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Biological Proverbs as Tools for Bioinspired Design and Artificial Intelligence: A Transdisciplinary Framework

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Abstract
This article examines how animal and plant proverbs can be used as tools for artificial intelligence (AI) and bioinspired design (BSD) to address problems facing society like climate change and poverty. BSD and AI strengths and opportunities can be leverage to radically transform societies and industries. Proverbs knowledge and expertise are rarely used in modern advanced technologies, though as sublanguage, they are applicable in some degree to all areas where language is applied. AI and BSD innovation revolutions are changing the world and those who don't embrace their research, development, innovation and adoption will be left behind and possibly never catch-up. Tools like proverbs are required for everyone to participate and collaborate in catching up. The study used transdisciplinary literature review, analogy design science research and purposive sampling methods. There is need to experiment with proverb creativity and to explore ways of creating systems of proverbs.

Keywords: Analogy, Artificial Intelligence, Bioinspired Design, Biological Proverbs, Inventiveness, Metaphors.

Introduction
People use biological knowledge and experience to create proverbs which are solutions to commonly recurring problems they face. Bioinspired design (BSD) uses analogical similarity between human problems and biology solved problems to

generate solutions to human problems. Since time immemorial people used trial and error and informal BSD to create biological proverbs. Designers and technologists have now transformed informal BSD into an emerging field (Aziz and Sherif 2016). It's often easier to solve a problem by reusing solutions of similar solved problems than from first principles. Proverbs are ready made available solutions that can help solve some technology problems like directing BSD and AI to grow in directions that benefit society.

A large amount of knowledge and many solutions are available that don't reach many people who need them especially those at the bottom of pyramid. If such knowledge and solutions could be cast into proverb, they would become tools to understand and diffuse knowledge faster to more people. Proverbs can be to advance 21st competencies like creative thinking and be catalysts for catching up and sustaining fourth industrial revolution (Quarshie and Poku, 2025) by creating a critical mass people with skills who share knowledge. A proverb toolkit is a set of systematized proverbs that can be leveraged to solve AI and BSD problems like AI, BSD and 4IR catch up, climate change and poverty problems. There is a significant amount of indigenous research but no effective methods to put it to practice.

Tools are basis of human progress. It is inconceivable how a person can become a successful farmer or carpenter without using physical tools. Proverbs are wisdom and knowledge tools more powerful than physical tools and complementary to them. Fostering innovation, collaboration can accelerate Industry 4, BSD and AI to build equitable and sustainable society (Ajaj et al. 2024). Proverbs are tools that can include everyone as a knowledge actor and align society efforts for action. Just like cases of carpenter and farmer people at with low global knowledge but high indigenous cannot expect to navigate AI, BSD and industry 4 innovation revolutions without knowledge based tools like proverbs.

A proverb framework synthesizes biological concepts enabling connection of cases, models and theories up to level of paradigm (Partelow, 2023). A toolkit is system of knowledge, expertise, best practices and skill resources to construct strategies and tactics to aid researchers, practitioners and others reach their goals by providing a means of action (Conole and Oliver, 2002). A framework provides theoretical foundations to build toolkits.

This study focused on global biological proverbs rather than regional proverbs. The first reason is that biological (excluding humans) proverbs are less than 5% of total proverbs as illustrated in most published books. Proverb books often have larger number proverbs than research articles. Focusing on animal proverbs from a region or country would have resulted in few articles. The second is many computing systems developed are used across more than one culture. This implies proverbs in computing should focus both on those used across cultures and within a culture. A structuration theory study developing insurance software for a Jamaican insurance company found Jamaican and Indian developer team member differences that impeded project were: degree of systemness in cultural attitudes, high productivity versus working closely with users respectively (Walsham, 2008). Comparing western and eastern information systems (IS) perspectives helps determine how different users respond to system warnings and dialogs (Warkentin et al. 2015). Including African perspectives through proverb toolkits increase IS perspectives diversity.

The study's research objectives are:

1. Identify animal and plant proverbs and their functions in literature.
2. Identify missing scientific and technical elements and connectors in reviewed literature and find proverbs author knows to fill the elements.
3. Explore how biological proverbs can be systematized and improved to create a toolkit for valorizing BSD and AI.
4. Adapt a design science research method for proverb research, development and innovation.

