Designing Per-Poor system of innovation proverbs

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Abstract

The purpose of the study was to explore how to create a Per-Poor innovation (PPI) approach in a way that contributes knowledge. A lot of indigenous system research exists, but the percentage transformed into approaches, products and services is low. The study will create a low income level innovation artifact by integrating indigenous knowledge (IK) and global knowledge (GK) for Per-Poor innovators. Analogy design science research method was used to create a system of innovation proverbs. Analogy between indigenous Harambee and global sysems: Open source software, Software patterns and Kaizen was used to discover innovation rules and principles applicable to PPI. The research findings are synthesising African philosophies and provide a paradigm for integrating IK and GK. Synthesising proverbs and Theory of inventive problem solving (TRIZ) principles aided in the discovery of possible ways beeping innovation was created. The originality of this research is being first to create an indigenous PPI.

Keywords: indigenous knowledge, Per-Poor innovation, proverbs, global knowledge, systems

Introduction

People at the lowest income levels (LIL) innovate by trial and error due to lack of innovation approaches and little explicit innovation knowledge. Local communities especially LIL have through the ages developed technological innovations that meet their social, economic needs, conditions of production and have contributed to the evolution of knowledge and practice (Adrian 2008). African societies thus have skills and capabilities to create indigenous technologies, but have no systematic ways of creating and managing them.

Sub-Saharan Africa (SSA) discovered fire. This was among the first proto-typical innovations that changed the world. Fire is the direct or indirect foundation of all modern technologies. Analogy is better than invention for making breakthrough innovations (Hargadon 2003). The technology staircase journey from junkyard to wonderland starts with crawling, followed by walking, followed by running and on to flying (Holmstrom *et al*. 2012). Analogy is a vehicle for navigating unknown innovation landscapes. It uses relevant similarities between things and ignores irrelevant ones. Every person and generation invents. The first person to create a habitable cave house was an inventor and first person to build "caves" that were bartered for other products was an innovator.

Per-Poor innovation (PPI) is innovation by people at the bottom of the pyramid LIL (Heeks 2008:30). PPI solves problems that firms are not interested in, that only the poor are motivated to solve. Humanitarian engineering should build capacity for PPI (Ryan 2013). This capacity is built by creating Per-Poor support artifacts.

Innovation success depends on bridging the gap between available knowledge and social lacunas by linking ideas and processes in their social context (Afolabi 2013). There is a large lacuna between Per-Poor innovators and ways available for them to innovate, which reduces

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their confidence. A prerequisite for building the innovation capabilities of developing countries' innovators is increasing their confidence (Intarakumnerd and Virasa 2004). Self-esteem is part of a capability to solve a problem that is necessary to trigger solution development (Srinivas and Sutz 2008). Innovators with self-esteem and confidence persist in innovating longer in the face of failures. The earliest innovations such as fire were created by innovators in environments more constrained than LIL. Innovating in environments of scarcity occurs everywhere, always.

Proverbs represent local viewpoints that can be integrated with global knowledge (GK) for projects involving local communities (Local researchers and Easton 2004). Proverbs are the kernel of indigenous technology development systems. Research is needed to balance IK and GK for technology development and innovation (Bwisa 2005). Harambee is a Kenyan indigenous social technical system for building traditional houses, modern school buildings, and social activities like organising, managing and raising funds.

Innovation principles are building blocks of innovation methods. Some innovation principles are common sense, so can be used by anyone. Theory of inventive problem solving (TRIZ) is an innovation methodology consisting of several methods. TRIZ is based on invention science similar to the way the scientific method is based on research science. TRIZ was developed by Altshuller with the goal of creating an invention system. Altshuller created the invention system by studying how patented inventions were created. Different countries, regional and international organisations patent databases are the largest source of invention knowledge. Two differences between TRIZ methodology and other popular innovation methods like creative problem solving and lateral thinking is that TRIZ is focused on technology innovation while the others are general innovation methods. The second difference is TRIZ is comprehensive, while other methods are not.

This study uses TRIZ Invention algorithm (ARIZ) and inventive principles. TRIZ and ARIZ are Russian abbreviations that don't exactly match the English translation. The ARIZ algorithm is a detailed specification of innovation instruction steps. TRIZ inventive principles help people transfer problem-solving skills from one domain to another, can be taught and used by anyone at any level of education, from schoolchildren to management consultants to PhD researchers (Smith 2005). This study used the principles to transfer professional global innovative systems knowledge to an informal Per-Poor innovators' technology development approach. It found proverbs useful for transferring indigenous knowledge to global systems in order to extract similar elements. Technologists can build technology and innovation capabilities by following the staircase model: acquiring and using; assimilating, transforming, exploiting knowledge as they modify and innovate technologies (Intarakumnerd and Virasa 2004).

This study creates a PPI approach. Per-Poor innovators have created novel techniques, new products and business models (Heeks 2008). PPIs' details are captured as folklore known to several or as tacit knowledge possessed by a few and known only by their close peers.

