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Criteria for Empowering Innovation in Higher Education

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ABSTRACT

Although academic staff have a key role to play in innovation at higher education institutions (HEIs), current innovation adoption among academic staff is disappointing. Most curricula at HEIs are stalled in the traditional pedagogical model of knowledge transmission for teaching and learning with little exploration of technologies for innovative/inventive outputs. This article explores the essential issues of innovation/invention in higher education and provides criteria for empowering innovation. Starting from reflections and perspectives on innovation at South African HEIs and the theories on innovative problem solving, the article provides arguments on multiple issues of innovation/invention that culminate in crucial criteria for innovation. The real dilemma for innovation is caused by external and macro-level factors that require the analysis of existing business models. The management of HEIs have to take into account the underlying barriers, such as knowledge of patenting and academic valorisation, when they create policies that encourage academic staff to explore innovative endeavours.

Keywords: innovation; higher education; criteria; interdisciplinary; barriers; academic communities of practice; homological innovation transfer; theory of the resolution of invention-related tasks

Introduction

Research findings claim that there is no appropriate foundation for producing innovation/invention at higher education institutions (HEIs) in South Africa (Oanda 2013; Pouris and Pouris 2011; Sibanda 2008). There are no adequate criteria for forming innovative/inventive outcomes in organisations and academic communities (Gumusluoglu and Ilsev 2009; Heher 2006; Hsiu-Fen 2007). Innovation is the implementation of a new, significantly improved product, service or process that serves as a new marketing

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method or a new organisational method in business practices, workplace organisation or external relations (OECD 2005).

A major cause of inadequate innovative initiatives and production of inventive outputs at HEIs is the absence of support for accumulated innovation/invention efforts and the presence of multiple barriers, such as the long process of obtaining funding and academic staff's multiple training and administrative tasks, which undermine innovative activities (Armstrong 2014; Badran 2007; Bedny and Seglin 1999; Cervantes 2016; Pouris and Pouris 2011; UN 2015; Warburton 2009). Given the financial constraints of HEIs, the continuation of institutional support for technology transfer and innovation is likely to be at risk (Heher 2006). In organisational settings, the application of evaluation criteria plays a significant role in promoting the competitive and business potential at the front end of innovation (Martinsuo and Poskela 2011).

It has generally been accepted that modelling of innovative behaviour (Lubart 2001) has little practical application in academic contexts, due to academics' teaching load and their unpreparedness for innovative design (Buckley and Jakovljevic 2013; Jakovljevic 2013). Moreover, there is a need for a theory that comprises tools, methodologies and an algorithmic approach for innovative problem solving.

Altshuller and Shapiro (1956) designed the theory of the resolution of invention-related tasks (TRIZ), but academics seldom apply TRIZ due to the complex nature of the methodology and underlying organisational and application issues (Ilevbare, Probert and Phaal 2013).

The principles, processes, stimuli and sub-processes of innovation have not been systematically examined in academic contexts (Utterback 1971). If university policies on innovation amount to questionable governance mechanisms that do not adequately reference the principles and criteria of innovation, then concerns that innovation outputs are likely to be side-lined, are well-founded.

The main purpose of the current study was to explore underlying issues of innovation in higher education so as to suggest criteria for empowering innovation among academics and to create a network of innovative "cells" within academic communities. This led to specific objectives, namely:

1. to create a theoretical framework;
2. to derive criteria based on this framework;
3. to critically analyse the criteria in terms of raising awareness of innovative outputs among academic;
4. to challenge academic practice by inspiring colleagues to take innovative actions at their institutions.

Phases of the Research and Research Questions

The study was divided into two phases. In the first phase, criteria for innovation were developed. In the second phase, a model for innovation will be developed. The following research questions (RQ) were set for the first phase:

RQ1: What are the criteria for building innovative endeavours in higher education?

RQ2: How do the criteria raise awareness of innovative outputs among academics and challenge academic practice?

RQ3: What are the barriers to establishing innovative academic initiatives?

