## Measuring creative potential: Using social network analysis to monitor a learners' creative capacity

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Despite the burgeoning rhetoric from political, social and educational commentators regarding creativity and learning and teaching, there is a paucity of scalable and measurable examples of creativity-centric pedagogical practice. This paper makes an argument for the application of social network visualisations to inform and support creativity-enabling pedagogical practice. This paper first describes social networks and how they relate to creative capacities and learning as a social process. It then provides an initial case study of how social network analysis may be meaningfully applied to evaluate students' learning networks and creative capacities, and elaborates on how such an evaluative resource can allow educators to design and implement creativity-enabling pedagogical practice. In so doing, this paper contributes conceptual, methodological and empirical advances that can take learning and teaching for creativity, particularly in higher education, beyond rhetoric towards more observable and measurable mainstream pedagogical practice.

### Introduction

The terms *creativity* and *creative capacity* are of burgeoning interest within research literature and related scholarship (for example, Craft, 2006; Florida, 2005; McWilliam, 2008; Pink, 2005; Robinson, 2000). The questions these and other commentators are attempting to address are, Why creativity now? and How creativity now? The response to these questions can be largely framed around the reported importance of creativity as a form of social capital needed for productive participation in a knowledge society. *Creativity* as a set of core skills and attributes is argued to enhance future organisational productivity and is thus being positioned as an essential workforce skill for managing the challenges associated with an uncertain economic and social world (Florida, 2002; Pink, 2005; Robinson, 2000). Given the perceived importance of creativity for the future workforce, the matter of how to embed and develop a culture of creativity is becoming more urgent in education, and particularly in higher education (McWilliam, 2008; McWilliam, Tan & Dawson, 2010; Robinson, 2000). However, recognising and arguing the importance of creativity is a much simpler exercise than constructing the systemic framework for large scale adoption of creativity-enabling pedagogical practice. This paper responds to this challenge in higher education by elaborating on a teaching and learning innovation – a social

networking visualisation tool - that can be used to evaluate and subsequently inform the design of creativity-enhancing pedagogical practice.

In recognition of the social, political and economical imperatives associated with developing creativity, the higher education sector has committed international resources for implementing the educational practices that will lead to greater graduate creative capacity. For example, reports by the European Union Association (EUA) (2007) and the UK based National Advisory Committee on Creative and Cultural Education (NACCCE) (1999) discuss the processes and practices required for educational institutions to develop graduate skills and attributes compatible with future workforce requirements. As the EUA report states:

The complex questions of the future will not be solved 'by the book', but by creative, forward-looking individuals and groups who are not afraid to question established ideas and are able to cope with the insecurity and uncertainty that this entails. (p.6).

While the importance of creativity for future workforce requirements has been established, the specific learning and teaching activities that serve to enact and foster creativity are less well informed. To address this issue, the UK Higher Education Academy has attempted to embed creativity-enhancing practices within education via the imaginative curriculum project (Jackson, Oliver, Shaw & Wisdom, 2006). So too research by Craft (2000, 2006), McWilliam (2007, 2008) and others is directed towards solving this problem by developing scalable, creativity-focussed pedagogical practices for institutional adoption. However, there are considerable complexities associated with moving an ephemeral concept such as creativity from the sidelines to observable and measurable mainstream practice. The challenge, as Norman Jackson frames it, is "not that creativity is absent but that it is omnipresent" (p.3). Jackson explains further, that while creativity may be implied in teaching practices it is "rarely an explicit objective of the learning and assessment process" (p.4).

While research will continue to inform creativity-enabling teaching practice, to date there have been few examples of scalable and replicable practice made available for mainstream adoption. What follows is an elaboration of how the development of evaluative tools can better support creativity-enhancing pedagogy through data visualisations that enable educators to observe and monitor its occurrence in learning as a social process. Specifically, the development of an evaluative resource, which allows educators to visualise student creativity in action, that in turn informs the design of their pedagogical practice, is documented and discussed. In undertaking this task, the paper draws extensively on the work of sociologist Ronald Burt (1992) to demonstrate the relevance of social network methodologies to creative pedagogical practice.

## **Creativity and networking agility**

Research on creativity has challenged the notion that creativity is a skill possessed solely by those associated with the more artistic fields or disciplines. Definitions of creativity and its application within the broader economic and social context have evolved from these perceptions of the 'arty individual' to encompass a larger set of social, aesthetic and functional attributes (McWilliam & Dawson, 2008). While the debate over the possibility of an authoritative definition of creativity continues, there is growing consensus regarding the core characteristics underpinning creativity. This is well canvassed in the EUA (2007), and the UK NACCCE (1999) report on creativity in

higher education, in their identification of the central tenets of creativity as including: originality; imagination; problem solving; adaptability; networking and communication. This list of individual attributes is being augmented by the work of Jackson (2006), McWilliam (2008), and Tierney, Farmer and Graen (1999) who point to the importance of skills related to team and individual leadership in the creative mix. Few would now dispute the idea that, regardless of the level of specificity of the definition, the process of creativity involves participation in diverse social interactions (Csikszentmihalyi, 2006; McWilliam & Dawson, 2008; Robinson, 2000), either in an early stage of learning for imagining, or in the promotion and dissemination of the products of creative imagining.

