# Transdisciplinary convergence in the performing arts

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## Abstract

This paper concerns transdisciplinary convergence in the performing arts with particular reference to film and musical performance. It examines transdisciplinary convergence in the context of radical evolution and how the performing arts employ elements of genetics, robotics, information technology and nanotechnology (GRIN) for innovations to transform performance. On-screen digital and Gonzo innovations, the tonal manipulation of singers, miniaturized amplification devices, synthesized orchestras, and hyper-reality performances attest to the emergent enhancement of human performance and the rise of the transhuman artist resulting from transdisciplinary convergence. It is contended that Garreau's radical evolution is being assimilated into the performing arts by way of serial innovation resulting in both hybrid and new stand-alone approaches for commercial benefit with innovative consequences. This paper thus documents research concerning transdisciplinarity in the commercial setting of the performing arts and so contributes to transdisciplinary literature by way of applied, contextualized research.

# Trandisciplinarity

This paper examines transdisciplinary convergence in the performing arts premised on technological evolution with particular reference to film and musical performance. Published articles about transdisciplinarity to date have focused predominantly on academic research concerning the epistemology of transdisciplinarity. There is little documentation in academic research concerning transdisciplinarity in the commercial setting. This paper seeks to rectify the deficiency with reference to the commercial performing arts.

Transdisciplinarity involves a methodology of knowledge production distinct from multidisciplinarity and interdisciplinarity. Multidisiciplinarity is defined as the juxtaposition of disciplines towards an understanding of an issue or problem from various disciplinary perspectives. Interdisciplinarity is defined as a process of knowledge development in which different disciplinary approaches are synthesised to deliver a more comprehensive understanding of an issue or problem than is derived from a single discipline. A definition of transdisciplinarity, however, is complicated by diverse schools of thought. The origins of transdisciplinarity are

comprehensively documented by Klein (1990, 1996, 2001) who, at the end of the 20th century, defined transdisciplinarity as:

> ... creating different futures by way of improving choices, heightening reflexivity and inclusivity, generating new languages, designing new structures, and devising new pluralistic and more complex knowledge structures. (Klein, & Macdonald, 2000, p. 217)

This implies a more complex approach to knowledge production than Nicolescu's concept of theoretical transdisciplinarity which, despite being set in and alluding to quantum hyper-reality, is generally accepted as the definition in which transdisciplinarity is:

> … at once between the disciplines, across the different disciplines, and beyond all discipline. Its goal is the understanding of the present world, of which one of the imperatives is the unity of knowledge. (Nicolescu, 2002, p.44)

Other transdisciplinary schools of thought have since emerged. In 2010, Klein (2010a) described three further schools: transgressive transdisciplinarity involving new theoretical paradigms of social and cultural integration which approximate anti-disciplinarity; transcendent transdisciplinarity involving the creation of new methodologies and theoretical frameworks that transcend a disciplinary worldview in the definition and analysis of complex social issues; and trans-sector transdisciplinarity involving the concept of framing research according to questions and practices rather than as disciplinary components. Each of these schools adopts a unique philosophical paradigm which complicates a universal definition of transdisciplinarity. Although Hirsch-Haddorn, Hoffmann-Riem, Biber-Klemm, Grossenbacher-Mansuy, Joye, Pohl, Wiesmann, & Zemp (2008, p. 20) had delineated four generally agreed to principles that apply across the different schools, (transdisciplinarity as having a focus on applied (life-world[1]) problems; transcending and integrating disciplinary paradigms; involving participatory research; and searching for unity of knowledge beyond disciplines), they acknowledge that there may be contention with the application of their third and fourth principles to some schools of transdisciplinary thought.

Regardless, all schools of transdisciplinarity assert the dominance of transdisciplinary knowledge production as an academic pursuit to assure the reliability and validity of transdisciplinary research (for example, Klein 2010b; Frodeman, Klein, & Mitcham, 2010; Hirsch-Haddorn, et al. 2008; Nicolescu, 2007; Klein, Grossenbacher-Mansuy, Haberli, Scholz, & Welti, 2001). It is as if academia had hijacked transdisciplinary knowledge production without concern for the transdisciplinary knowledge produced by industry in economic pursuit beyond the academic institution. This dichotomy between academic and industrial transdisciplinarity reflects the dichotomy between pure and applied research exemplified by Mode-1 and Mode-2 knowledge production as defined by Gibbons, Limoges, Nowotny, Schwartzman, Scott, & Trow (1994).