Creative engineering innovates by analogy and metaphoric reasoning based on object attributes and relations dimensions with 20% overlap (Hey *et al*. 2008). Corollary of metaphor and analogy overlap is theories and techniques of each can be partially applied in other. Analogy is better than invention for breakthrough innovation influenced this study to privilege analogy over invention (Hargadon 2003). Analogy uses similarities between a better known problem and solution and a new problem with no solution. This required study to start by identifying similarities between Harambee and selected GK systems.

Research questions

Design science research questions are exploratory, constructive, guide the selection of research method (Nguyen *et al*. 2019). They align literature review, and other research components.

This study's research questions are:

1. What are similarities between Harambee proverbs and elements of global innovation systems: open source innovation, software patterns and Kaizen?
2. Can some of these similarities be represented by proverbs, famous sayings, innovation principles and rules be combined to create Per-Poor innovating system?
3. What global innovation systems structure can provide a structure to combine proverbs, sayings, innovation rules and principles into a Per-Poor innovation system?
4. How can Per-Poor proverb innovation systems be implemented?
5. How can African philosophies aid the development of Per-Poor innovation approaches?

Literature review

Literature review is presented in the following sections: proverbs and sayings, software patterns, innovation theory and principles, Kaizen and open source innovation model.

Proverbs and sayings

Africans must design science, technology and innovation (STI) into play, songs, existence, work lore and folklore through turning dreams into realisable future vision (Odhiambo 1993:44). Technology culture drives the spread of innovation and creativity through entire individual and community cognition and existence (Ogungbure 2011). Different SSA STI visions and dreams should be aligned and synthesised into a vision of visions and dream of dreams (Urama *et al*. 2010). Visions and dreams are important starting points to be built on. V*ision without action is daydreaming; action without vision is a nightmare* is a proverb that captures the importance of combining vision and action, dreaming and designing dreams into solutions.

Proverbs are fundamental subsystems of language, part of folklore and work lore used by all members of society, from children to the elderly. They are more widely used in SSA than other parts of world. Proverbs are pervasive in indigenous social technical systems due to their being simple, widely used and having a high problem-solving ability. A random collection of facts and old proverbs is not expertise; expertise is organised, integrated, consists of interrelated elements focused on particular domain and are capable of solving problems (Jackson 1999). Human proverb expertise comes from skillfully combining proverbs and other knowledge using cognitive systems. This study explores ways of organising and integrating proverbs, saying and innovation principles into an expertise system.

Proverbs present local attitudes, insights and proverb reasoning mental models (PRMM) that interleave different ideas, perspectives, experiences and knowledge into novel work practices (Local researchers and Easton 2004). Designers' strategy can leverage this by using the multiple transforming and transformable knowledge and multiple perspectives of others to create novel artifacts (Lindberg *et al*. 2010). Design science research methods are based on design strategy.

Integrated IK and GK have economic and cultural advantages of familiarity and self-sufficiency (UNESCO 2005). These make it easy to adopt and use. Emerging Knowledge societies need more producers of knowledge than consumers (UNESCO 2005). Knowledge producers integrate knowledge from different knowledge basis. Grassroots indigenous innovation emphasise local creative thoughts that pinpoint local needs that firms are reluctant or unable to address (Lizuka and SadreGhazi 2011). Innovation by synthesis is a better way of solving major individual and community problems (Osborn 1957).

Polysymbolism theory states that a proverb's constituent words are symbolic concepts that are substituted with other concepts during problem solving (Wanjohi 1997). Substituted concepts can be novel, such as discovery, creativity and invention that extends proverbs into other domains. "A proverb is a horse that carries you to quickly discover ideas" was polysymbolised to innovation, invention, technology through polysymbolic creativity (Mambo 2017).

Proverbs are discovery and invention heuristics (Polya 1985). Everybody designs as things people create have a structure, good or bad. This is supported by the proverb “Everything is designed”. Design means a plan, a pattern, a composition, or an intention and involves two phases: creating a mental plan for something and creation of forms (Taura and Nagai 2010). Therefore, design is fundamental to thinking and cognition. The questions arise how indigenous social technical were designed and whether they can be indigenously redesigned in a better way? The second question is answered by the proverb “There is nothing that cannot be improved”. Polya’s discovery that proverbs are design heuristics, their wide use, high ability to codify knowledge and Alexander’s observation that indigenous societies apply patterns genetically leads to the corollary that proverbs were and are used to design indigenous systems.

Polya, the great mathematician, suggested collecting proverbs for planning, finding means to reach ends and choosing between means of action. These are design proverbs as design is defined as planning (Taura and Nagai 2010). Proverbs such as “You are because I am” and “Let’s pull together” are planning strategies woven into society’s culture. Alexander who invented building design patterns was inspired by ways indigenous people used patterns genetically to build houses, villages and towns (Coplien 1999). This study’s uses Alexander’s reverse inspiration from global systems to indigenous systems. Alexander’s patterns borrowed from indigenous proverb patterns as Kaizen borrowed from Western quality management. A lesson learnt from this is successful borrowing from other domains is followed by creative adaptation and improvement. Indigenous societies designed their buildings and towns using genetic strategies; the corollary of this is that indigenous social technical systems were designed by Bioinspired design strategies. Nature creates organisms genetically similar to indigenous genetic design. Alexander’s work demonstrates how indigenous proto-typical design method worked.