Research Methodology

Based on the collected and processed scientific literature, an in-depth reflective analysis was carried out in order to gain insight into the design of criteria for innovation/invention in higher education. The analysed literature was synthesised into several major sub-topics that were evaluated as the most relevant in explaining the phenomenon of innovation in higher education environments. The method of analysis included breaking down complex concepts, judgements and conclusions into their simpler component parts and elements (Belak 2005). The analysis of the theoretical framework and a combination of practical and reflective experiences will yield broad criteria that underpin the innovation applicable to HEIs.

Theoretical Framework for Criteria for Innovation/Invention in Higher Education Environments

An idea is generated through creativity, but an idea only becomes an innovation when it is transformed into something meaningful in the form of a product or service with a market value (De Miranda, Aranha and Zardo 2009). Invention is the development of a novel idea that has a useful application. Innovation is a more complex term, referring to how an invention is brought into commercial usage (Badran 2007; Sibanda 2008).

A successful innovation includes exploration of the process of innovation that includes sources and stimuli, actions and actors (Utterback 1969; 1971). Stimuli activate an intensive thought process/cognitive search for a solution to a real-world problem. The process of innovation has sub-processes, such as the recognition of a problem, awareness and analysis of the problem, adoption decision, and implementation process (Anderson and King 1993). Crucial elements are needed for the fulfilment of innovation, such as an inherited drive for creativity and the availability of financial resources.

Perspectives on Innovation in Higher Education in South Africa

The output of scholarly publications by South African universities is much higher than IP (intellectual property) applications, particularly patents (Kaplan 2009; Lubango and Pouris 2009; Sibanda 2007). There were also fewer than 300 South African academic inventions between 1996 and 2006 compared to 8 000 academic inventions in the United States (US) during the year 2000 (Cervantes 2016; Pouris and Pouris 2011).

According to Bansia and Reddy (2015, 186), IP developed by researchers either "lies idle" at HEIs in South Africa, "or is sold off to private companies, often overseas, with no benefit accruing to the HEIs or the government or South African people". The low IP registration activity at HEIs in South Africa resulted in the government revising the old IP policy (Sibanda 2007; 2008) in an attempt to speed up innovative initiatives. South African enterprises, on the contrary, have a fairly high innovation rate and the degree of novelty of South African innovations is also relatively high (Moses et al. 2012).

IP activities are relatively unsuccessful in developing countries (Pouris and Pouris 2011) due to the impracticality of changing an existing business model; a lack of systematic innovation training; ignorance of how to evaluate innovations; and limited funding (Armstrong 2014). "Finally, it is worth noting that many societal needs around the globe have not yet received a lot of attention from researchers, companies and governments, despite the enormous potential for innovative solutions which accommodate widely shared public value" (EC 2013, 15). It is clear that academics need guidelines in the form of criteria, knowledge on theories and tools for innovative problem solving.

Theories, Models, Approaches and Frameworks on Innovative Problem Solving

The Theory of Innovative Problem Solving and Axiomatic Design

Altshuller and Shapiro (1956) developed the theory of the resolution of invention-related tasks (TRIZ). TRIZ encompasses 40 principles of invention; the algorithm of inventive problem solving (ARIZ); the contradiction-solving matrix; and other tool sets. *TRIZ* is a problem-solving, analysing and forecasting tool (Hua, Yang, Coulibaly and Zhang 2006) that highlights an algorithmic approach to the invention of new systems and to the improvement of contemporary inventions. TRIZ is based on the fundamental concepts of ideality (systems improvement); contradiction (evolution involves resolution of conflicts); resources; and the use of functional diagrams to represent a problem (De Carvalho 2005 cited in Hua et al. 2006).

Furthermore, TRIZ provides a fact-based method for the evaluation of innovations: (1) analyse the evolutionary potential of the innovation; (2) determine its ideality; (3)

produce a functional analysis; (4) predict an anticipatory failure analysis; and, based on these, (5) justify research and development costs (Schaper 2017).

For generating innovative solutions, TRIZ includes a knowledge base, analytical tools, systems analysis, failure analysis in problem formulation, and an interdisciplinary approach for the improvement of products, systems and services (Sheng and Kok-Soo 2010). Evolutionary patterns and innovations take advantage of the results of research in other areas (Barry, Domb and Slocum 2010).