Active participation in a diversity of social interactions or networks is crucial for increasing the quality, quantity and scope of knowledge building. This fact is made apparent in the comprehensive studies of the impact of diverse social networks on creativity by sociologist Ronald Burt. Burt (2004) observed that individuals who act as 'links' or 'bridges' across previously disparate groups (structural holes) have richer access to information and resources than those with a more insular network structure. As Burt states, these individuals "are able to see early, see more broadly, and translate information across groups" (p. 354), and this in turn provides them with "a vision of options otherwise unseen" (p. 354). Burt describes this 'translating' or brokering function as value-adding creativity. These 'translators' have both the ability to move knowledge around in value-adding ways, and the capacity to initiate and maintain "boundary-spanning relationships" (Geletkanycz & Hambrick, 1997, p. 654) within and outside their immediate environment.

The interplay between network agility – the capacity to create 'boundary spanning relationships' – and creativity is further highlighted in the research of McWilliam and Dawson (2008), who note parallels between creative teams and the 'flocking behaviour' of social organisms in their elaboration of the social dynamics that facilitate the development of creativity. As McWilliam elaborates elsewhere, "*flocking* together allows birds to fly higher and exhibit greater scheduling and routing capacities than each bird can do alone" (McWilliam, 2008, p. 144). In a learning context, student outcomes are likewise optimised through aspects of teamwork (Cockrell, Caplow & Donaldson, 2000), play (McWilliam, 2007), interchange of leadership, networking and communication (Cabrera, Colbeck & Terenzini, 2001). These characteristics are typical of a dynamic community of practice or learning community where student engagement is both rich and diverse (Dawson, 2006; Garrison, 2007).

When applied to the higher education environment, the development of student learning communities can be seen to demand more than the generation of a single good idea or shared need in order to thrive. Effective teaching is essential, and this teaching practice often takes the form of identifying or creating opportunities for individuals to bridge across - and thus link - previously separate groups. The study of social network analysis (SNA) provides a robust and established methodology for evaluating and monitoring the development of individual and team creativity. With the application of SNA affording an opportunity to identify and graphically represent the key creative individuals within a network (Tepper, 2006) within the field of education, SNA can provide more explicit evidence of creativity as a learning outcome and graduate attribute.

Furthermore, through monitoring the evolution of student social networks teachers can determine the impact of the specific pedagogies designed to foster creative

capacity. Building upon Burt's prior work, it is hypothesised here that the analysis of 'linking' activity evident across student social networks would indicate the presence of significant nodes where brokering work was actively being undertaken. The challenge, then, is to implement community building teaching practices that are targeted to identify, enable, and support these 'bridging individuals', and thus enhance the creative capacity of the broader network.

### Observable and scalable creative action

While SNA provides a robust methodology for observing and measuring student creativity, the practical matter remains of how to visualise these student networks in a scalable, automated process. The solution to this problem lies in the increasing adoption of information and communication technologies (ICTs) across the higher education sector. The vast majority of higher education institutions internationally have adopted ICTs to enhance flexibility of access to student learning resources. These ICTs have largely taken the form of commercial and open source learning management systems (LMS) such as *Desire2Learn* or *BlackBoard* (including the former *WebCT*), *Moodle* and *Sakai*. A key feature of these systems is the ability for students to initiate interactions with peers and staff via computer mediated communication (CMC) resources such as discussion forums and synchronous chat. Importantly for the task of visualisation, as students engage with these systems, a history of interaction is logged or recorded in an associated database. The extraction of this student interaction data provides an opportunity for re-constructing the student social networks mediated through these ICT systems. Dawson and colleagues (2006, 2008; Macfadyen & Dawson, 2010) have previously demonstrated the value of broad scale data mining of institutional LMS for evaluating learning and teaching practices. This work highlights the benefits associated with analysing LMS data in order to establish pedagogical lead indicators that can assist educators in assessing teaching practices in a proactive and timely manner.