LITERATURE REVIEW

This section presents methodology and literature review animal and plant proverbs.

METHODOLOGY

The study used three research methods: transdisciplinary literature review (Montuori, 2013), conjecture analogy design science research (CADR) (Gero, 2000) and purposive sampling. Transdisciplinary method was selected because reviewed literature crosses disciplinary boundaries, goes beyond disciplines, moves between disciplines and requires co-creation with society (Nicolescu, 2010). The author added proverbs, elements and connectors to reviewed literature as member of society based on convenience. A society member is its smallest atomic unit. Purposive sampling method was used to select some biological proverbs and elements the author knew that made study's theoretical framework more coherent. Purposive sampling is a non-random method that allows researcher to select, based on convenience, only things that meet certain criteria. CADR method was used to create, discover elements and links to connect and extend literature. Figure 1 shows how the three research methods interacted. Figure 2 illustrates CADR method steps: making conjecture, prototyping to validate conjecture and synthesizing validated conjectures with literature.

Search was done by Google scholar using concatenation of search keywords: animals, plants, categories of plants and animals like livestock and vines. Papers with plant and animal proverbs or biological terms like ecology in title and abstract were selected. The author read papers and those with significant plant and animal proverb content or significant proverb application to a biological area were included and those that didn't were excluded. One or a few proverbs from articles were included based on their ability to illustrate significant biological characteristics. The number of animal and plant proverbs is large and beyond the scope of single paper so the study limited articles to those with significant proverb focus. The Search found 191 articles and 61 were included.

The study focused mainly on animals and plants but included a few human proverbs as humans are biological organisms but not commonly considered social animals. The study uses older biological taxonomy that divides all living things into plants and animals to make it easy to understand. The latest biological classification would have introduced many categories making literature difficult to understand without adding significant benefits.

Transdisciplinary literature review method models a topic as subsystem that is part of a larger system to form ecology of related ideas (Montuori, 2013). Transdisciplinary enables moving beyond and extending topic, domain and disciplinary boundaries (Nicolescu, 2010). To meet second, third and fourth objectives required extending boundary of literature review results of objective one in directions of other three objectives. The first research objective is literature review of biological proverbs that forms the core subsystem. Moving beyond core topic to related areas by transdisciplinary literature review enabled meeting the other three research objectives. Proverbs are transdisciplinary (Mambo, 2021) making transdisciplinary research and practice approaches appropriate.