Gibbons (1994, URL) contends that the academic fraternity employs scientism to enforce rigid control of the Mode-1 agenda with disciplinary structures providing

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[1] The term 'life-world' refers to the activities in the context of individual or corporate life as distinct from science which is commonly regarded as detached from practical life.

the pattern of cognitive and social control. In consequence, the concept of applied transdisciplinary knowledge production is resisted by academic purists (Godin, & Gingras, 1996; Pestre, 1999) who regard the shift to Mode-2 knowledge production as 'new vocationalism' (Ball, 1994; Grubb, 1996). Nonetheless, Gibbons et al., (1994) describe the context of application as determining the nature of the transdisciplinary process and the context of application is as much the industrial as the academic setting. Gibbons et al. (1994) do not define a methodology for creating transdisciplinary knowledge because they observe that it varies with each application. Thus, the way in which transdisciplinary knowledge is produced pertains specifically to the context in which it is derived. The performing arts constitute an industrial context in which transdisciplinary knowledge is produced and applied. The context is competitive and commercial which is consistent with Mode-2 transdisciplinarity. Although Klein (2010a) categorises Mode-2 transdisciplinarity as trans-sector transdisciplinary problem solving, in this paper the term 'Mode-2 transdisciplinarity' is employed in order to distinguish it from the other schools of thought within the broader category of trans-sector transdisciplinarity.

## Mode-2 transdisciplinarity

Nowotny, Scott and Gibbons (2001) contend that Mod-2 transdisciplinarity arose with the transformation of society to post-modernity in the late 20<sup>th</sup> century for which Nowotny et al. employ the term 'Mode-2 society'. In Mode-2 society, economic imperative is a significant driver of new knowledge production. Mode 2 transdisciplinarity, then, provides a framework for evaluating transdisciplinary convergence in the commercial setting of the performing arts. Nowotny et al. (2001, p. 29) define Mode-2 society as one in which the categorisations of modernity are dissolving:

> Industrial society, and indeed the process of modernization, has been characterized above all, and has been driven, by processes of functional differentiation, as more and more specialist activities have developed that require specialist institutions occupying conceptual as well as material levels of organization. The state, market and culture, and the relative autonomous spaces they occupied, were products of this differentiation—as was science. The society of the future, while being more specialist still in its technical processes, may be less well differentiated.

Nowotny et al. (2001) contend that in Mode-2 society, knowledge production is opened to and by people other than scientists who collaborate on socially generated problems in the public arena or 'agora'. In the agora, science is regulated not by Mode-1 homogenous knowledge producers (academics) but by social robustness (Nowotny, Scott, & Gibbons, 2001). Social robustness generally involves disparate and conflictual participants which Nowotny et al. refer to as 'the context speaking back' to science (2001, p. 50). It includes social, political and economic dimensions. Thus, in Mode-2 society, the cognitive authority of academia is diminished and, in order to maintain public confidence, the agora assumes dominance for the regulation of knowledge. The post-modern milieu pervades the social, political and economic institutions of Mode-2 society so that knowledge becomes transgressive and the significant driving force of capitalism.

> Mode-2 knowledge production, in contrast [to Mode-1], takes place in and between open and shifting boundaries. It consists of the reconfiguration of knowledge and people. It is transgressively bounded because… a new kind of integration with the context is made possible. This integration transcends the channeled and predictable interactions which take place under a socio-

scientific [Mode-1] regime that still practices (and believes in) some form of separation and segregation (Nowotny, et al., 2001, p. 19).

The transdisciplinary convergence of knowledge across disintegrating boundaries of formerly discrete activities does not necessarily distinguish academic from commercial activities. Whereas Mode-1 knowledge producers employ multidisciplinarity and interdisciplinarity as 'touching points' between disciplines to overcome such objections (Klein, et al., 2001), Mode-2 knowledge producers assert that these fail to produce unified outlooks because they rely on the simple juxtaposition of mono-disciplinary approaches (McMichael, 1998). In Mode-2 society, then:

> Reliable knowledge will no longer suffice, at least in those cases, where the consensuality reached within the scientific community will fail to impress those outside. In a 21st century view of science, more will be demanded from science: a decisive shift towards a more extended notion of scientific knowledge, namely a shift towards socially robust or context-sensitive knowledge (Nowotny, 1999a, URL).

Nowotny (1999b, p. 253) refers to this as "people have been allowed a place in our knowledge" with social networks act as mediators of new knowledge. Mediation occurs in the plural, democratic agora which Nowotny et al., (2001) contend has come about because science and society are mutually invasive and invaded. With increased knowledge residing in society resulting from higher levels of education and digital access to knowledge, experts proliferate and challenge the isolation of Mode-1 knowledge production:

> Objective knowledge is no longer sufficient in itself if the outcomes of its objectivity are ceaselessly negotiated, contested and even rejected (Nowotny, et al., 2001, p.177).