More recently, learning analytics research has investigated the capacity for extracting LMS data to measure and visualise the student social networks that transpire in discussion forum learning activities (Dawson, 2008, 2010; Dawson, Bakharia & Heathcote, 2010). While this research relates the SNA findings to students' sense of community rather than creative capacity *per se*, these studies highlight the usefulness of the application of ICT data in informing and guiding educators in the implementation and evaluation of their teaching practice. Importantly, this prior work demonstrates the potential for extracting LMS data to form opportunistic representations of the student social network. As the data is tracked over time, it becomes possible to examine the evolving social network and the individual positions that students occupy within the network at significant points in the course of the learning and teaching activities. These data can be used to inform the implementation of creativity-enabling pedagogical practice. As a potential feedback mechanism, such forms of visualisations are pro-active, scalable, and naturally occurring as a result of the events and interactions within the online environment.

The generation of student interactive 'sociograms' provides educators with an opportunity to visualise, and then identify individual students who are bridging 'structural holes' in a learning network. These visualisations potentially provide a mechanism for identifying individuals exhibiting a higher level of creative capacity – such as network and enterprise agility, teamwork and communication. McWilliam and Dawson (2008) have previously described these individuals as *border crossers*. Border

crossers demonstrate the enterprise and agility required for bridging the network gaps and introducing new knowledge, ideas and processes to the larger network. In short, the identification of these individuals and the changing dynamics of the social network can differentiate some of the creative capacities developing within the student cohort. Educators can use this evidence to redesign their learning and teaching activities in a timely manner, and then observe the impact of these pedagogical modifications in the network composition.

## Methodology

### Study overview

In light of the above discussion, this study aimed to investigate the relationship between students' positions in the social network and their creative capacity. In so doing, the study sought to validate Burt's (2004) findings regarding the relationship between individuals bridging structural holes and creativity in an education context. Specifically, the study addressed the following research questions:

- What is the relationship between a student's social network position and perceived creative capacity?
- To what extent do discussion forum mediated social networks allow for the identification and development of student creativity?

The study proceeded as an exploratory investigation designed to evaluate the potential for ICT mediated data to construct and visualise student social networks, as well as to identify student creative capacity in the form of social networking and brokering agility. The study participants ( $N = 76$ ) included all first year enrolled medical students at the Graduate School of Medicine (GSM), University of Wollongong, Australia. The GSM course is a four year program incorporating extensive use of the institutional LMS (*Blackboard Vista* – formerly known as *WebCT Vista*). As students progress through the four year course, there is an increasing reliance on the online learning environment for content delivery and student and staff communication and engagement. Given this trajectory in the pedagogical approach, the curriculum has been designed to rapidly familiarise and engage commencing students with the online environment and the associated learning activities. In this context, the GSM curriculum can be seen to be a blended model incorporating both on campus and online learning activities.

### Constructing social networks

The study extracted discussion forum data from the institutional LMS (*Blackboard*) and re-constructed social network relationships based on student and staff interactions. Forum data (including 400 posts by the investigated cohort) was analysed after eight weeks of course progression. Although, LMS such as *Blackboard* have in-built student tracking capabilities, the aggregation and presentation of these data are commonly restrictive and poorly represented (Mazza & Dimitrova, 2007). To overcome the inadequacy of the proprietary LMS data tracking resources, this study adopted a prototype social network extraction tool, known as *Social Network Adapting Pedagogical Practice* (SNAPP) developed by Bakharia and Dawson (2009; Dawson, et al., 2010). SNAPP provides social network analyses and visualisations to better represent the student and staff interactions that transpire in discussion forum activities. The

application of SNAPP provides an opportunity to generate network visualisations at any stage of the course progression. This affordance therefore provided teaching staff with the ability to 'see' patterns of student engagement and learning network interactions not only at a specific point in time, but also over time as the course progressed (Dawson, et al., 2010).

The SNAPP social networking extraction tool (Bakharia & Dawson, 2009; Dawson, et al., 2010) was developed as a 'bookmarklet' – a web link that activates javascript to extract the forum interaction data for analysis and visualisation. The adoption of a 'bookmarklet' effectively circumvents issues surrounding access to a proprietary database and is non-browser specific. The extracted forum data is imported into *Netdraw* (Borgatti, 2002), a third party social network visualisation software program that allows further more sophisticated calculations of network centrality properties such as *degrees*, *closeness*, and *betweenness* to be performed. In the section that follows, these network properties are explained in greater detail. Figure 1 illustrates the type of network visualisations derived from student and staff participation in the discussion forum. Notwithstanding the fact that, in this example, student names have been removed, the figure demonstrates the position of each student within the network. Consequently, the extracted data can also be used to identify students not engaged in the learning network.