TRIZ's main concern is the conceptual solution to a given problem using ARIZ, an algorithmic approach to finding inventive solutions by identifying and resolving contradictions. Human beings continuously invent new methods to reduce problems, which previously required creative thinking, to algorithms (Altshuller 1984 cited in Wickelgren 1985).

Axiomatic design (AD) is a systems design methodology that introduced the principles of industrial design and its applications to all phases of systems planning and production. AD uses matrix methods to systematically analyse the transformation of customer needs into functional requirements, design parameters, and process variables.

Two axioms govern the analysis and decision-making process in developing systems designs, namely: (1) the independence axiom (maintain the independence of the functional requirements); and (2) the information axiom (minimise the information content of the design) (Suh 2001).

Yang and Zhang (2000) improved AD to a powerful analytical tool for problem solving by applying functional, physical and process hierarchies to the design of a system. AD needs a vast knowledge base in order to support the application of its theory (Yang and Zhang 2000). TRIZ is very useful in dealing with one-on-one functional requirement situations, but in multi-objective situations or multi-level system structures AD contributions are obvious (Yang and Zhang 2000). Since academics are involved in solving real-world problems, the knowledge and skills of AD and TRIZ could advance their innovative solutions.

Diffusion Theory and Innovation Opportunities

Diffusion is the process of spreading ideas, concepts, skills and knowledge through society. Innovation diffusion theory (IDT) explains how innovations or technology becomes adopted and spreads through societies (Rogers 2003 cited in Kaminski 2011). The diffusion of an innovation depends on individuals and their social influence, the context in which the innovation takes place, its characteristics, and time.

Rogers' theory is frequently used for technology diffusion and adoption in educational environments (Medlin 2001 cited in Sahin 2006). There are many cross-disciplinary applications of IDT. Martins and Terblanche (2003) devised a model to show the influence of organisational culture on creativity and innovation.

Diffusion decisions regarding innovation are not as simple as "accept" or "reject" (Taylor and Perry 2005, 210). Accordingly, adopting innovation is undoubtedly one of the main foundations for forming academic spin-offs enterprises (Anderson and King 1993; Callaert, Van Looy, Foray and Debackere 2006; Etzkowitz, Webster and Healy 1998). This could justify the request for a criterion based on IDT to further develop an innovative spirit at HEIs.

Multidisciplinary, Interdisciplinary and Transdisciplinary Approaches to Innovation

Successful innovation includes the exploration of the networks of interdisciplinary players, efficient methods and sources of funding (Wenger, McDermott and Snyder 2002). A multidisciplinary approach draws on knowledge from different disciplines but stays within their boundaries. An interdisciplinary approach analyses, synthesises and harmonises links between disciplines into a coordinated and coherent whole. A transdisciplinary approach integrates the natural, social and health sciences in a humanities context, and transcends their traditional boundaries (Haynes 2002; Kleinberg 2008 cited in Jones 2010).

Multidisciplinary, interdisciplinary and transdisciplinary (MIT) approaches are seldom communicated to academics through university policies, promotion criteria or seed-funding programmes (Buckley and Jakovljevic 2013; Kanakia 2007 cited in Jones 2010). The organisational structures in higher education and global academic norms are often biased towards more conventional approaches to enhance innovation. It is therefore important to introduce criteria that will validate the use of MIT approaches in academic contexts.

Homological Innovative Transfer

In the 19th century, the biologist Owen (Rupke 1994) introduced the word *homology* to refer to the fact that many organisms are similar in some of their features, or similar in some of the relationships between their features. Von Bertalanffy (1968) subsequently widened the meaning of the word *homology* to include the abstract level of human knowledge, including homologies between concepts, propositions, arguments and theories.

Based on these perspectives, Mende (2005) developed a model of homological transfer meaning that constructs from many disciplines are transferable to other related disciplines with small adjustments (Adams 1966). Homological innovative transfer **(**HIT) focuses on commonalities between disciplines and these commonalities can ease the process of innovation. Researchers cannot borrow all the principles of the source field, because the relevant systems are merely homologous, and not identical; but they can borrow those

principles that pertain to homologous features and relationships (Lenzing 1983; Mende 2005).