Nowotny et al. (2001, p. 37) describe Mode-2 society in terms of the pervasiveness of a new economic reality that is not simply means-and-end related or profit-oriented in a familiar way:

> Rather, this new form of reality resembles the 'futures' instruments in financial markets whereby economic activity derived from first-order operations rooted in material production and exchange is displaced onto a second-order level where abstraction and speculation predominate. Potential values assessed, and profits and outcomes which have not yet materialized, become tradable in their own right; 'futures' objects assume a separate existence from actual outcomes.

Mode-2 transdisciplinarity, then, involves contexts of complexity, no-linearity, heterogeneity and economic imperative (Gibbons, et al., 1994; Nowotny, et al., 2001).

In this paper, Mode-2 transdisciplinarity involves a cooperative effort towards the integration of knowledge from across disciplines in order to innovate solutions to real-world problems for potential economic advantage, the solution being beyond any single contributory discipline and which cannot be reduced to the component disciplinary contributions (Gibbons, et al., 1994; Nowotny, et al., 2001). It is from the perspective of Mode-2 transdisciplinarity that transdisciplinary convergence in the performing arts is examined.

# Radical evolution

It is contended that transdisciplinary convergence in the performing arts approximates Garreau's thesis (2005) of the evolutionary human strain that connects the brain and computers. Termed 'radical evolution', Garreau's thesis asserts that if genetics, robotics, information technology and nanotechnology (GRIN) follow or approximate Moore's Law, the synergistic activity of GRIN sciences is likely to transform homo sapiens into a transhuman species (Garreau 2005). While there is no evidence that Moore's Law pertains to each of the GRIN sciences, the advances in each are nonetheless exponential providing evidence for Garreau to assert that homo sapiens could be on the verge of evolving into the product of the GRIN technologies procreated by a new genetic code spliced into germ-line stem cells (Boyle 2005).

Garreau draws an analogy between radical evolution and the human assumption of comic-book super-strengths:

> If you can watch a car chase in Afghanistan with a Predator, you've effectively got telescopic vision. If you figure out what's inside a cave by peering into the earth with a seismic ground pinger, you've got X-ray vision. ... the U.S. Army has got a functioning prototype exoskeleton suit that allows a soldier to carry 180 pounds as if it were only 4.4 pounds (Garreau, 2005, p. 5).

Based on such examples and numerous scientific updates (Garrea Group 2011), it is thus that Garreau envisages a logical step towards the assimilation of technology within the genetic coding of homo-sapiens.

# Transdisciplinary convergence and the performing arts

The potential of GRIN technologies for the performing arts is potentially irresistible to the creative mind. Pharmacological enhancements are attractive for performance endurance, enhanced physical attributes are sought by performers who desire physical perfection and stamina, and digital enhancement has become almost de rigueur in contemporary film and musical performances. Collectively, these suggest the convergence of transhuman attributes and the performing arts and provide evidence of transdisciplinarity operating in a commercial setting. This has been alluded to in earlier articles. For example, Sjuve (2008) provides an historical review of electrical enhancements in stage performances from the early 1800s to the digital age and Rzevski (2005) notes that actors, players and agents pursue their own goals by way of interaction with each other which might suggest transdisciplinary knowledge production. Harvey (2007) is more incisive:

> Transdisciplinarity in the visual and performing arts is often defined through practice that is a hybrid or new in form, that while being influenced by disciplinarity it is a 'stand-alone approach' (2007, p. 20).

Klein and Parncutt (2010) refer to performing arts as representing disciplinary clusters. In an article concerning interdisciplinarity, transdisciplinarity and corporate innovation, Vojak et al (2010) describe innovation in the commercial setting as the product of interdisciplinary and transdisciplinary teams. While Vojak et al. (2010) propose that technological innovation is predominantly the outcome of interdisciplinary/transdisciplinary knowledge production which is spread by innovative individuals and companies across industries for economic advantage, it

can be argued conversely that industry seeks technological innovation in order to profit as well as to meet the expectations of the market (or a section of it) which expects and demands the application of new knowledge as a consumer-benefit - which is consistent with the Nowotny et al. 2001 thesis.

This explains how and why Garreau's radical evolution is slowly being converged with the performing arts in the process of serial innovation that delivers transdisciplinary hybrid and new stand-alone approaches. The on-screen digital manipulation of dancers, digital and Gonzo innovations, the tonal manipulation of singers, miniaturized amplification devices, synthesized orchestras, and illusions of hyper-reality attest to the emerging enhancement of human performance and the rise of the transhuman artist resulting from transdisciplinary knowledge production.