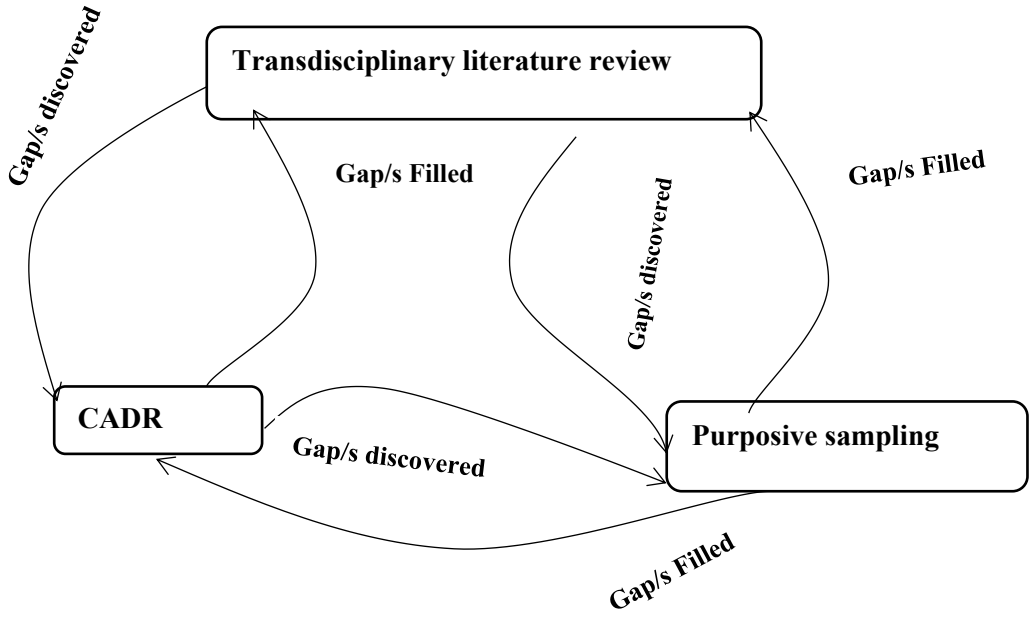


Figure 2: Interaction between three research methods

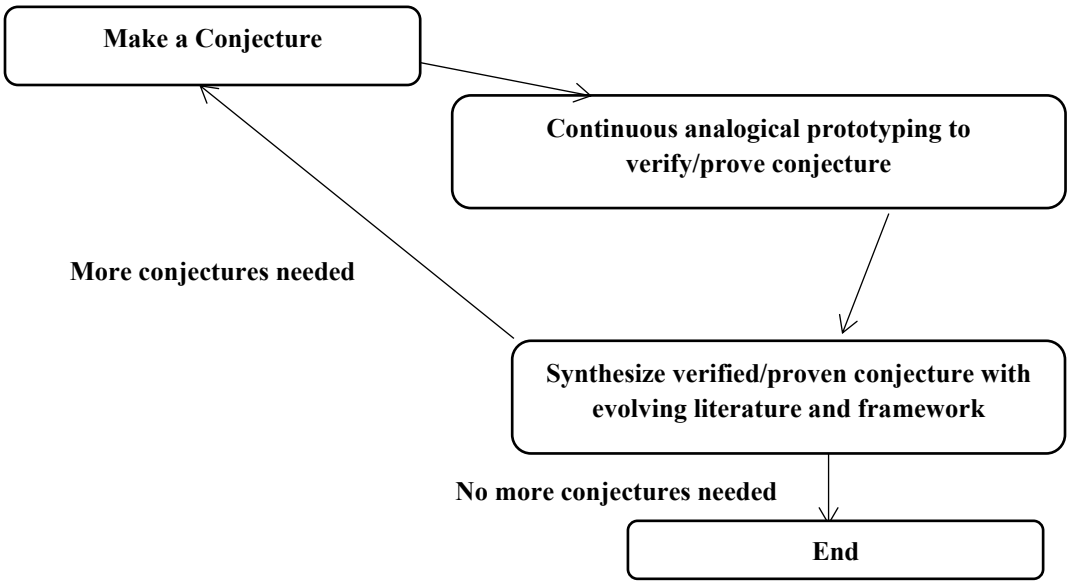


Figure 2: CADR method process

BIOLOGICAL PROVERBS

Chicken proverb metaphors mirror human traits and relationships (Kobia, 2016). The Northern Ethiopian hornbill bird is widely used to construct bioinspired proverbs (Asefa, 2021). One informal bioinspired design characteristic is using organisms in region to create local proverbs. It's plausible because proverbs are designed to be widely used by all people, which would be hindered by using unfamiliar animals and plants. Proverb creation process uses some knowledge and experience from old proverbs. For example, by using old proverb templates and by inventing novel templates (Kipury, 1983). Invention breaks rules introducing novelty.

Animal differences in shapes and characteristics are used to model human problems and solutions in biological proverbs (Phuong and Van Dung, 2016). Several studies on animal and plant proverbs in areas like agriculture and environmental studies have been done. BSD learns from biology to design solutions for other disciplines. Plant and animal proverbs are based on conceptual metaphors: human are plants and humans are animals (Fu, 2008). The metaphors enable transfer of biological knowledge to solve human problems. Metaphors compare human problems with those solved by animals and plants in local area. Proverb creativity and leveraging one's imagination can lead to transformative learning, innovation (Tedam, 2013) and capability building which can help influence paths along which technologies develop. Inventiveness bridges the gap between imagination, creativity and innovation.

Bioinspired design is a subset of design by analogy and both subset and set fields have been basis of innovations throughout history aided by diversity thinking (Katherine et al. 2014). Diversity thinking is used by proverb toolkits, creativity techniques like brainstorming; innovation and design methods like design science. Biological success is diversity driven benefiting organisms by increasing their variants. Table 1 presents biological proverbs literature, the results objective one. It is organized according to proverb concepts. Proverbs in table without source quoted are from author knowledge.