Knowledge of homological transfer and HIT is scarce and seldom discussed in academic environments in terms of innovative outputs. In-depth knowledge of HIT can provoke an innovative spirit and collaboration between academics in different disciplines, 5provided criteria are formulated.

Knowledge of Patenting and IP Funding

Patenting

Academics have little knowledge of patenting (Sibanda 2007) and may not realise that a patent protects a device or a process based on a novel or unique idea but not the idea itself (Choudhary, Saroh and Kavita 2013). They do not know what the criteria for innovation are (Shelton and Arciszewski 2007; White 1979), nor when an idea is ready for patenting. Subsequently, there is a need for knowledge of patenting and the evaluation criteria for novelties (Choudhary, Saroh and Kavita 2013).

IP Funding

Sibanda (2007) argues that in South African academic contexts, a lack of funding for IP registration as well as a lack of understanding of HEIs' IP policy prevail. Researchers, such as Bansia and Reddy (2015), Oanda (2013) and Sibanda (2007), recommend educating researchers on how to protect their ideas, familiarising them with commercialisation, and getting them to trust the process.

Academic Valorisation

The valorisation of knowledge and scientific discoveries is often debated in higher education and in business. NlemvoNdonzuau, Pirnay and Surlemont (2002) point out that the commercialisation of scientific and technological knowledge for developing and sustaining regional economic growth is progressively well thought out by policymakers. One of the most promising ways to transfer research results to the market place is the creation of academic spin-offs. Academic entrepreneurship as a form of academic valorisation has been widely accepted among researchers, practitioners and policy makers (Etzkowitz, Webster and Healy 1998).

Callaert et al. (2006) investigated practice-informed views of university professors in terms of academic and entrepreneurship engagements. A combination of scientific and entrepreneurial activities seems feasible in academia and its success depends on the acquisition of internal and external funding.

Academic valorisation and HEIs' economic support are narrowly understood among academics (Jongbloed and Benneworth 2010). This is particularly important for

developing economies, due to a lack of resources. Therefore, having criteria for valorisation is decisive in academic contexts.

Technologies for Innovation

Information and Communications Technology

Information and communications technology (ICT) equips researchers with a diversity of programs that help in searching for and designing innovative solutions to real-world problems (Archibugi and Pietrobelli 2002; Cainelli, Evangelista and Savona 2006; Hsiu-Fen 2007; Miles and Green 2008).

Second Life (SL) is an ICT platform with the ability to create complex objects and environments that can facilitate innovations in pedagogy and it complies with Engeström's (2005 cited in Warburton 2009) conceptualisation of an "object-driven sociality". In developed countries there are an increasing number of applications developed through immersive technology and ICT that produce radical, potentially unlimited innovation, such as in innovative learning systems (Roure 2013).

The combination of ICT and innovation has the potential to take innovative traditional universities to new levels (Varis 2007). HEIs, business and ICT laboratories have occasionally collaborated to develop innovations at academic institutions (Archibugi and Pietrobelli 2002; Booyens, Molotja and Phiri 2013). Accordingly, it is necessary to highlight ICT and technological collaborations through a criterion.

Personality Traits for Enabling Innovation

Multiple research studies on personality traits and innovation exist (Barrick and Mount 1991; Batey and Furnham 2006; Digman 1990; Patterson 2002). However, there is no generally accepted framework or taxonomy on innovative personality traits (Barrick and Mount 1991; Digman 1990). This creates all sorts of unanticipated consequences for innovative practice.

Some personality traits relevant to innovation are: the ability to deal with abstract concepts; a favourable attitude to change, risk and science; empathy; intelligence; a less dogmatic outlook and fatalism; a higher level of aspiration; and a rational outlook (Batey and Furnham 2006; Patterson 2002).

Amo and Kolvereid (2005) conclude that employees' inter-entrepreneurial personalities have a significant impact on innovative behaviour. Deliberation, spontaneous thinking and personal initiative, self-discipline and proactivity are further characteristics important to innovation (Barron and Harrington 1981; Bedny and Seglin 1999).