Among design proverbs Polya found illustrating discovery and invention are: “If you fail, try, try again”, “It’s not enough to try again, try different means”, illustrated by the proverb “Try all keys in the bunch”. A more general African proverb equivalent to these proverbs is: “Trying is succeeding”. When one tries difficult or novel things, success in not guaranteed, but there is no other way of succeeding. This is supported by the African proverb “One who knows proverbs gets what he wants”. This proverb point of view is expert reasoning as using the right proverbs can be used to get everything. Directed by the two African proverbs, this study continuously searched and tried proverbs until the System of innovation proverbs was created.

Some proverbs are software patterns used to teach and develop software (Mambo 2017). Software patterns are innovative and each pattern consists of two or more TRIZ inventive principles (Kluender 2006). The corollary of this is that software pattern theory is at least partially applicable to proverbs.

Integration of proverbs with other constructs is common in SSA culture. Proverbs and riddles are integrated in proverb riddles (Messenger 1960). Gicandi integrated proverbs, poems to create music used in competitions (Sunkuli and Miruka 1990). Gicandi was also used in work, education and managing indigenous social technical systems. People at the bottom of the pyramid used PPI to create novel techniques, processes, business models and others (Heeks 2008). Using social science and the arts to create technology innovation methods is increasing. An example: Essence is an agile software innovation method founded on innovative dance elements (Aaen 2008).

Harambee is a Kenyan indigenous social technical system driven by self-help strategy applied in several domains, including technology development. People volunteer their expertise, time, knowledge and money for communal projects. At independence, Harambee was widely used and adopted as a Kenyan tradition for self-help activities (Chepkwony 2009). Identifying social, cultural and technical gaps ensures the feasibility of design and deployment of digital tools in rural areas (Nocera and Camara 2015). These are critical success factors for Per-Poor technological innovation. Harambee was designed with proverbs and is a long-lived system with

advantages that make it persist. The corollary of this is that proverbs are a design language. Any useful system can be mined for insights for creating artifacts. Data mining is automated insight mining while Alexander's patterns is manual insight mining.

Software patterns

A software pattern is a good, frequently used way of solving a particular class of problems. Patterns are discovered by recognising other people's good ideas not by exceptional brilliance (Raymond 1998). Patterns originated from Alexander's building architecture design work and were borrowed by several other disciplines. Software discipline adapted Alexander's pattern concepts and constructs, then used them to mine patterns from software systems. This inspired this study to mine proverbs from the Harambee system in analogous ways. Alexander's goal was to provide local communities including LIL with easy to use best practices in the form of building design patterns to apply to design of their buildings and towns. Invention of building patterns was driven by the realisation there will never be enough architects.

Complex phenomena generic pattern of scientific discovery is detecting patterns woven by patterned behaviour similar to the cloth weaving loom (Valdes-Perez 1995). Proverbs are patterns woven into indigenous social technical systems. Science and indigenous discovery apply generic pattern genetically.

Innovation theory and principles

Scarcity is the mother of invention and may lead to innovation. Developing countries' scarcity causes lack or inadequate innovation inputs and necessary environmental innovation elements, barriers which are absent in developed countries (Srinivas and Sutz 2008:131). Improvisation and bricolage are used to overcome these barriers. Scarcity-driven heuristic solutions are created for problems solved elsewhere, but with inappropriate or unaffordable solutions (Srinivas and Sutz 2008). The scarcity heuristics may be indigenous or a hybrid of GK and IK.

Innovation in all fields results from unconventional acts of traveling along scarcely or unexplored paths, connecting concepts and methods situated in distant branches of knowledge structures (Assogna and Taglino 2013). When exploring these unknown areas, paradigm mapping techniques are broken or stretched. Furthermore, innovation is not an issue of working with either global or local knowledge, doing, using and interacting or STI, but by hybridisation of them (Jensen *et al*. 2007). Exploring ways of hybridising Harambee, GK elements is discovery journey in unknown wilderness.

Kaizen

Kaizen is a lifelong continuous improvement journey. Kaizen journey is as important as the destination. Journey builds capabilities and destination achieves results. Innovation is a journey of journeys; past journeys build knowledge and capabilities for future journeys. Kaizen like TRIZ inventive principles are used in Information communication technology development, manufacturing, education, social sciences and applied by all levels of society. Kaizen exists in two variants, the Japanese Kaizen and Western Kaizen referred to as continuous improvement (Suarez-Barraza *et al.* 2011). The two variants are adaptation of Kaizen to different environments. Kaizen will from this point be used to refer to the Japanese Kaizen.