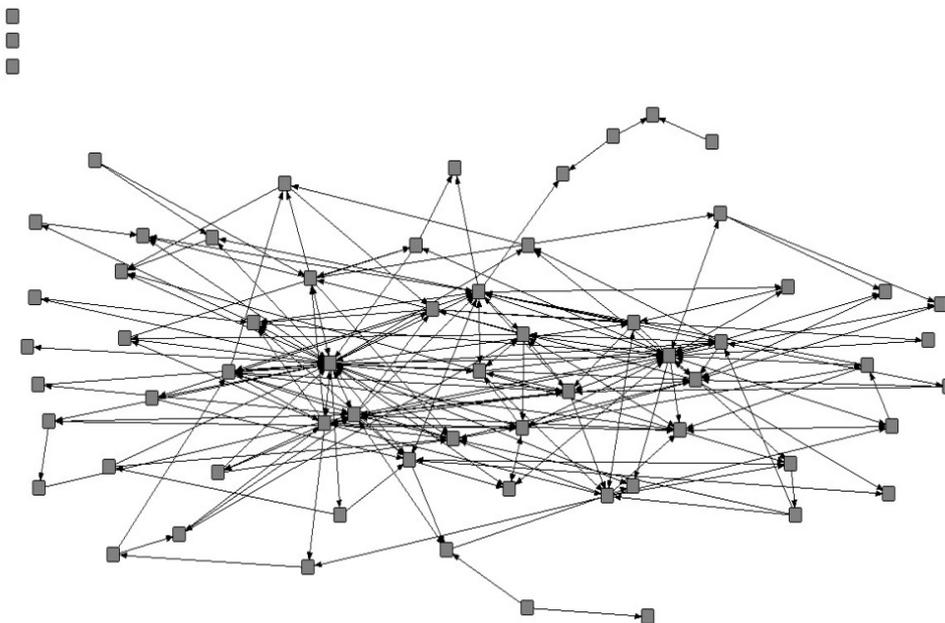


Figure 1: Sociogram of the medical student network interactions  
(student names have been removed)

### Calculating the network properties

*Social Network Analysis* (SNA) is a commonly adopted methodology for examining the patterns of interaction that occur within a group of actors (a network). SNA draws on concepts from graph theory and structural theory to evaluate network properties such as density, centrality, connectivity, betweenness and degrees. These centrality

measures provide a structure for interpreting the relationships formed between actors and where an individual is positioned in reference to the overall network formation. Through the process of SNA a visual representation of the network can be generated. This sociogram, provides a readily interpretable diagram to assess engagement and levels of interactions between actors in the education context (Dawson, 2008; Dawson, et al., 2010). For further information, Wasserman and Faust (1994) and Scott (2000) provide comprehensive overviews of SNA.

The social network centrality measures of *degrees*, *closeness* and *betweenness* were calculated using the software *Netdraw* (Borgatti, 2002) in order to provide greater insights into the developed relationships. These centrality measures are frequently used to determine the level of importance and influence an individual has on the broader social network (Otte & Rousseau, 2002). It is important to note that an individual's position in the social network influences their capacity to not only receive but also disseminate information (Haythornthwaite, 2001). The *betweenness* centrality measure relates to the frequency an individual occurs within the shortest path between other actors or in the context of this study, other students. Actors with a high betweenness value are commonly referred to as 'gatekeepers'. These individuals are ideally positioned in the network to control the flow of information and resources (Lipponen, Rahikainen, Lallimo & Hakkarainen, 2001). This centrality measure echoes Burt's (2004) focus on assessing an individual's capacity to bridge 'structural holes'. In short, students with a high betweenness score act as 'links' or 'bridges' across disparate network clusters. Thus, the identification of students with a high betweenness value provides an indication of individuals exhibiting high levels of creative capacity.

Two other network measures - closeness and degrees centrality - completed the network analytics. *Closeness* is defined as the degree of relationships an actor has formed with the entire network (Otte & Rousseau, 2002). For example, a student with a high closeness measure will have many linkages to other peers via a small number of paths. The *degrees* centrality measure was used to determine the number of ties an individual student has with other actors in the network.

### **Perceived creativity**

Tan's (2009) learning disposition questionnaire was adopted to quantify the level of perceived student creative capacity. Tan's (2009) original questionnaire consisted of 42 self-report items ranked according to 5-point Likert scale. Although in Tan's study further modifications were required for appropriate factor loading and internal consistency, this study followed Tan's approach and opted to validate the original designed version. Additionally, a 7-point Likert scale was incorporated to further enhance the instrument's validity and reliability. The Tan (2009) questionnaire consists of five factors: learning goals (LG); performance goals (PG); personal innovativeness (PI); and cognitive playfulness (CP), which in turn consists of two dimensions: creativity (CP-cr); and curiosity (CP-cu). For the purposes of this study the *cognitive playfulness-creativity* (CP-cr) factor is the primary focus of the results and subsequent discussion. As detailed below, the questionnaire items designed to measure the creativity factor loaded satisfactorily and hence, represent a reliable measure. Creativity is calculated according to the aggregated scores for the 10 items that measure this latent variable. Thus, the self-report creativity score ranges from a minimum of 10 to a maximum of 70. Students who report a higher CP-cr score are

taken to exhibit higher levels of perceived creative capacity. The implemented survey is included as Appendix A.