The researcher identified six personality traits that need further empirical evidence:
a burning desire to solve real-world problems;
persistence in resolving barriers to innovation;
observational and reflective experience in searching for innovative solutions;
tolerance for psychological and social pressures in terms of innovation;
an ability to monitor and control your own innovative performance;
taking responsibility for innovative contributions in the community.

Innovative personality traits are thus considered valuable for higher education and they need to be based on agreed criteria.

Barriers to Innovation in Higher Education

The framework of the existing higher education business model helps to identify aspects that heighten some of the universal barriers to innovation and change (Armstrong 2014). Christensen (1997 cited in Armstrong 2014) distinguishes between sustaining innovation that is absorbed into an existing business model without causing a fundamental change, and disruptive innovation that can lead to a major change in the existing business model.

Innovation activities at HEIs are often troubled by the unavoidable burden of writing up research articles and conference papers with not much originality. Innovation processes are frequently disturbed by multiple teaching, training and administrative tasks and the long process of obtaining funding (Armstrong 2014; Warburton 2009). Further barriers to innovation include poor modelling, inadequate communications, conflict between teaching and research tasks, insufficient incentives for promotion and the exclusion of innovation components from integrated performance management systems' (IPMS) rating criteria.

Similar barriers are identified in organisational environments: a shortage of funding, insufficiency of government funding mechanisms, high costs, lack of skilled staff, time constraints, perceived lack of readiness to accept innovations, challenges in registering trademarks to protect IP (Booyens et al. 2013).

It is clear that there are numerous barriers that are not explicitly recognised by academic communities and these must be resolved by defining a criterion for sustained innovative actions.

Academic Communities of Practice

An academic community of practice (ACoP) involves a group of academics and professionals from industry and/or a community with the aim of solving a real-world problem and producing innovative products or services. ACoPs support the idea of

internationalisation that provides academics with opportunities to cut across disciplines, institutions, knowledge systems, and nation-state boundaries (Oanda 2013).

Creative individuals comprise scientists, engineers, artists, musicians, designers, and knowledge-based professionals who drive the process of innovation (Florida 2002 cited in Booyens et al. 2013) and who are motivated to engage collaboratively on innovative projects (Jakovljevic 2013; 2015). Within communities of inquiry (Wenger, McDermott and Snyder 2002), critical thinking moves through a triggering event, exploration, integration, and application (Garrison and Kanuka 2004).

The principles of knowledge sharing and exchange in the interdisciplinary environment of an ACoP can empower academics, community members, institutions and the society (Buckley and Jakovljevic 2013), depending on the ACoP's leadership and dissemination of knowledge. Little research has been done on ACoPs as collaborative networks for innovation and tools for academic valorisation, but ACoPs can be a starting point for negotiations with multiple stakeholders involved in academic knowledge dissemination.

Criteria for Innovation in Higher Education

From the theoretical and conceptual framework discussed above, the criteria underpinning innovation are not explicitly visible. To equip academics with knowledge, skills, attitudes and values to improve their innovative capabilities, they need benchmarks that focus specifically on the pedagogy of innovation and invention. The criteria for innovation were derived from the multiple conceptual and theoretical concepts discussed above and will be presented and justified here.

The current programmes at HEIs should aim to develop academics' knowledge, skills, attitudes and other personality traits for innovation and invention in everyday activities. The development of these capabilities should ultimately develop academics' innovation competence, as well as enrich institutional and national knowledge bases. This can be accomplished through a combination of theoretical, practical and reflective experiences that culminate in explicit criteria for innovation at HEIs conducive to innovative activities. Table 1 presents 13 criteria that underpin innovation and invention in higher education.