Kaizen is a popular approach that hybridised Japanese IK with borrowed Western quality management knowledge (Wittenberg 1994). The hybridisation created an improved technology development system. Kaizen, Western Six sigma and Business process engineering are parts drawn from the same quality management knowledge whole (Anderson *et al*. 2006). Kaizen was created through three interacting processes. First, quality management knowledge was acquired, assimilated and mastered from the West. Second, Kaizen was created by cross fertilising Japanese local and assimilated GK quality management. Third, Kaizen was improved

through learning by doing and from developments of Six Sigma in the West. Six Sigma also borrowed from emerging Kaizen. Kaizen development is one proven way of developing indigenous systems. Kaizen today has transitioned from an IK to a GK system.

Kaizen consists of several components including 10 rules and six wastes (Wittenberg 1994). One Kaizen rule is “Use wisdom not money”. The rule is adapted to “Prioritise using wisdom over money”. Another rule, “Wisdom comes from difficult situations”, is applicable to scarcity environments. The TRIZ principle “Lemon to Lemonade” enables turning difficult situations into beneficial ones. The two rules and one principle align with the proverb “Necessity is the mother of invention” aligned by the proverb “Add effort to wisdom”. The Kaizen rule “Use wisdom of ten instead of one” is contained in the Harambee self-help strategy proverb “Let’s pull together”. Synthesising the best knowledge of Harambee and selected GK into a system (SIP) creates synergy to leverage efforts.

Open source innovation model

Open source innovation model (OSIM) is a software development guide. The model is used to organise a virtual community of volunteer software developers, testers and users, who create software utilising their own resources. They communicate and host software produced on the Internet. The model has created some of the largest and most complex software systems.

OSIM, Wikis and genome are open information production systems with increasing usage, showing open innovation models can do as well as conventional closed models (Pullock 2008). The selection of project innovation model is based on project objectives, cost, duration and scope. Open innovation starts with a mindset change, by creating a culture that values competence, knowhow from outside and provides incentives for volunteers (Gassmann *et al*. 2010). Borrowing ideas from Kaizen, TRIZ and open source is a way of valuing global knowledge.

There is no reason ideas pioneered in open source cannot spread to other areas of economic and social activity (Krogh and Hippel 2006). The analogy between open source and Harambee will be used to adapt open source ideas for Per-Poor innovation. OSIM is the best chance for developing countries (DC) to join the IT revolution and missing this opportunity has worse consequences than when DC missed the industrial revolution (Oreku and Mtenzi 2013). The model allows production of high quality, low cost software, through building and leveraging a developer’s capabilities and volunteering culture. These enable penetration of competitive markets.

Transforming and transformed knowledge

Design allows creation of artifacts even with insufficient or no knowledge (Vaishnavi and Kuechler 2005) by transforming science into technology through crossing partially understood regions between theory and practice; science and technology (Vincent *et al.* 2005). Crossing GK and IK is least understood and is complicated by Per-Poor innovators having a lot of IK and little GK.

There are several ways of combining transforming and transformable knowledge as shown in Table 1. For example, a potter creating a pot uses pottery creation methods as transforming knowledge and pottery material properties as transformable knowledge. System of innovation proverbs (SIP) Table 1 quadrant 3 combines GK and IK transforming knowledge to process IK transformable knowledge. Per-Poor innovators have strength in quadrant 1 which they can use to overcome weakness in areas 3, 7 and 9 by learning through inventing. They can work with GK experts to develop innovations in areas 2, 4, 6 and 8. In the long run Per-Poor will be able to create simple innovations in quadrants 6, 8. They should learn from simple GK innovations they use daily. Quadrant 5 should be left to professionals.

Table 1: Transforming and transformed knowledge and experience matrix

		Transforming knowledge and perspectives		
		IK	GK	IK and GK
Transformed knowledge and perspectives	IK	1	2	3
	GK	4	5	6
	IK and GK	7	8	9

Open source innovation is driven by intrinsic motivation, reciprocity and reputation and catalysed by small efforts, small costs, and high knowledge contribution (Belenzon and Schankerman 2008). Open source and Harambee have shared values: respect for community, habit of voluntary work and reciprocating (Ng'ethe 1983). When people participate in many Harambee projects there are reciprocal benefits from projects of others. Harambee is based on low cost efforts, using available knowledge and resources of volunteers. OSIM uses a self-help strategy by computing professionals and users forming volunteer communities that create artifacts to satisfy their needs and those of others. There are many similarities between open source software development and Harambee.

Method

This study used two research methods: Conjecture design science research method (CDSRM) based on Analogy (Gero 2000) and design reasoning based on intelligence (Takeda *et al*. 1990). Design reasoning was used for the literature review and proverb collection; and CDSRM for developing SIP. Analogy aided in determining similarities between open source development, software patterns and Kaizen innovative systems with Harambee proverbs. Analogies are fundamental to human thought and play a heuristic role in discovery (Bartha 2019).

Design science research is used in computing, engineering, management, education and social sciences. Fused Design science and social science research method uses Design science to create artifacts and social science to develop artifacts behavioral theory (Gregor and Baskerville 2012). Developing SIP theory will require social science research. This is left as future work.

Design science research problems are ill structured social messes with solutions that are neither true nor false but are bad or good (Rittel and Webber 1973:162). Integrating GK and IK is a social mess with no guaranteed solution. Strong and weak Knowledge flows between social sciences catalyse technology innovation (Gregor and Baskerville 2012: 10). A bad solution that can be economically improved to a better solution may be adopted.