## Actor enhancement

Peter Jackson's Weta Productions comprises two arms: Weta Digital for digital effects and Weta Workshop for physical effects. Jackson's *Lord of the Rings* trilogy and *Avatar* (a James Cameron film) are possibly the two most digitally innovative films to date. Actor Andy Serkis won a number of film acting awards for his portrayal of Gollum in *Lord of the Rings*:

> Gollum is probably the most actor-driven digital creature that has ever been used in a film before. (Peter Jackson, cited by Serkis 2010, URL)

The notion of acting awards bestowed upon a digitally enhanced actor raised some concerns in 2003 but has since become accepted. Sam Worthington was nominated for a 2010 Academy Award for his digitally enhanced character in *Avatar*, the result of Weta Digital technology that "clones" facial expressions:

> The computer scientists have challenged assumptions about human behaviour and what influences that behaviour when people communicate by tracking the expressions of individuals during live conversations on a video conference, and mapping the facial movements to models of faces. (Behind the Scenes, 2009, URL)

In *Avatar*, James Cameron used a Gonzo approach to capture more data from the actor's face than Jackson had been able to achieve in *Lord of the Rings*. It is significant that the magazine Popular Mechanics reviewed the actors' technological enhancements with as much readership interest as is normally reserved for the performers' artistry.

Jackson and Cameron converge known technologies to evolve new applications in the quest for artistic and commercial success. They work with teams of experts from a variety of disciplinary backgrounds and the resulting innovation equates to contextualised transdisciplinary knowledge production the effect of which is diminished bby reduction to the component contributions. The methodology is evolutionary, deriving in part from other transdisciplinary experiments.

These examples of actor enhancement demonstrate the transdisciplinary convergence of GRIN-approximating technologies and human artistry and the realisation of transdiscipinary convergence with innovative solutions to complex problems that expand the arts economy.

## Dancer enhancement

The convergence of GRIN derived neuropharmacology and dance is well documented. Although accurate statistics are hard to come by, dancers appear susceptible to performance enhancement because of the physical endurance required to dance professionally. *The American Journal of Sports Medicine* reports that a significant number of ballet dancers per annum suffer injuries and repeatedly use drugs to treat trauma, inflammation and repetitive-use stress (Liederbach et al 2008). Tindall (2006) cites a 1993 study of the medical problems of performing artists that finds 27 per cent of high school dance students use non-prescription drugs regularly. Tindall suggests that dancers hide injuries to protect themselves against unsympathetic artistic and casting judgments and for over-weight. Hamilton et al (1998) report that North American ballerinas weigh 6 to 12 per cent less than standard weight ideals resulting from the digestion of diet pills, diuretics and amphetamines, the latter being also used to combat fatigue (Fukushima 2002). Adderall, Ritalin and Dexedrine are used as stimulants by some dancers (Rasminsky, 2008). Tindall contends that Ibuprofen and beta-blockers are used by some dancers to combat stage fright and suggests that that numerous performance-enhancing drugs have applications for dancers:

> ... especially stimulants, diuretics, amphetamines, steroids, hormones, and narcotics used for energy, weight control, muscle building, and pain management. (Tindall, 2006, p. 2)

The abuse of performance enhancement drugs is graphically documented in the biography of dancer Gelsey Kirkland (Kirkland, & Lawrence ,1987) and while the ingestion of drugs is not considered to constitute knowledge production, the consequences are. There are two levels of relevance here. First, the voluntary ingestion of performance enhancing drugs suggests, as in competitive sports, that some performers aspire to attain transhuman attributes; and second, GRIN technologies are converging with artistic performance to approximate transhuman attributes.

The continuing evolution of new performance enhancing drugs implies further convergence in this regard. The discovery of the brain hormone Orexin A which reverses the effects of sleep deprivation (Madrigal, 2007), although intended for the treatment of narcolepsy, combats fatigue without raising blood pressure or causing mood swings and seems destined for enhancing dance performance. The hormone RGS-14 which boosts layer six of the visual cortex region V2 by creating visual memories (Mandal, 2010) similarly has the potential for enhancing the memory of choreography.

The dangers of drug enhanced performance are well documented and it is not the intention of this paper to advance the practice. Nonetheless, the convergence of drugs and dance represents a hybrid form of artist performance motivated by economic survival and artistic success, influenced by disciplinarity but ultimately a stand-alone outcome. It can be said that it represents the outcome of actors (dancers) pursuing their own goals by way of interaction with neuropharmacology (Rzevski, 2005).

## Vocal enhancement

Transdisciplinarity convergence in the performing arts is overtly illustrated by vocal enhancement. Condensers at the foot of a stage to amplify singers and actors with a small amount of sound reinforcement have been replaced by electret

microphones with small-diaphragm condensers and wireless transmitters which can be hidden in a singer's hair, glued to the forehead or positioned at a singer's mouth like a headset.

> We just clip on the mics and the weakest voice will come thundering out, in tune, over the band next to the stage (Ashton, 2006, URL).