Table 1: Biological animal and plant proverbs organized according to concept.

Proverb concept	Findings and proverb examples	Observation, basis and possibilities
Teaching, learning and competence	Proverb: nature is the best teacher (Zuhud et al. 2017). Proverb: the young cock crows like the older one, the proverb emphasis importance of observation and learning from experts (Kemi and Chijioke, 2021). Leopard learned to scratch by observing people (African proverb). Humans have learned to use animals to learn about their social interaction (Lauhakangas, 2019).	Best teacher proverb is based on template X is the best Y that has been used to create other proverbs. The commonly used mother nature metaphor together with best teacher proverb can help increase treating nature with more respect. Nature is best teacher proverb can be concept substituted to create nature is best designer.
Collaboration, correlation and cause and effect	The child of a snake is snake - Kenyan proverb. A crab doesn't give to birth to a bird - Ghanaian proverb (Kambon and Dzahene-Quarshie, 2017). The foot doesn't go on journey and leave thigh at home - African proverb - (Vigbedor et al. 2016). If leg doesn't move the mouth won't eat (African proverb). Proverbs no trees grow in the sky and what goes up comes down are based on pattern that a singular extreme event meets natural tendencies in opposite direction (Shapin, 2001). Human and chicken traits correlate in Igbo proverbs (Amaka, 2023).	Thigh and mouth proverbs relate to animal body as a system and could be introduced introduce system theory and goals to learners. Scientific and technological laws, meta-principles and meta-practices are proverbial for example Newton law for every action there is an equal and opposite reaction (Shapin, 2001). Child and snake proverbs are based cause and effect that can be enriched with cause and effect proverbial theories, principles and practices.
Genius and failing	The squirrel jumps intelligently, but it must have fallen once, the Balinese proverb is about squirrel as a tree to tree jumping expert (Budiarta and Kasni, 2017).	It's by jumping and falling squirrel that it learned and built capabilities to become an expert.
Pedagogy, ecosystem and sustainability	Folk pedagogy uses proverbs to refine and expand knowledge and can be used to develop technology, institutional and policy solutions for ecosystem sustainability (Syzdykov and Iskakuly, 2017). Some proverbs contain ecological philosophies and can be used to educate people on ecosystems and environment (Bhattacherjee and Sinha, 2023).	Ecosystems health is responsibility of all.
Animal, plant and human relationships	Animal to animal, animal to plant, plant to animal, plant to plant, human to plant, plant to wind and human to animal relationships were found in Ghanaian proverbs (Awuah-Nyamekye, 2014).	These relationships combine different things in different levels of great chain metaphor.
Business	The cow is a bank - African proverb. One who loves goats is a farmer -African proverb.	The cow proverb shows how business organization can be used to transfer knowledge to turn farming activities into a business.

	Want a banana, you plant, want a child get married Vietnamese proverb (Chien et al. 2017).	The other two proverbs illustrate importance of taking action and loving what one wants to achieve.
Conceptual metaphor mapping	Animal traits similar human problem metaphors are used to map the animal traits into human knowledge and experience (Yakub, 2019). Proverbs functions are tolerance, patience, cooperation, obedience, kindness, faithfulness and hard work (Yakub, 2019).	Biological proverbs and AI borrow biological intelligence to solve human problems.
Technology adoption and invention proverbs	The hyena asked does it have meat. (African proverb). This is what the hyena asked when it first saw a car. It's not only the fox, even the tortoise arrives (Nigerian proverb) means differences between people brings richness to collaboration, co-creation and co-invention (Tedam, 2013).	Hyena proverb teaches invention needs to be adopted to become innovation directing innovation designers to answer questions of adopters during design.
Symbol substitution created virus and software testing proverbs	The proverb the one who walks about does not eat what those at home consume was transformed to proverb It is the one who walks about that will contract COVID-19 (Raji-Oyelade, 2022). The proverb: the leg that walks about should know that the eye that looks around is watching: symbol substitution converted proverb to: the leg that walks about should know that COVID-19 is waiting for it (Raji-Oyelade, 2022). The proverb close association brings understanding was symbol substituted to: close association breeds illness (Raji-Oyelade, 2022). Proverb the fish likes swimming was modified to proverb virus like swimming (Szpila, 2023). Software testing proverbs: code is like wine it gets better with age, if you love writing code love fixing it and perfect code is not written with first try were derived from other proverbs like Rome was not built in a single day (Kenzhebulatova et al. 2024). We cannot let the cure be worse than the problem itself – proverbial created to deal with excessive methods used to deal with disease (Haberman and Sanger 2020, Haas, 2022).	Symbol substitution created virus proverbs by substituting proverb concept with COVID concept. Epidemiology has been used to create software adoption models for example programming adoption as epidemiology (Barreiros et al. 2017). Epidemiology could be used transform non biological proverbs into biological proverbs. Raji-Oyelade (2022) and Kenzhebulatova et al. (2024) studies included several other transformed virus and software testing proverbs respectively. Polya (1985) used analogy inspired design to show how disciplinary research, practice and knowledge can be cast into proverbial form.
Proverbs based of a single animal or class of animals	Hornbill proverbs are used to construct socially healthy relationships by playing socioeconomic roles like dispute resolution and peaceful coexistence (Asefa, 2021). The snake that doesn't fly has caught the hornbill that flies (African proverb). Chicken proverbs are a social discourse (Kobia, 2016).	The large number of biological animals creates exhaustible gold mines for creating biological proverbs. Finding proverbs that are based on different concepts like power can be used to organize proverbs as concept subsystems.