Proverb collection

Collecting proverbs started informally during researcher's undergraduate studies triggered by being puzzled as to whether SSA could have developed chemistry discipline from indigenous knowledge if they had not been interrupted by colonisation. Whether SSA could have developed chemistry and if it was feasible were informal research questions. Explained from personal construct theory (PCT), solving new problems in domains outside one's expertise is doing personal informal science by developing an hypothesis, testing them to become personal theories (Kelly 1955). These theories are important as they show how professionals and lay people build theories outside their expertise domains. The researcher's background as chemist,

system analyst and artificial intelligence systems developer influenced the exploration. The goal was to come up with personal conclusions acceptable to the researcher, not the scientific community.

Being puzzled how chemistry could have developed based on indigenous knowledge made researcher curious to find what Harambee building blocks were. Harambee projects dominated media and public debate in the early days of independence. Proverbs were used in these forums to show why projects could succeed even when faced with major challenges. Proverbs were used to chart a route from current project state through or around barriers to success. This showed how projects could be completed. Proverbs were a better approach than plain language for understanding and explaining how projects could be carried out. Workers working on Harambee projects also used proverbs. From these the researcher learned how proverbs were applied in social technical systems. Another observation was proverbs and famous technological sayings performed similar functions. The final observation was proverbs and sayings were used together in everyday technical arguments. The corollary of these observations was proverbs and sayings could be combined to create artifacts.

The proverb collection process progressively became more scientific over the years. When this study started the process became formal and scientific and was based on design reasoning: problem awareness, solution suggestion and development (Takeda *et al*. 1990). Problem Awareness enabled breaking problems into sub-problems. Solution suggestion phase searched for proverbs by observing their application in projects. Since Harambee is a way of building technologies the corollary is proverbs are applicable to technology development and innovation.

Per-Poor system of innovation proverb

Artificial intelligence problem solving search and software patterns solutions are guided by graphs. System of innovation proverbs (SIP) adapted this graph, with paths determined by the way the problem is decomposed into sub-problems, order they are solved [?] and techniques used. The graph was the answer to research question 3 as the global system structure suitable for synthesising appropriate elements into PPI approach. SIP graph start node is the “Let’s pull together” strategy. That combines people’s efforts, knowledge and finances to implement community projects

The proverb “Nothing cannot be improved” is complementary to the Kaizen rule “Avoid perfection; do it right away even if it’s only 50%” (Wittenberg 1994). For novel problems it’s often better to act and learn from results than wait until you have complete knowledge as not all knowledge exists. Linus who developed the Linux operating system started with an imperfect Linux version that was improved to become a world-class operating system.

The study found that both Harambee and Kaizen are incremental and iterative. When building a Harambee school, the first class was built to completion, students admitted, teachers posted and learning started. The usable partial project benefited the community, motivating it to continue. Harambee incremental model shares OSIM direction of starting a project based on plausible promise and creating a useful, but not perfect partial product, may be even crude (a kind of Edison’s junk) and reusing relevant parts of existing systems (TRIZ cheap copies principle) (Raymond 1998, Sanders 1998).

Figure 1 is a SIP graph consisting of innovation principles, rules, proverbs and sayings, nodes and transitions, edges. The graph guides solution development. Each node is a solution to a sub-problem. Per-Poor innovators select the next node based on next sub-problem to be solved.