#### *Validation of the questionnaire*

The self-report questionnaire was validated through the use of student focus groups and exploratory factor analysis. Building on this prior validated scale developed by Tan (2009), a focus group was conducted with a selected group of medical students to identify any issues regarding the usability and understanding of the items that might adversely affect the face validity of the instrument in the research context pertinent to the study. Students were requested to review the questionnaire and highlight any items that were perceived as ambiguous or confusing. Based on the student focus group, no further changes or amendments were required.

Table 1: Factor loadings for Tan (2009) questionnaire

Question items	Factors				
	LG	PG	PI	CP-cu	CP-cr
1	0.772				
2	0.750				
3	0.742				
4	0.791				
5	0.755				
6	0.539				
7	0.644				
8	0.425				
9		0.662			
10		0.671			
11		0.687			
12		0.524			
13		0.692			
14		0.659			
15		0.692			
16		0.619			
17			0.660		
18			0.794		
19			0.842		
20			0.835		
21			0.738		
22			0.716		
23				0.748	
24				0.759	
25				0.630	
26				0.590	
27				0.763	
28					0.597
29					0.495
30					0.625
31					0.783
32					0.765
33					0.544
34					0.450
35					0.467
36					0.569
37					0.698

The questionnaire was administered in hard copy to all students during a designated teaching period. The completed questionnaire responses ( $N=76$ ) were used to demonstrate the factorial validity of the instrument. The item loadings observed in the exploratory factor analysis reflected those reported in the Tan (2009) study. A small number of items related to the CP-cu and CP-cr factors loaded across multiple constructs. These items were subsequently excluded and the factor analysis repeated. For the second iteration of factor analysis, all question items loaded discreetly across the 5 factors (Table 1). Item loadings ranged from 0.425 to 0.794, thereby indicating an acceptable level of convergent validity (Tabachnick & Fidell, 2001).

Cronbach's *alpha* was calculated to assess the internal reliability and consistency of the questionnaire. Within the social sciences it is commonly accepted that an *alpha* value  $\geq 0.70$  represents satisfactory internal consistency and reliability. As shown in Table 2, the questionnaire items reported an overall Cronbach *alpha* of 0.751, thereby indicating acceptable internal consistency.

Table 2: Internal consistency of the modified Tan (2009) questionnaire

	Factors				
	LG	PG	PI	CP-cu	CP-cr
Cronbach <i>alpha</i>	0.860	0.817	0.879	0.778	0.826

### Statistical analyses

Data collected from the sampled cohort were analysed using the software package *SPSS for Windows* (Vers 15.0) incorporating descriptive statistics and a simple parametric correlation to ascertain the degree of relationship between the investigated variables. Specifically, the statistical analyses were undertaken to investigate the relationship between social network centrality measures and student self-reported creativity.

## Results

### Participants

The response rate for the study was 88% ( $N=76$ ) of all students enrolled in the first year (Phase 1) of study for the MBBS program at the Graduate School of Medicine, University of Wollongong. Females represented 51.3% ( $n = 39$ ) and males 48.7% ( $n = 38$ ) of the sampled population. The mean age of participants was 25.3 (SD = 4.54), with the male group slightly older than females reporting a mean of 26.6 (SD = 5.00) and 24.18 (SD = 3.75) respectively.

### Descriptive statistics

Descriptive statistics were generated to ascertain the students' perceived creative capacity. Although females reported a slightly elevated mean CP-cr compared to their male counterparts, there was no significant difference ( $p > 0.05$ ) between the two groups. Creativity scores ranged from a minimum of 22.0 to maximum of 64.0. While the maximum creativity score was the same for the males and female sub groups (64.0), the minimum reported creativity score for males (22.0) was observed to be lower than the female respondents (29.0). Table 3 summarises the descriptive statistics related to the cognitive-playfulness/creativity factor.