Wireless electret microphones employ complex technologies involving hundreds of frequency channels that interact with each other and other radio sources. Each transmitter has controls which require discrete settings for omni-directional microphones on belt-packs. Musical productions employ sound engineers to design sound systems and to program computers for the control of individual electret microphones as singers enter and exit the stage. Theatres are now designed or modified to incorporate sound system control panels and sound engineers sit at the rear of the auditorium. In this way a balance between weak and strong singers is effected along with the balance between singers and orchestra.

Whereas voice projection was formerly the primary attribute of vocal performance, sound engineering and the miniaturization of amplification have equalized the vocal projections of performers using technological enhancements such that the weakest singer can appear as competent as the strongest.

An even more remarkable enhancement involves altering a singer's pitch with Auto-Tune technology, a computer technology that corrects mistakes in pitch and so disguises off-key singing. Created by Exxon engineer Andy Hildebrand, Auto-Tune enables the manipulation of vocal effects so that untrained singers can carry a melody line.

> One industry insider said that autotuning techniques were commonly used, especially in American TV talent shows. Normally an audience would not notice (Guardian, The, 2010, URL).

The on-going refinement of technologies to enhance vocal performance represents serial innovation which employs technology as a means to an end in the context of making money and solving complex problems across the disciplines of acoustics, vocals and stage management. Vocal enhancement represents another step in the realisation of Garreau's radical evolution of the transhuman performer.

## *Orchestral enhancement*

Similarly, orchestral enhancement can be said to represent serial innovation by employing technology in the context of the arts economy by solving complex problems transdisciplinarily.

In a production of The Wiz, the sound of a small orchestra of fifteen players (four brass, three woodwind, three strings, one bass, two keyboard and two drums), was doubled using SM7b microphones on the brass, DI microphones on bass and keyboards, D112 microphones on drums, e914 microphones on woodwind, DI on the bass and keys and feed them through monitors, and AKG clip-ons for the strings (Vent 2004). One synthesizer can double for multiple instruments individually and simultaneously. Indeed, a five-month North America tour of a revival of the musical Camelot had an orchestra of only four people: one violin, one cello, one French horn and a conductor with a computer using Notion software. The effect was that of a full orchestra (Space Daily 2010).

Sophisticated synthesizers, which include computer-manipulated recordings, are assuming dominance in many musical productions especially in provincial and touring companies where the cost of transporting large orchestras is commercially prohibitive.

> There are computer programs able to read and play back music scores—a boon to composers who can now hear their work as they write—and software allowing conductors to control the tempo of the machine, in the same way that they direct live players. (Space Daily, 2010, URL)

In July 2010, the producers of the Broadway production of West Side Story announced they were reducing the size of the orchestra, replacing five musicians with an off-stage synthesizer (Woodiel, 2010), demonstrating that even the classics are not immune to the trend.

Although early virtual orchestras were afflicted with computer dropouts, sophisticated back-up technology has eliminated this threat. The contemporary goal is no longer for synthesizers to supplement certain phrases or expand instrumental parts, but to perform the entire score. Audiences do not seem to mind given that hit productions like Priscilla and Mama Mia play to sold-out houses world-wide with extensively synthesized pit orchestras.

The transdisciplinary convergence of technology and orchestra is clearly driven by economics underpinned by technological innovation and application in the context of economic gain. This is the transdisciplinary drive that equates innovation in industry with economic rationality.

## *Performance in hyper-reality*

Umberto Eco documents hyper-reality in the image of fake history, fake art, fake nature and fake cities (Eco, 1986). He argues that imitations no longer reproduce reality but improve it. He refers to Disneyland and Disney World as 'absolutely fake cities' with animatronic robots replicating people such that reality by comparison seems disappointing. Eco's distaste for hyper-reality resonates with Baudrillard's (1988) earlier criticism of mass consumer society, which he claims conceals the fact that it is not real. Baudrillard is obsessed with saving 'the principle of reality'.

Given that it is more than two decades since Eco and Baudrillard made these critical observations, one might ponder what they might make of the extreme hyper-reality of artistic performances enhanced like the animatronic robots of Disneyland. The star system which relied on the unique talent of the individual performer has been subsumed by clones. Anyone with the required physical attributes can play any part in *The Phantom of the Opera*. No matter where it is performed, the characters of Christine, Raoul and the Phantom are physically and technologically enhanced to look and sound the same. The individual performer has become secondary to the simulacra. The commercial imperative of Mode-2 transdisciplinarity is converging the performing arts inextricably with elements of radical evolution such that it is becoming increasingly difficult to distinguish between culture and mass media, between reality and simulacra and, in consequence, between human and transhuman artist.