	The proverb every cock crows on its own dung-hill represents both a generalized rooster and generalized human being (Shapin, 2001). Igbo chicken proverbs guide people toward positive behaviour like unity, cooperation and hard work by revealing peoples philosophy and world view (Amaka, 2023). Chicken and egg metaphor is pattern for solving interdependent problems that lock each other solutions development forcing their solutions to be developed in parallel. Malawian insect proverbs project parasitic-symbiotic human relationships (Mdoka, 2022). Conceptual metaphor and great chain theories were used to explore how concept of power is applied in Sundanese bird proverbs (Saripudin et al. 2019). Proverb eagle don't catch flies means great people don't concern themselves with trifling matters (Saripudin et al. 2019).	Proverbs application is only correct when applied in right context (Shapin, 2001).
Future sustainable development	Eleven universal and five international sustainability principles were presented two examples are environment is a result of natural systems historical evolution and its activities should be designed by this principle and good neighbour principle requires satisfying mutual interests of nature and human(Scarlat and Petrişor, 2021). Proverb the forest is the Romanian's brother supports some these principles (Scarlat and Petrişor, 2021)	Connecting biological and sustainability principles can catalyse dialogue towards common understanding between practitioners' academia and society.
Medical proverbs	Sometimes words are cure for sick person and proverbs integrate medical knowledge directing people towards taking actions that lead to good health (Ozkul et al. 2023). Proverbs are used in many ways in medicine for example some are medical proverbs while others proverbs are derived from medical content (Fialkova, 2010). Proverb doctor cure yourself first (Fialkova, 2010) Juxtaposing a Ukrainian, German and Polish non-medical proverbs created a medical proverb (Fialkova, 2010). Proverb where there is a will there is a way encouraged people to invent ways of differentiating reliable and fake news about COVID on Internet (Szpila, 2023). Everybody is a blacksmith of their own fate versus every man is an architect of his own fortune	Proverbs can capture medical knowledge and provide ideology to drive health knowledge to flow faster through society. The way medical proverbs are used in medicine can be used to create techniques for applying proverbs for other disciplines. Juxtaposing proverbs from several disciplines can create a proverb in another discipline. The innovation principle: strive to determine your destiny and construct your future (Liker, 2004) actualize blacksmith and destiny proverbs. The two proverbs are innovation principles.

	emphasize need to fight to the end to bring life activities back to normal state by ending COVID (Szpila, 2023).	

Table 2 is organized according to languages, regions and countries. Table 1 and table 2 overlap but splitting was necessary to highlight both regional and concept aspects.

Table 2: Biological animal and plant proverbs organized according to languages, regions and countries.