Table 3: Mean and standard deviation for student self-reported creativity as measured by Tan's (2009) learning disposition questionnaire

	Males	Females	Total
CP-cr	44.65 (SD = 10.06)	46.05 (SD = 9.24)	45.37 (SD = 9.61)
Range*	22.0 - 64.0	29.0 - 64.0	22.0 - 64.0

\* CP-cr factor scores range from a minimum of 10 to a maximum of 70

### Discussion forum data

All student contributions to the subject discussion forum were extracted and analysed using Bakharia and Dawson's (2008) discussion forum extraction tool. This resource mines the data inherent in all forum contributions within the *Blackboard Vista* LMS such as *name*, *replied to*, *thread depth*, *total number of posts* and *posts per individual*. Table 4 highlights the number of posts for the sampled population and specific sub-groups investigated.

Table 4: Discussion forum contributions

	All students	Male students	Female students
Total posts	400	168	232
Mean	5.26 (SD = 7.35)	4.54 (SD = 5.51)	5.95 (SD = 8.77)

### Social network analysis

The extracted social network centrality measures were correlated with CP-cr results using Pearson's correlation coefficient ( $r$ ). For social studies, Cohen (1988) has suggested that correlation analyses with an effect size of .1 to .2 are considered small; .3 to .4 medium, and .5 and above as large. Significant correlations were observed between CP-cr and degrees ( $r = 0.334$ ) and also CP-cr and betweenness ( $r = 0.338$ ) centrality scores (Table 5). The analyses indicate a medium relationship exists between the centrality measures and student self-reported creativity. Upon delimiting the sampled population further into the gender based sub-groups only the male participants demonstrated a significant correlation between network centrality and CP-cr scores (Table 5).

Table 5: Correlation between social network properties and self-reported creativity

		Degrees	Betweenness	Closeness
All students ( $N = 76$ )	CP-cr	$r = 0.334^{**}$	$r = 0.338^{**}$	$r = 0.145$
Male students ( $n = 38$ )	CP-cr	$r = 0.394^*$	$r = 0.453^{**}$	$r = 0.149$
Female students ( $n = 39$ )	CP-cr	$r = 0.295$	$r = 0.225$	$r = 0.184$

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

### Limitations of the study

Any investigation into social networks is complex and multifaceted and influenced by numerous internal and external factors. Thus, there are several limitations which will impact upon the generalisability and interpretation of these findings. For example, while this study extracted network relationships formed through online discussion activity, the study did not capture all interactions students undertook both within and external to the medical education program. Additionally, the study measured creativity from a self-report questionnaire. While the cognitive playfulness-creativity

questionnaire items used in this study reflects current social and pedagogical understandings of creativity and exhibits robust reliability and validity, the self-report nature of the instrument meant that issues of individual perceptions need to be considered in the interpretation of the findings. Future research should be directed towards validating self-report instruments with other established measures of creativity such as Torrance *Tests of Creative Thinking* (Torrance, 1988), *Wallach-Kogan Creativity Tests* (Wallach & Kogan, 1965) or Amabile's *Consensual Assessment Technique* (Amabile, 1982). Lastly, while this study was exploratory in nature, the focus on one institution necessitates that further large scale investigations are necessary to validate these initial findings.

## Discussion

John Dewey once wrote that "to be playful and serious at the same time is possible and it defines the ideal mental condition" (Dewey, 1910, p. 218). The recent avalanche of literature related to creativity and its importance for the future workforce is testimony to the accuracy of Dewey's earlier vision. However, despite the burgeoning rhetoric from political, social and educational commentators regarding creativity and learning and teaching, there is a paucity of scalable and measurable examples of creativity-centric pedagogical practice. This paper has argued that the development of replicable creativity-enabling practice has been in part stifled by the lack of evaluative resources and methodologies for assessing and reporting on student creativity, despite the digital affordances that have been part of the learning environment for some time now in higher education.

In an attempt to move forward from this impasse, this study applied research from business, education and sociology to demonstrate the capacity for social network methodologies not only to provide an indication of student creativity, but also to generate evaluative visualisations of individual creativity and its relationship with implemented learning and teaching practice. Specifically, the study investigated the relationship between an individual's position in the Graduate School of Medicine (GSM) social network and student creative capacity. The findings demonstrate that a relationship exists between an individual's self-reported creativity score and their overall position in the social network. The results suggest that the SNA centrality measures of *degrees* and *betweenness* may be read as positive indicators of a learner's creative capacity.

### Social network agility

Social network analysis comprises the measurement of exchanges of information or resources among actors and how these interactions lead to the establishment of relationships within a social system (Haythornthwaite, 2002). The mapping of these exchanges affords analysts an opportunity to reconstruct and visualise the relationships between actors and subsequently where each individual is positioned within the broader network. The evaluation of actor locality is commonly achieved through social network centrality measures, such as degrees, closeness and betweenness.