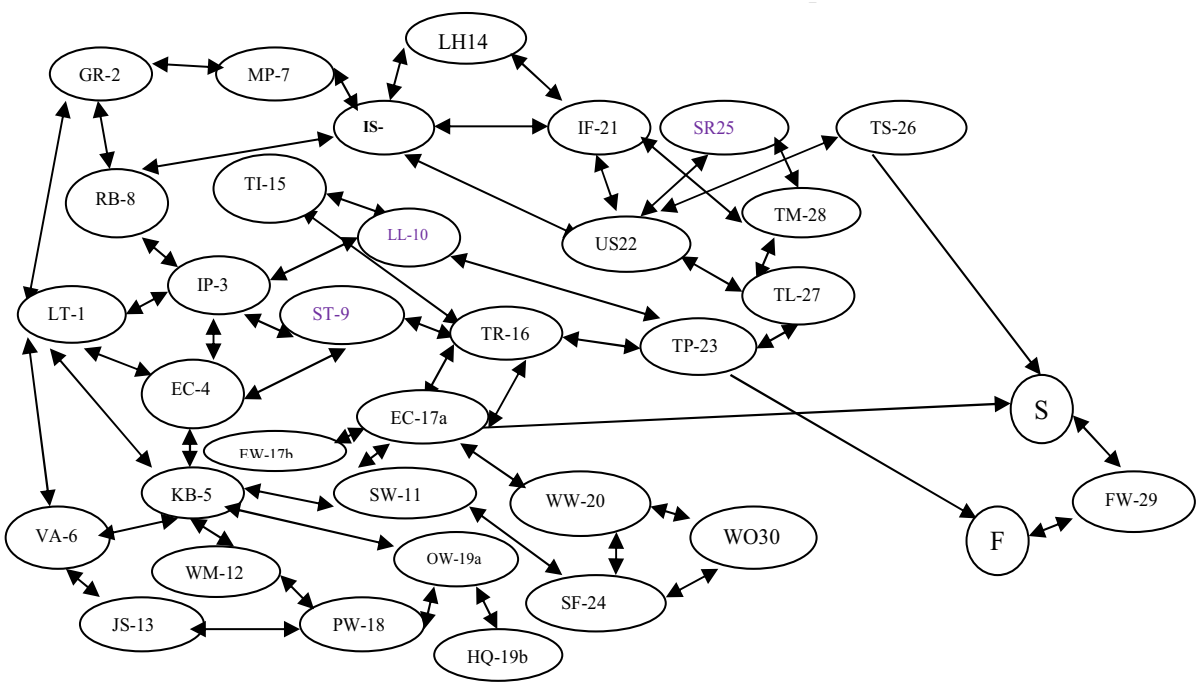

Figure 1. Per-Poor System of proverb innovation patterns

The following are SIP node elements: Let's pull together (proverb) (LT-1). A group lifts a heavy load (proverb) (GR-2). If you want to eat an elephant, you divide it into pieces (proverb) (IP-3). There is nothing that can't be improved (proverb) (EC-4). Knowledge is like a baobab tree (proverb) (KB-5). Vision without action is day dreaming, action without vision is a nightmare (proverb) (VA-6). Merge principle (innovate by combining parts) (TRIZ principle) (MP-7). Rome was not built in a single day (proverb) (RB-8). Segment (innovate by dividing into parts) (TRIZ principle) (ST-9). A little a little becomes much (proverb) (LL-10). A string waits for a rope (proverb) (SW-11). Prioritise wisdom use over money use (Kaizen rule) (WM-12). A journey of thousand steps starts first step and is completed by remaining steps (proverb) (JS-13). If I have seen far it's by standing on shoulders of great men (Newton saying) (IS-14a). Searching for a needle in haystack (LH-14b). To innovate you need a junk and imagination (Edison saying) (TI-15). Turn the other way round (TRIZ principle) (TR-16). Efforts are more important than Capability (proverb) (EC-17a). Add effort to wisdom (proverb) (EW 17b) People are wealth (proverb) (PW-18). One who doesn't know this knows that (proverb) (OW-19a). A proverb is a horse that carries you to quickly discover ideas (HQ-19b). The road to what works is through what doesn't work (proverb) (WW-20). I never failed once I found 500 ways that don't work so that I could finally find the way that works (Edison saying) (IF-21). Use cheap copies (TRIZ principle) (US22). That which defeats people is much turned over (proverb) (TP-23). The snake that doesn't fly has caught the bird that flies (proverb) (SF-24). A string is transformed into a rope (proverb) (SR25). Trying is succeeding (proverb) (TS-26). Turn lemon into lemonade (TRIZ principle) (TL-27). The journey is more important than the destination (TM-28) (proverb). If you fall don't wake up empty handed, and then try again (Proverb) (FW-29). Use wisdom of ten instead of one (Kaizen rule) (WO30).

SIP extends GK graph by substituting unidirectional with bi directional links to allow cyclical problem solving analogous to design science. The second extension linked indirectly linked nodes with weak links allowing innovator to jump from any node to an indirectly linked node in usual circumstances. An example is a situation where solution is found before last node is

reached. The third extension is thesis, antithesis and synthesis dialectic pattern was made part of every node. The fourth extension is Hargadon rule “Analogy is better than invention” is made part of every node making SIP analogy oriented.

Alternatives for Per-Poor innovation

Design requires exploration of several alternatives before selecting the alternative to implement. This study explored following alternatives:

1. Borrowing global methods followed by up scaling Per-Poor GK,
2. Downscaling global methods.
3. Creating simple global methods similar to TRIZ inventive principles that can be used by Per-Poor innovators. This would still require up scaling Per-Poor GK but on smaller scale than borrowing global methodologies.
4. Creating a PPI approach bottom up. This alternative was selected and used to create SIP
5. Downscaling global methods was also found appropriate. SIP had an extra advantage over downscaling global methods by being improvable by Per-Poor innovators. Specifically down scaling Exploratory programming a global software development method based on experimenting to discover how to innovate, was second most promising alternative.

System of innovation proverbs evaluation

One way of evaluating design science research artifacts is by showing they could have been used to create an existing innovation. An example is Soft design science research (SDSR) method evaluated by showing it could have been used to create a bank’s diffusion and adoption technology innovation (Baskerville *et al.* 2009 pg. 4). SIP was evaluated by showing it could have been used to create a Per-Poor beeping innovation (BI). Limitation of SIP evaluation compared to SDSR is lack of BI documentation. Undocumented Innovations can be evaluated using design thought experiments (DTEs) to mentally simulate possible ways they were created. DTEs are suitable for environments with many alternatives to be explored, many considerations to weigh at once and difficult to predict barriers to turning unknowns to known (Bass *et al*. 2013 pg. 286). SIP Figure 1 is used as an innovation map starting from start node LT-1 to success (node S) representing possible BI path.