Proverb region, language or country.	Findings and proverb examples	Observation, basis and possibilities
Asian coastal proverbs	Proverb our struggle is for the future: ours and the fish, indicates connectedness between people, resources pointing to an intertwined future that makes sustainability critical for survival of both (Kurien, 1998). Proverb the wealth of the sea belongs to the dead, the living, and those yet to be born is a sustainability principle requiring each generation to ensure survival of next generation as the dead generation did for them (Kurien, 1998).	Fisheries have integrated sustainability principles in their strategies by learning from past and present (Kurien, 1998).
Bengali proverbs	Proverbs provide a community framework to conceptualize importance of nature, its wellbeing and why all should treat it with respect that should made be part of policy (Bhattacherjee and Sinha, 2023).	Proverb conceptual framework can be used as foundation to create theories and methods.
Bukusu and Gusii proverbs	Animal proverbs reinforce an ideology and a belief system (Barasa and Opande, 2017). Animal kingdom is a potential rich source of proverbs because of many similarities between people and animals (Barasa and Opande, 2017).	Nature is your gold mine but you need skills to mine the gold.
Cameroonian proverbs	Eco-friendly proverbs remind Cameroonians of their roles in dealing with environmental challenges (Angwah, 2020). Proverbs a blind person knows his environment more than a visitor with eyes and he who sits in the shade won't take an axe to cut the tree (Angwah, 2020).	Creating a system of eco-friendly proverbs can help diffuse environmental knowledge and act as an ideology to promote it.
Chinese and Japanese proverbs	Thinking mode differences between Chinese land based and Japanese ocean based cultures was discerned in cattle metaphors (Pan and He, 2023). Cultural differences between Japanese and Americans were explained by rice and wheat farming respectively which is reflected in their different innovation approaches (Herbig and Jacobs, 1996).	Cultural differences have impact on most aspects of life.

English, Kenyan, Nzema and Japanese plant proverbs	A tree supports a creeping plant before it can grow upright (Yakub and Owu-Ewie, 2020). Kenyan proverb a gourd with a flat bottom stands on its own. The proverb advices using self-help strategies. Japanese use plant parts to describe human traits mirrored in nature in proverbs (Fitri and Rini, 2022). Turn lemon into lemonade (English proverb). It advices taking something that not good and turning it into something better.	Plants and their parts as mirror metaphor is biological knowledge transformation mechanism. Turn lemon into lemonade is a TRIZ invention principle (Mann and Domb, 1999). Divide and conquer with balancing design science pattern (Vaishnavi and Kuechler, 2015) is an innovation pattern that ex-tends a proverb.
English and Romanian animal proverbs	There several animal English and Romanian proverbs equivalents (Tronea-Ghidel, 2023). English proverb it's better a bird in hand than two in the bush has Romanian equivalent (Tronea-Ghidel, 2023).	The similarity of proverbs from different countries is due to diffusion or invention in those countries.
English proverbs	Animal elements in English proverbs have functions: praise, advice, motivate, give warning and moral formation (Riyanto, 2018). Most animal proverbs in their study emphasized above all animals struggle for survival (Landmann and Ganz, 2024). The world is your cow but you have to do the milking (Riyanto, 2018).	Survival represents massive human efforts to win and prosper. The cow proverb implies there is no free lunch from nature. The world concept in proverb stands for living organisms or planet/universe.
English and Myanmar animal proverbs	There several Myanmar and English animal proverb equivalents like you are don't put the cart before the horse (English) and Don't put harrow before the cow (Myanmar). (Ni, 2019).	Cow and horse proverbs are animal machine proverbs.
English and Vietnamese animal proverbs	There several Vietnamese and English animal proverb equivalents both positive and negative like dog proverbs are: every dog has his day and dog bites, shirt torn meaning: hardships never come alone (Phuong and Van Dung, 2016).	Same organism may be perceived differently by two cultures making proverbs using organism difficult to diffuse between them.
English and Uzbek proverbs	Proverbs show how people process experience and conceptualize the world (Normuradova, 2024).	Experience may start as tacit knowledge then is codified to explicit knowledge.
English and Persian proverbs	Animals are used as symbols, for example fox is a symbol for strategy, wisdom and quick thinking, fox symbolizing strategy is found in several cultures (Anjomshoa and Sadighi, 2015).	The symbolism associated with an animal can be used to build on a particular area of knowledge like strategy or wisdom.
English, French and Greek animal proverbs	There several English, French and Greek animal proverb equivalents like let sleeping dogs sleep (English) and wakeup not sleeping dogs (French). (Landman and Ganz, 2023). Animal struggle for survival and related predation, and hunger is common theme in these proverbs (Landmann and Ganz, 2023).	Hunger and predation represent huge obstacles that people have to overcome in life. Event structure metaphor represents obstacles as large moving objects that exert resistance to achievement of goals (lakoff, 1993, Kendall, 2008).