This study demonstrates that a positive correlation exists between student social network position and the centrality measures of betweenness and degrees. These findings mirror the earlier work of sociologist Ronald Burt (2004) who noted that

managers with a high betweenness value were perceived as the more creative individuals within an organisation. In short, Burt's work emphasises the notion that small, tightly formed groups evolve towards a homophilic culture. Individuals who transcend these groups have access to a greater diversity of information, knowledge, and ideas. It is in this context that individuals enact brokering roles and thus build skills that become valuable as creative capital. For instance individuals with high brokerage positions are located in ways that enable networking agility, communication, and the translation of information across network clusters. Importantly these individuals have opportunities to market new ideas or solutions to problems for future uptake or access by the broader social system. Hence, these individuals are more exposed to a diversity of 'good ideas' and information that can be translated and transformed to fulfil the requirements of alternate small world network clusters (Uzzi & Spiro, 2005).

### **Strong or weak ties**

The strength of relationships or ties between individuals is also an important means for individuals to capitalise on the opportunities afforded by their locality within a network. Early social network research by Granovetter (1982) discusses the notion that social relationships can be classified as either strong or weak. Simply put, individuals with strong ties share numerous resources and are mutually dependent upon one another. These strong ties require substantial personal investment and therefore tend to manifest through close personal relationships. In contrast, weak social ties are developed through a small number of interactions with peers across more distant and separate clusters. Granovetter (1982) describes weak ties as less emotionally bound than strong ties and more focused on the reciprocal exchange of resources and information. The network analyses measured in this study would suggest that the medical students are, at the time of analysis, establishing numerous weak ties with their peers. The adoption of weak ties represents a greater level of network mobility. As Richard Florida (2002), author of *"The rise of the creative class"* argues, individuals with strong social ties are often constrained by the long term commitment these relationships require. Consequently, individuals with a high number of weak ties have high degrees of network mobility.

The students in this study with a high degree score may be argued to possess a high level of network mobility and thus, by implication, be more disposed to creative team endeavour. They are also more likely to be successful as graduates of academic programs. Through extensive social network analyses, Thomas (2000) highlighted the specific academic advantages available to students with access to a high number of social ties. In short, Thomas demonstrated that students with broad and numerous access to peers are more likely to persist in their study, have higher grades and be more satisfied with their course. In the present study, students with a high degree of centrality are well positioned to call upon a greater number of resources to assist them in their academic endeavours and ideas development. However, the small sample size makes it difficult to discern those who will become more agile brokers in larger networks from those well connected and embedded in cliques or small world clusters.

While education researchers commonly advocate the pedagogical advantages associated with learning communities, there are circumstances when these same social groups can also suppress creativity. Uzzi and Spiro (2005) have previously described this community-centric phenomenon as the small world problem. The authors noted

that within a small world network creative benefit is initially enhanced but to a “threshold, after which the positive effects are reversed” (p.447). The monitoring of the social network formation and evolution can ensure that the learning benefits associated with community do not deteriorate into *intense homophily* or what the business discipline commonly refers to as un-creative ‘group-think’. By implication, teaching and learning for creativity needs to assist students to move beyond their immediate class or group to link with more disparate groups, ideas, literature and products, in order to make new connections, to innovate, to ‘translate’ knowledge and to “unlearn” (McWilliam, 2005) through networking.

### **Social network application and teaching for creativity**

This study demonstrates the application of a social network tool to measure and visualise student creative capacity in an organic and non-intrusive manner. The extraction of forum relationships to reconstruct social networks utilises data that is naturally occurring as students’ progress through implemented learning activities. In the present study, while forum participation was not mandatory, the implemented medical curriculum program does stress the importance for merging both LMS-based activities with more traditional face to face teaching practices. This curriculum model is not an isolated instance. All universities in Australia, for example, have an LMS to supplement on campus teaching or as a medium for distance education delivery. It is envisaged that ICT integration will continue to become more central to learning and teaching practice. The *Horizon Report* (Johnson, Smith, Willis, Levine, & Haywood, 2011) reinforces these sentiments, noting that universities worldwide have been actively adopting and implementing Web 2.0 socially oriented technologies such as blogs and wikis into their daily teaching practice. For instance, the 2008 *Horizon Report* noted that, “the essential ingredient of next generation social networking, social operating systems, is that they will base the organization of the network around people, rather than around content” (New Media Consortium and EDUCAUSE Learning Initiative, 2008, p.4). As these technologies have continued to become more mainstream, there has been an associated increased capacity to extract user data to reconstruct social networks as detailed in this present study. This is well reflected in the 2011 *Horizon Report* in noting the drive for educational institutions to implement increased levels of learning analytics (Johnson, et al., 2011).