## *Economic imperative and return on investment*

*Avatar* (2009) is the highest grossing film of all time having grossed $2.8billion by October 2010 (IMDb, 2010). *The Lord of the Rings: The Return of the King* (2003) is the third highest grossing film of all time having taken $1.1billion by the same date (IMDb, 2010). However, the stage musical *The Phantom of The Opera* is the highest grossing entertainment of all time, having grossed $5.1billion by 2008, more than the blockbuster films *Titanic, Lord of the Rings, Jurassic Park* and *Star Wars*. It has been seen by over 80 million people in 124 cities in 25 countries (Best of Broadway, 2008). It is this level of return on investment that is driving transdisciplinary convergence in the performing arts.

Cameron Macintosh exemplifies the impresario model of Mode-2 society. Macintosh is the producer of a number of musical productions with varying degrees of success but it is his productions of *Cats, The Phantom of the Opera, Les Miserables* and *Miss Saigon* which establish him as the most successful musical theatre entrepreneur of all time. These productions employ state-of-the-art technology which is updated as technical innovation progresses. There is little reliance on star drawing power and total reliance on the quality of spectacle and performance such that wherever productions occur world-wide, the standard of performance is assured for the audience.

Milestones of Macintosh's productions spawn enhanced productions such as the 2006 technologically updated Las Vegas production of *The Phantom of the Opera*, the reinterpreted 2004 *Miss Saigon*, and the 10th and 25th Anniversary productions of *Les Miserables*. The 25th Anniversary production of *Les Miserables* delivered an arena-spectacle concert version in costume at London's O2 Arena held in October 2010 with a cast of over 300 singers and musicians (Les Miserables, 2010). To date, 56 million people worldwide in 42 countries have purchased tickets for *Les Miserables* (Les Miserables, 2010). The 25th Anniversary production played to a 20,000 capacity audience (WhatsOnStage, 2010b) while being simulcast to 160 cinemas in the UK and ultimately released to over 1,100 screens world-wide (WhatsOnStage, 2010a). This demonstrates that, as Nowotny et al. (2001) theorised, the context does speak back and, in the case of Macintosh, with a positive response. In essence, Macintosh merges culture and mass media to drive the performing arts and employs technological evolution to respond to ways the audience expects and accepts the performing arts. In this way he challenges the isolation and cost-ineffectiveness of traditional performing arts by the commercially viable 'creative destruction' of his own productions. Macintosh exemplifies the industry entrepreneur who re-engineers disciplinary components for profitable, transdisciplinary outcome.

# Conclusion

The performing arts provide a rich field of Mode-2 transdisciplinarity in application involving contexts of complexity, no-linearity, heterogeneity and economic imperative as expounded by Gibbons et al. (1994) and Nowotny et al. (2001). It is displayed in the convergence of technology and performance which approximates both the transhuman elements of radical evolution and the evolutionary economics that drives Mode-2 society. The convergence of GRIN technologies and the performing arts in the form of digital, drug, acoustic, synthesised and simulacra enhancements responds to the arts performer who constantly seeks heightened senses and new opportunities to interpret and expand characterisations by transforming the self into a new persona. Conversely and

ironically, the impresario employs Mode-2 transdisciplinarity to standardize and, as in orchestral performance, to limit the artist in pursuit of quality assurance and return on investment.

Transdisciplinary convergence in the performing arts demonstrates that the transdisciplinary production of knowledge is pursued in industry regardless of academic perspective. It is dynamic and employs disciplinary knowledge, science and logic driven by economic imperative. It develops in a less orderly way than academic transdisciplinary knowledge production because it is responsive to a real-time market - the agora of Nowotny et al (2001) which speaks back by way of pecuniary investment in the form of ticket sales.

> People enter. Whenever we speak about the contextualization of knowledge, there is some place in the knowledge where people have entered. (Nowotny, et al., 2001, p. 256).

This refers to the serial-innovators, impresarios, performers and public who comprise the performing arts in the evolving arts economy.

> New ideas and technologies are the drivers of economic growth, yet only to the extent that they are adopted and retained by people. The creative industries are the entrepreneurs and manufacturers of this socio-technical process (Potts, 2007, p. 1).

By demonstrating such examples of transdisciplinary convergence in the commercial context of the performing arts, this paper contributes to Mode-2 transdisciplinary contextualized research distinct from the evolutionary epistemology which academic transdiscipinary literature has come to exemplify.