		Hunger and predation can be visualized as large moving objects that resist achievement.
English and Chinese proverbs	Some Chinese and English proverbs are based on same conceptual metaphor and others on other types of metaphors (Fu, 2008). Researching Chinese and English animal proverbs deepened understanding of two cultures (Liu, 2013). Proverb danger is a tiger (Liu, 2013).	An innovation's compatibility with people's values, beliefs and experience increases its adoptability (Rogers, 1995). Borrowed proverbs are innovations because they are novel and useful to borrower.
Ghanaian sustainability proverbs	Ghanaian proverbs support design thinking and innovation for social environmental sustainability (Quarshie and Poku, 2025). Proverb a single tree doesn't make a forest can support industry 4.0 collaboration for sustainability (Quarshie and Poku, 2025). Proverb when you cut a tree it goes up directs need to rethink design thinking to align it with sustainability (Quarshie and Poku, 2025).	Proverbs can be made foundation of indigenous design thinking, innovation and industry 4.0 for sustainability. Design thinking has been used for over 50,000 years (Shneiderman, 2017) leaving mental models across human cultures.
Hassani proverbs	Popularity and frequency proverb use is due to metaphoric value and symbolizing cultural concepts or personal characteristics (Baba, 2014).	Using metaphoric reasoning and symbolization are key proverb creativity strategies.
Indonesian proverbs	Proverb positive functions are self-motivation, hard-work, and devotion to duty, truthfulness, dependability, being well adjusted, fairness and justice while negative functions are foolishness, arrogance, hypocrisy and wickedness (Mirahayuni and Garnida, 2017). More functions were identified by (Mirahayuni and Garnida, 2017, Riyanto, 2018, Yakub, 2019). Wolio proverb human part is used to describe human which based on metaphor SPECIFIC is GENERIC (Mansyur, and Said, 2019).	The functions that proverbs perform are many, so many more are yet to be discovered.
IsiXhosa proverbs	IsiXhosa people observe plants and animals to extract lessons and solutions that they represent as proverbs (Mvanyashe, 2019). Proverb to be a chameleon. Demonstrates importance of adaptability in learning to deal with different circumstances (Mvanyashe, 2019).	People can observe biological phenomena to derive lessons to deal with on-going technology revolutions.
Kazakh and Malay proverbs	Proverbs are used to teach sustainability by enabling dialogue between academia and tradition proverb on sustainability and environment (Anuar and Mun, 2024).	What is taught is supposed to be put to practice; therefore, proverbs can be applied to direct sustainability and environmental actions.
Korean eco-literacy tree proverbs	Small trees do not benefit from big trees (while people benefit both ways) (Kim et al. 2017).	Ecosystems have mutual and non-mutual beneficial relationships.
Myanmar and Thai Animal proverbs	There are several Myanmar and Thai animal proverbs equivalents like a crocodile blocks the	Same animal can be used to describe good and bad