Creating BI using SIP could have been initiated by an individual or a group. Group initiation starts with “Let’s pull together” (node LT-1) by a group working together to find ways of communicating at no cost. Group could have considered three variables cost (lowest), knowledge (highest), time (lowest) and a constraint that solution be acceptable by mobile service providers. The proverbs “If you want to eat an elephant you divide it into pieces” (node IP-3), “Adding effort to wisdom” (EW 17b) and Kaizen rule “Using wisdom instead of money” (node WM-12) could have been used to direct group efforts in exploring alternatives where money was minimal or decreasing. Past experiences of mobile calls terminating due to exhausting credit could have been used. Analysis of crude solution could have led to learning. This is an application of proverbs “A string waits for a rope” (node SW-11) and “A string is transformed into a rope” (node SR25). Learning from doing could have helped transform a crude solution in small continuous incremental steps into BI. It’s not often possible to invent at the first attempt, so there were many failures.

Lessons learned creating BI could been captured by proverbs “Trying is succeeding”, combining “Group lifts a heavy load” and “A little a little becomes much” makes a difficult task easy, “That which defeats people is much turned over” , learning from attempts that don’t work and continuing until discovery of what works (interpretation of Edison saying node IF-21), “If you fail don’t wake up empty handed, and try again”. Realisation that indigenous knowledge passed from past generations was applicable to state of art innovation increases innovators’ confidence.

It's likely no-one or a specific group knows they invented or contributed to beeping invention and commercialisation due to a tacit innovation process used. Had BI process been codified and documented, its innovators would be known, given credit and benefited from their innovation. Others would have been inspired and learned from BI role models to become innovators. An observation from DTE is proverbs combined into a system have knowledge management (KM) and other GK fragments.

An individual creating BI could have followed open source and Harambee pattern of creating a crude but usable solution to seed project formation and attract others to further develop solution by applying Kaizen rule "Do it right away even if it's only 50%" and proverb antithesis "Begin pulling alone" followed by "Lets pull together". The proverb "You are because I am" word view could have been the project guide. Different group members could have applied invention proverb "Looking for a needle in a haystack" (node LH-14) in parallel to speed up innovation. Analysis of reasoning of this experimentation process shows different proverbs, saying and rules reinforce each other during solution development.

BI is a simple innovation that everyone can understand. It can be used as a teaching example for school children, Per-Poor innovators, and professional innovation trainees. BI shows that simple product innovation is for everyone, not just geniuses.

Fitting per-poor innovation within the context of African philosophy

To answer the research question how African philosophy can support developing Per-poor innovation cycling was done between African philosophy of proverbs (Wanjohi 1997) and design science research (DSR). Gaps identified from cycling were filled by cycling between DSR, Ubuntu, Vital force (Tempels 1969) and Sage (Oruka 1997) African philosophies. Cycling between knowledge base and DSR is a way of discovering novel ways of building things and creating knowledge (Hevner *et al.* 2004). Thesis, antithesis and synthesis dialectic is a proverb problem-solving and reasoning strategy (Wanjohi 1997) and research, development and innovation heuristic (Johnson 2005). The dialectic is the basis of social paradigm change (Olsen *et al*. 1992). Applying paradigm change dialectic to philosophy: global philosophy is a thesis; Tempels's vital force philosophy is its first African antithesis. Other African philosophies put forward are the antithesis of global philosophy and some or all existing African philosophies. Most basic African philosophies (BAPs) have been classified by their creators as real African philosophy and some or all other African philosophies as ethno-philosophies. This is continued propagation of antithesis between African philosophies and with global philosophy. BAPs have now matured for synthesis to better support indigenous knowledge, technology development, research and innovation.

Thesis, antithesis and synthesis is a computing technology innovation, research and development method (Johnson 2005). It models past, present and future computing technology trajectories. The dialectic pattern occurs at paradigm, method (system of systems), system and component (e.g. proverb) levels. Dewey's pragmatism views the world as in flux, emergent, never fully realised, therefore theories and paradigms have temporary stability after which they change (Dalsgaard 2014:146). The rate of change is higher at lower levels, with component changing fastest. Three steps of paradigm change dialectic have fundamental contradictions that triggers new cycles (Olsen *et al*. 1992). Contradictions orchestrate Dewey world flux. Global and African philosophies have contradictions that trigger new cycles of flux.

Individual BAPs are unlikely to become mainstream due to failure to have critical mass of researchers and funding to tip over. BAPs research funding is lower than philosophy funding in other regions. Each BAP is based on a unique perspective, is well developed in some areas and not others, and has different strengths, weakness, opportunities and threats. An African philosophy paradigm progression from antithesis to synthesis stage is proposed due to the maturing of antithesis research, lack of critical mass of researchers, low funding that prevents

any BAP becoming widely researched and used. Synthesised BAP will benefit from development of individual BAPs. In the absence of African philosophy of technology a decision was made to nest global transdisciplinary and philosophy of technology within BAPs synthesis using design science research.