The field of learning analytics is gathering rapid momentum as evidenced by the *EDUCAUSE Next Generation Learning* grants [<http://nextgenlearning.org/>], and the introduction of the first *International Conference on Learning Analytics and Knowledge* [<https://tekri.athabascau.ca/analytics/>]. Learning analytics relates to the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs. While much of the research related to learning analytics has centered on student attrition and learning support (Macfadyen & Dawson, 2010) the field offers far greater nuanced interpretations. For example, Dawson and colleagues (Dawson, Macfadyen & Lockyer, 2009; Dawson, Macfadyen, Lockyer & Mazzochi-Jones, 2011) have demonstrated the potential of learning analytics to provide significant leading indicators of student learning dispositions and engagement in a learning network. As the field further evolves the predictive modeling and interpretive power linked to data extraction and analysis will also become increasingly sophisticated and more contextualised to the design of the curriculum activities. At present the question is no longer how to extract user data,

more so what does this data mean in reference to the specific learning and teaching practice in which it is generated.

Within the domain of education, creativity is commonly perceived as a highly valued graduate asset. However, the teaching practices that lead to the development of creative skills are poorly understood. Evaluative resources such as the network extraction tool in this study (SNAPP) can be applied by educators not only to assess individual position in the network, but also to assess the design of implemented learning activities. If creativity is going to move beyond the rhetoric of university policy and into pedagogical action, then the capacity to 'read' the daily activities that are the hallmarks of creative endeavour is essential.

Of course within the social network not all creative students will act as brokers and not all brokers will be creative. However, this study does illustrate that the analysis of social networks can provide educators with one of a set of indicators of the achievement of the skills and attributes that characterise creativity. The study outlined above is an example of a new way that teachers can instigate purposeful learning interventions that socially re-engineer networks to ensure that all students - particularly those who are 'at risk' in their programs - have opportunities to act in a brokerage role. The opportunity now exists for students to be positioned, or to position themselves, as brokers or links across clusters for the explicit purpose of improving their communicative, leadership, agility, and marketing skills such as those discussed in this paper. In summary, the development of student social network visualisations now has the potential to provide teaching staff with evaluative resources for determining the impact of their teaching practices, and for monitoring the development of skills underpinning creativity. When teaching staff have the capacity to implement learning interventions to re-engineer the social network in order to cultivate opportunities for students to develop, practise and utilise creative skills, then creative learning outcomes do not have to simply be hoped for. They can be seen and worked towards as a real, and observable, learning outcome.

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## Appendix A

Please rate the following statements from: Strongly Disagree (1) to Strongly Agree (7). Do not spend too much time on any one statement.

### Learning goals orientation

- a. The opportunity to do challenging work is important to me.
- b. When I fail to complete a difficult task I plan to try harder the next time I work on it.
- c. I prefer to work on tasks that force me to learn new things.
- d. The opportunity to learn new things is important to me.
- e. I do my best when working on a fairly difficult task.
- f. I try hard to improve on my past performance.

- g. The opportunity to extend the range of my abilities is important to me.
- h. When I have difficulty solving a problem, I enjoy trying different approaches to see which one will work.

**Performance goals orientation**

- i. I prefer to do things that I can do well rather than things that I do poorly.
- j. I am happiest working on tasks which I know I won't make any errors.
- k. The things I enjoy the most are the things that I do best.
- l. The opinions others have about how well I can do certain things are important to me.
- m. I feel intelligent when I do something without making any mistakes.
- n. I like to be fairly confident that I can successfully perform a task before I try it.
- o. I like to work on tasks that I have done well on in the past.
- p. I feel intelligent when I can do something better than most other people.

**Personal innovativeness**

- q. I am generally cautious about accepting new ideas.
- r. I rarely trust new ideas until I can see whether the vast majority of people around me accept them.
- s. I am usually one of the last people in my social group to accept something new.
- t. I am reluctant about adopting new ways of doing things until I see them working for people around me.
- u. I must see other people using new innovations before I will consider them.
- v. I often find myself being sceptical/wary of new ideas.

This question is about how you see yourself as a learner. Indicate what best describes you in general. Do not spend too much time on any one statement, please rate from: Strongly Disagree (1) to Strongly Agree (7).

**Cognitive playfulness - curiosity**

- a. Questioning
- b. Inquisitive
- c. Scrutinising
- d. Investigative
- e. Inquiring
- f. Intellectually active
- g. Curious

**Cognitive playfulness - creativity**

- h. Spontaneous
- i. Experimenting
- j. Inventive
- k. Imaginative
- l. Conscientious/ hardworking

- m. Serious
- n. Bored
- o. Flexible
- p. Mechanical
- q. Unpredictable
- r. Self conscious/ restrained
- s. Unoriginal
- t. Routine/ repetitive
- u. Creative

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