# References

Ashton, D. (2006). Australia tech talk. Retrieved, August 12, 2011, from http://www.theatre.asn.au/forums/tech_talk_0?from

Ball, S.J. (1994). *Education reform: A critical and post-structural approach.* Buckingham: Open University Press

Baudrillard, J. (1988). Simulacra and simulations. In M. Poster (Ed.), *Selected writings.* Stanford: Stanford University Press

Behind the Scenes. (2009). Peter Jackson's Weta Digital helps to 'clone' facial expressions. 2 June, Retrieved August 12, 2011, from http://behindthescenestv.net/visual-effects/peter-jacksons-weta-digital-helps-to-clone-facial-expressions

Best of Broadway. (2008). News. July. Retrieved September 10, 2011, from http://www.bestofbroadwayspokane.com/news0708.asp

Boyle, A. (2005). The human strain. In *The Australian*, May 14, 2005.

Eco, U. (1986). *Travels In hyperreality*. New York: Harcourt Brace Jovanovich

Frodeman, R., Klein, J. T., & Mitcham, C. (2010). *The Oxford handbook of interdisciplinarity*. Oxford: Oxford University Press.

Fukushima, R. (2002). Overdoing over-the-counter drugs. *Dance Magazine*. June.

Garreau Group, The. (2011). Understanding the world culture and values: Who we are, how we got that way and where we're headed. Retrieved August 12, 2011, from http://www.garreau.com/main.cfm?action=book&id=2

Garreau, J. (2005). *Radical evolution: The promise and peril of enhancing our minds, our bodies—and what it means to be human*. New York: Broadway.

Gibbons, M. (1994). Innovation and the developing system of knowledge production. Paper for University of Sussex, *Trinational Summer Institute on Innovation, Competitiveness and Sustainability*. Whistler B.C., August 14-21. Retrieved December 22, 2002, from http://edie.cprost.sfu.ca/summer/papers/Michael.Gibbons.html

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. & Trow, M. (1994). *The New Production of Knowledge*. London: Sage Publications.

Godin, B., & Gingras, Y. (1999). The place of universities in the system of knowledge production. *Observatoire des sciences et des technologies*. Montreal. Retrieved November 15, 2003, from http://www.ost.qc.ca/OST/Document/Helix.pdf

Grubb, W. (1996). The new vocationalism in the United States: Returning to John Dewey. *Educational Philosophy and Theory*, *28*(1), 1-23.

Guardian, The. (2010). Fans suspect X Factor of enhancing singers' pitch with Auto-Tune. *The Guardian*, 22 August. Retrieved December 12, 2010, from http://www.guardian.co.uk/tv-and-radio/2010/aug/22/x-factor-accused-autotune-enhancing-singers

Harvey, M. (2007). They say it's cutting edge: interdisciplinary and transdisciplinary practice in the visual and performing arts. *The International Journal of Arts in Society*, *1*(4), 19-22.

Hirsch-Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., Wiesmann, U., & Zemp, E. (Eds.) (2008). *Handbook of Transdisciplinary Research*. Netherlands: Springer Science.

IMDb. (2010). All-time box office: World-wide. *Imdb*. Retrieved December 12, 2010, from http://www.imdb.com/boxoffice/alltimegross?region=world-wide

Kirkland, G. & Lawrence, G. (1987). *Dancing on my grave: An autobiography*. USA: Jove Books

Klein, J. T. (1990). *Interdisciplinarity: history, theory and practice*. Detroit: Wayne State University Press.

Klein, J. T. (1996). *Crossing boundaries: Knowledge, disciplinarities and interdisciplinarities (Knowledge, disciplinarity and beyond)*. Charlottsville: University of Virginia Press.

Klein, J. T., & Macdonald R. (2000): What is transdisciplinarity? In M. Somerville & D. Rapport (Eds.) (2000). *Transdisciplinarity: Recreating integrated knowledge*. UK: EOLSS.

Klein, J. T., Grossenbacher-Mansuy, W., Haberli, R., Scholz, R., & Welti, M. (Eds.) (2001). *Transdisciplinarity: Joint problem solving among science, technology and society*. Switzerland: Birkhauser Verlag.

Klein, J.T. (2010a). A taxonomy of interdisciplinarity. In Frodeman, R. (Ed.) *The Oxford handbook of interdisciplinarity*. Oxford: Oxford University Press.

Klein, J. T. (2010b). *Creating interdisciplinary campus cultures*. San Francisco: John Wiley and Sons.

Klein, J. T., & Parncutt, R. (2010). Art and music research. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity*. Oxford: Oxford University Press.

Kurzweil, R. (1999). *The age of spiritual machines: When computers exceed human intelligence*. St. Leonards: Allen & Unwin Viking Adult.

Liederbach, M., Dilgen, F., & Rose, D. (2008). Incidence of anterior cruciate ligament injuries among elite ballet and modern dancers: A 5-year prospective study. *American Journal of Sports Medicine*, *36,* 1779-88.