Dewey's definition of technology as a means or using instruments to reach ends and intended outcomes by constituting and altering experience (Dalsgaard 2014 pg. 148) was adopted as design definition of technology. Polya defined proverbs as discovery and invention heuristics that are a means to reach ends. This reveals science, technology; discovery, invention and innovation proverbs categories exist but have been excluded in current published proverb categories. The lack of these proverb categories in literature is due to: fewer proverbs in these categories, used categories are from oral literature and most of these works are not from creativity, discovery, innovation and invention perspectives. Design is the kernel of philosophy of technology (Franssen *et al.* 2018). Design provides an outlook and means to reach ends which can be guided by design science. Since proverbs are design heuristics, they are a means to reach ends.

African philosophy of science (APS) is at a nascent stage compared to BAPs. APS is based on three-value logic: true, false and both true and false (Chimakonam 2012). Three-value logic is also the kernel of transdisciplinary philosophy (Nicolescu 2010) and transdisciplinary engineering (Tate 2010). APS excludes multiple realities. Afrikology is not disciplinary but operates on, crosses, moves beyond disciplinary boundaries based on three-value logic (Nabudere 2011). Aligning APS, BAPs and Afrikology by three-value logic would make them complementary. Three-value logic has some similarities to Artificial Intelligence and mathematics widely used fuzzy logic. Saying somebody is tall is true if referring to the world's tallest person, false for the shortest person, and has a degree of truth for all others, according to fuzzy logic.

BAPs synthesises for technology innovation leverages their strengths and opportunities while minimising their weakness and threats by creating synergies between them. Figure 2 shows knowledge flows between and across African philosophies and beyond to nested philosophy of technology and transdisciplinary philosophy. Flowing knowledge is transformed closer and closer to a form applicable to technology innovation.

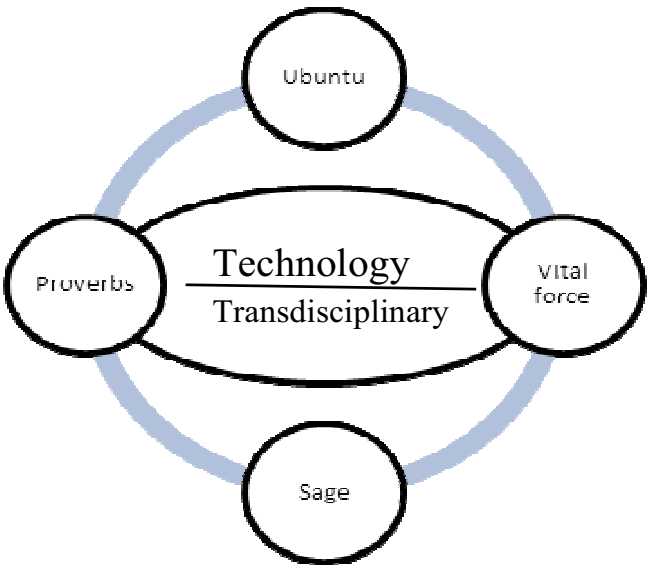

Figure 2. Transdisciplinary, Technology and basic African philosophies Radial cycle

Ubuntu management involves creating wisdom circles where voices of all participants are integrated and consensus built (Karsten and Illa 2005) pg. 613). Wisdom circles can manage wisdom using KM approaches as wisdom is meta knowledge. Wisdom is a type of knowledge of deepest causes of everything that removes ignorance barriers to happiness (Makumba 2007 pg. 32). Application of wisdom leads to achievement and benefiting from knowledge. Philosophy of proverbs and Ubuntu are based on wisdom perspective that benefits users. This prevents users becoming victims of knowledge banking.

Conclusion, key findings and recommendations

Similarity between Harambee with Kaizen, open source software and software patterns together with using proverbs and TRIZ invention principles as discovery heuristics enabled discovery of enough elements to create SIP connected by a graph structure. Proverb heuristics aided in discovery of innovation aspects in global systems while TRIZ aided in discovery in both Harambee and global systems. Both proverbs and TRIZ principles aided invention of SIP by being applied as CDRM design micro heuristics.

Many similarities were found between Harambee and open source development. Absence of software or hardware developed through Harambee was surprising. The study recommends exploratory pilot project to develop software based on Harambee model.

This study is analogy oriented and it was realised towards the end that it is a specifically analogy-inspired design. Design thought experiment (DTE) revealed two SIP alternative paths that could have been followed to create Beeping innovation. DTE further revealed GK fragments that can be used to integrate GK theories into Per-Poor innovation domain. DTE could become a major research technique for discovering how undocumented indigenous SSA innovations were created, opening a new frontier.

Importance of KM and learning through doing was recognised as important factor in innovation but no learning or KM concepts were included in SIP. These shortcomings and gaps can be addressed by future work. Research is needed to create an indigenous design science research method based on transdisciplinarity and dialectics, for small scale Per-Poor research and development. SIP social science research can provide basis for improving SIP. Down scaling global methods like Exploratory programming can provide different Problem solving approaches.

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