Table 1: Criteria for innovation in higher education

No.	Criterion for innovation in higher education
C1	The process, stimuli and sub-processes of innovation that will develop and release the educator's inherited drive for creativity should be understood and modelled in HEIs.
C2	The policy, infrastructure and business models that could empower academics in producing innovative outcomes for higher education should be re-examined.
C3	TRIZ and AD tools and methodologies should be an essential part of academic practice in order to invest in academics' innovative problem-solving skills and promote real-world experience and innovation accomplishments.
C4	https://sustainabledevelopment.un.org/post2015/transformingourworld that will advance academics' interdisciplinary, multidisciplinary and transdisciplinary knowledge and homological transfer awareness should be encouraged.
C5	Knowledge of patenting and criteria for deciding when an idea is ready for patenting should be explicitly taught to innovators in order to sustain their personal initiative for innovation.
C6	ICT and immerse technologies should be enabled in higher education to empower academics for technological innovations necessary for patenting new ideas.
C7	Awareness programmes for the nurturing of personality traits that could enhance the academic's personal innovative constructs should be introduced and monitored.
C8	Taxonomy of innovative personality traits should be derived in order to improve academics' traits and skills for innovation.
C9	Teaching load, administrative support and incentives provision as barriers to innovation should be addressed in depth with the aim to improve academics' knowledge, skills, attitudes and values towards inventive activities.
C10	Academic community of practice (ACoP) should be stimulated in order to develop academics' innovation capabilities and R and D collaborative skills.
C11	Institutional, national and international collaboration in higher education should be nurtured to develop academics' research and reflective innovative experiences.
C12	The pedagogy of innovation should be developed in HEIs in order to empower educators' motivation for innovative endeavours.
C13	Academic valorisation as a powerful means to enhance innovation outputs should be introduced, discussed and utilised in academic environments. The pedagogy of innovation should be developed in HEIs in order to empower educators' motivation for innovative endeavours.

The criteria for innovation in higher education are interrelated and could serve as a basis for a model for innovation and invention in the second phase of this study (see Table 1). The criteria are interwoven, and their justification is visible in the theoretical basis of the study.

Discussion

The theoretical framework for innovation comprises a variety of issues that were discussed above and corresponding criteria were formulated (see Table 1). The actual benefits of using criteria at the front end of innovation have rarely been studied (Martinsuo and Poskela 2011). These authors confirm the usefulness of evaluation criteria, particularly during idea and concept evaluation. The quality of higher education is important to its stakeholders and it is necessary to generate criteria with arguments about how these criteria can be used to produce results with immediate value for a successful innovation practice.

Criteria were derived from the vital issues on innovation in higher education, such as: the process of innovation and invention (C1); the state of innovation in South African higher education (C2); theories, models and frameworks for innovation (C3); MIT (C4); HIT (C4); knowledge of patenting (C5); ICT and related technologies (C6); analysis of personality traits (C7, C8); barriers to innovation (C9); ACoP collaboration (C10, C11, C12) and academic valorisation (C13) (in answer to RQ1: What are the criteria for building innovative endeavours in higher education?).

Current programmes on innovation in higher education offer very little training in the practical implementation of TRIZ theory, AD and HIT. The integration of TRIZ knowledge-based tools with AD analytical methods makes the innovative design process clear (*Altshuller and Shapiro 1956;* Yang and Zhang 2000).

The benefits of MIT perspectives are crucial to empowering innovations, to "look at situations from various viewpoints" (Jones 2010). Furthermore, the theory of HIT, ACoPs and ICT, in synergy with MIT approaches and consequent criteria, can improve a broad awareness of multiple aspects of innovative outputs and challenge academic practice.

If senior leadership of HEIs consistently signal that they value innovative activities by giving academics administrative support and offering them financial incentives, it is likely to lead to proactive innovative outcomes. Successive, strong efforts need to be directed towards inclusion of the suggested criteria as a preamble to developing a culture of patenting and academic valorisation (in answer to RQ2: How do the criteria raise awareness of innovative outputs among academics and challenge academic practice?)

Numerous barriers hinder innovation and adoption of innovation practices at South African universities. Innovation activities at HEIs are often troubled by inadequate business models (Armstrong 2014; Warburton 2009); the lengthy process of receiving funding; inadequate innovation modelling; unsatisfactory communications; unresolved conflicts between teaching and research tasks; and ignorance of academic valorisation (in answer to RQ3: What are the barriers to establishing adequate academic innovative initiatives?)