Les Miserables. (2010). *About the show*. Retrieved August 12, 2011, from http://www.lesmis.com/about/25th-anniversary-year/

Madrigal, A. (2007). Snorting a brain chemical could replace sleep. *Wired*, 2 December. Retrieved August 12, 2011, from http://www.wired.com/science/discoveries/news/2007/12/sleep_deprivation#ix zz0xs6yPtQ8

Mandal, A. (2010). Gene deletion could make you smarter: study. *The Medical News*, 20 September. Retrieved August 12, 2011, from http://www.news-medical.net/news/20100920/Gene-deletion-may-make-you-smarter-Study.aspx

McMichael, A. (1998). Plenary 2: What makes transdisciplinarity succeed or fail? *Simulating synergies, integrating knowledge*. UNESCO Symposium on Transdisciplinarity, Royaumont Abbey, May. Retrieved 2003 from http://firewall.unesco.org/philosophy/transdisciplinarity/4.html#4.1.1

Nicolescu, B. (2002). *Manifesto of transdisciplinarity*. Tr. Voss, K-C. Albany: State University of New York Press.

Niclosecu, B. (Ed.) (2007). *Transdisciplinary theory and practice*. USA: Hampton Press.

Nowotny, H. (1999a). The need for socially robust knowledge, *Collegium Helveticum*. Retrieved August 12, 2011, from http://www.itas.fzk.de/deu/tadn/tadn993/nowo99a.htm

Nowotny, H. (1999b). The place of people in our knowledge. *European Review*, *7*, 247-62.

Nowotny, H., Scott, P., & Gibbons, M. (2001). *Re-thinking science: Knowledge and the public in an age of uncertainty*. Cambridge: Polity Press.

Pestre, D. (1999). What is science? A simple question with no simple answer. In G. Folkers, H. Nowotny, & M. Weiss, (Eds.) *Sterwarten-Buch: Jarbuch des Collegium Helveticum 2*. Zurich: Haffmans Sachbuch Verlag, 161-73.

Potts, J. (2007). Art and innovation: An evolutionary economic view of the creative industry. *The UNESCO Observatory*, *1*(1), 1-18.

Rasminsky, A. (2008). Study drugs and dancers. *Dance Spirit Magazine*. Retrieved August 12, 2011, from http://www.dancespirit.com/articles/1908

Rzevski, G. (2005). Designing complexity into products and processes. Cited by D. Everitt, & A. Robertson. (2007). Emergence and complexity: Some observations and reflections on transdisciplinary research involving performative contexts and new media. *International Journal of Performance Arts and Digital Media*, *3*(2&3), 239-52.

Serkis, A. (2010). Andy Serkis. *Official website.* Retrieved August 12, 2011, from http://www.serkis.com/cinlotr.htm

Sjuve, E. (2008). Gestures, interfaces and other secrets of the stage. *Transdisciplinary digital art*, *7*(5), 301-12.

Space Daily. (2010). Broadway sings blues over synthesizer invasion. *Space Daily*, 29 July. Retrieved August 12, 2011, from http://www.spacedaily.com/reports/Broadway_sings_blues_over_synthesizer_invasion_999.html

Tindall, B. (2006). For dancers, a new athleticism—at what price? *New York Times*, 13 June. Retrieved October 18, 2010, from http://www.nytimes.com/2006/06/13/arts/13iht-tindall.1962911.html?_r=1&pagewanted=2

Vent, T. (2004). Live small orchestra in theatre—what mics? *Remote Possibilities in Acoustic Music & Location Recording Forum*, October. Retrieved December 15, 2010, from http://www.gearslutz.com/board/remote-possibilities-acoustic-music-location-recording/511996-live-small-orchestra-theatre-what-mics.html

Vojak, B., Price, R., & Griffin, A. (2010). Corporate innovation. In R. Frodeman, (Ed.), *The Oxford handbook of interdisciplinarity*. Oxford: Oxford University Press.

WhatsOnStage. (2010a). Final tickets for Les Mis at the O2: Tube strikes. *WhatsOnStage*, 1 October. Retrieved December 15, 2010, from http://www.whatsonstage.com/news/theatre/london/E8831285946873/Final+Tickets+for+Les+Mis+at+The+O2%2C+Tube+Strikes.html

WhatsOnStage. (2010b). *Les Miserables* marks epic 25th birthday. *WhatsOnStage*, 4 October. Retrieved December 15, 2010, from http://www.whatsonstage.com/tv/theatre/london/E8831286187434/WOS+TV%3A+Les+Miserables+Marks+Epic+25th+Birthday.html

Woodiel, P. (2010). Gee, Officer Krupke, I need those violins. *New York Times*, 9 July. Retrieved December 15, 2010, from http://www.nytimes.com/2010/07/11/opinion/11woodiel.html?ref=opinion