To summarise, the criteria can serve as part of the pre-determined criteria for the evaluation of programmes for innovation and invention at HEIs. The evaluation of innovation programmes against the identified criteria may inform their relevance to higher education practice and contribute to its refinement. Furthermore, since the multiple features of innovation are interconnected, criteria could be used to derive effective business models for innovation in higher education in South Africa. However, the author believes that some practice-based research is necessary to complement the theoretical perspective on the devised criteria.

Conclusions, Limitations and Recommendations

The derivation of criteria for innovation revealed new paths in the facilitation of innovative outputs in higher education environments. The results strongly support the following general arguments and conclusions:

The lack of academics' interest and engagement in innovation at South African HEIs is a visible symptom of deeply embedded problems. The author analysed these problems and derived criteria by which current innovative practice can be evaluated. This deepened intellectually as the article explored theoretical viewpoints on internal and external barriers to and multiple features of innovation in academic communities in an attempt to understand their influence on innovative outputs in higher education.

It remains the responsibility of an educator to build stamina, patience and self-awareness to manage the long journey of establishing a productive interdisciplinary team and put best ideas forward even if they are unfinished, and be open to alternative perspectives from other disciplines, policymakers, industry practitioners and community members (UN 2015).

Barriers, such as existing business models; budget constraints; a lack of knowledge of TRIZ, AD, MIT, HIT; unawareness of academic valorisation; and the absence of ACoPs, represent the most tangible reasons for the slow uptake of innovation in university environments.

Personality traits, such as conscientiousness, openness to new experiences, extroversion and emotional stability, a high appreciation of aesthetic qualities, broad interests, attraction to complexity, high energy, independence of judgement, autonomy, intuition, self-confidence, ability to resolve antinomies or to accommodate apparently opposite or conflicting traits in one's self-concept, and finally, a firm sense of self as creative (Barron and Harrington 1981), can positively impact innovation outputs provided that support from management and accreditation bodies is evident (Armstrong 2014).

Thus, it is important that the training for innovation is not purely generic, but that it is based on sound criteria and aimed at the unique features of the learning area, taking into account interdisciplinarity and the latest technologies. All stakeholders in South Africa should be involved in shaping the policy and practice of innovation, namely

the Ministry of Education, the National Board of Education, universities, education providers, municipalities, educational institutions and the functionaries in the third sector. There is an increasing need for a new renaissance in education where technology, art, science, humanities and religion are integrated (Varis 2007).

Every university should have a pattern of innovation that is continuous and focused on the university's unique mission – "without undue concern for either tradition or what other institutions are doing" (Armstrong 2014).

The process of deriving criteria for innovation in higher education should concentrate on: developing the right policies, infrastructure and business models for innovation; providing opportunities for implementing AD, MIT, HIT, ICT and immersive technology for knowledge of innovation; creating awareness programmes and taxonomy on innovative personality traits; redesigning the teaching load, establishing administrative and incentive support for inventive steps; encouraging forming ACoPs; nurturing multiple collaborations and developing the pedagogy of innovation.

In summary, it is contended that a synergy of derived criteria can provide a strategy to realise success in human innovation capability and institutional IP capacity development in the university context. From here, a shift to rethinking and restructuring the innovation experience is necessary in South African HEIs to develop a sense of distinctive identity.

Originality/Value

HEIs are intrinsically open to novelty and engaged in innovation processes but lacking systematic guidelines, such as criteria for innovation/invention. This review of the literature represents the first attempt to organise the scientific knowledge on the multiple aspects of innovation and their mutual intersection leading to derivation of systematic criteria essential to establishing innovative academic environments in developing countries.

Implications, Limitations and Future Research

The study produced a valuable in-depth knowledge on innovation for both academics and policy decision-makers at HEIs through better understanding of the role of criteria in innovation processes.

Although a theoretical rationale suggests that the criteria should be widely applicable, too few examples are given in the article to provide conclusive evidence of wide applicability. The synergy between theories on innovative problem solving, innovative outputs and higher education has not been sufficiently explored in practice and this should be further examined. Therefore, many experiments are still necessary to determine whether the criteria can actually be realised in academic environments.

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