	canal (Thai) and the crocodile becomes more savage, as it heads becomes paler (Myanmar) (Thin, 2020).	characteristics of human beings (Thin, 2020).
Ndebele sustainability proverbs	Proverbs provide effective means of communication that aids development and sustainability (Ndlovu and Ncube, 2014) Sustainability proverbs: if cobweb unit they can tie a lion and don't milk a cow until its dry advises leaving milk for calf that will provide future milk (Ndlovu and Ncube, 2014). Metaphor proverbs are like seeds and proverb as metaphor create strong mental picture that motivate people to action (Ndlovu and Ncube, 2014). Proverbs can be used to create soil erosion prevention techniques and environmental monitoring systems; and turn game reserves and forests into knowledge based cultural and linguistic laboratories (Maiwong, 2025).	Strong mental picture that motivates action makes it possible to use proverbs as ideologies.
Nigeria proverb imaginaries	Nigeria proverb imaginaries reflect philosophy and cultural values of society (Adaora, 2019).	Polya (1985) showed how a system for planning can be created using proverbs. This combined with proverb imaginaries as philosophy and cultural system indicate proverbs can be used as system or system components for several disciplines.
Oromo proverbs	Some Oromo animal and plant proverbs have ecological value emphasizing healthy human nature co-existence (Adugna, 2014).	Creating more ecological animal proverbs by BSD can assist eco-logical conversation.
Russian and Yoruba animal proverbs	The study found both similarities and differences and peculiar patterns between Russian and Yoruba proverbs (Faloju, and Oyewale, 2020).	Identifying logic and patterns can be used to create a proverb logic system.
Ubuntu proverbs	Ubuntu as unity philosophy principle can enable african sustainable development (Thakhathi and Netshitangani, 2020). Proverb wisdom is like a baobab tree; no one individual can embrace it teaches amplifying knowledge by social learning and peer learning (Thakhathi and Netshitangani, 2020).	Substituting baobab tree for wisdom and vice versa can create baobab tree is like wisdom directing learning wisdom from nature that can be improved by bioinspired design.
Yoruba proverbs	Turning proverb into icons and visualization can increase the usage in society (Olajide, 2016). The insects that eat up vegetables are always located within its premises (Olajide, 2016).	Proverb visualization can be used in design of artefacts like computer user interfaces and furniture.

Some proverbs are mirror images that reverse others source and target objects. Ghanaian bioinspired family is a forest (Tedam 2013) is a GENERIC IS SPECIFIC mirror image of Turkish proverb vineyard is a family (Akiş, 2021). Knowledge in two proverbs is transferred in reverse directions. The Ghanaian proverb can be reversed into the forest is a family which could imply respecting forests the way we respect humans because they support human life. Reversing is lateral thinking creativity rule (De Bono, 1970).

BIOLOGICAL METAPHORS AND PROVERBS

Tree is human is a metaphor found in proverb that leads to concepts: scholar, society, parents, action and sources, vineyard is family derived from tree metaphor leads to concepts: property, work, human, area and family (Akiş, 2021). Vineyard consists of group of vine trees; the vine metaphor can be derived from tree proverb by substituting tree with specific category of trees. The proverbs can be extended with other concepts like system or even chemical and machine concepts associated with vineyard. Sparrow and hornbill are not the same, cannot match well, meaning in forming teams you need to get members who skills and knowledge are complementary (Fui et al. 2017). The proverb everything is connected illustrates interconnectedness things in universe. Proverbs illustrate ecological interconnectedness and complementarity of actors (Maiwong, 2025). Proverbs ecosophy leverages social systems and surrounding ecology (Bhattacherjee and Sinha, 2023). Everything is part or potential part of a system (Bunge, 2000), is one of ways things are connected. Some proverbs can be nested in other proverbs and others organized as a hierarchy (Lemghari, 2021) and use metaphors to connect different concepts by mirroring human conceptual system (Saripudin et al. 2019) creating network structures.

The proverb the cow is a bank is also a metaphor. Proverbs consists of concepts that are substituted when reasoning. Substituting concepts in a proverb generates proverb variants useful for creating solutions. Machine learning is a horse and the doctor is the rider are two metaphors (Filho, 2020) used to transfer knowledge of horses and riding to machine learning. Machine learning is domain of AI that enables machines like computers to learn to perform intelligent tasks such as making business or agricultural decisions. Some radical innovations like chatGPT are general purpose and all people are capable of accessing and using them through mobile phones. Awareness of chatGPT was lacking among some developing countries lecturers in 2023 (Adarkwah et al. 2023). It's a modern tragedy of people not being aware of AI technologies that would benefit them (Adarkwah et al. 2023). Creativity, invention and innovation are the largest obstacles to least develop countries industrialization.

Proverbs based on creativity, discovery, design, invention and theory concepts are few, which limit diversity of solutions created. The proverb farmers should not discuss their theories during the rainy season can applied in other domains like informal sector by substituting farmer for artisan and rainy season with working time. The proverb farmer who never travelled beyond his/her home thinks his/her methods are best. It directs them to learn from others and invent based experience of others. Codifying how grassroots farmers develop and validate their theories and methods would convert tacit knowledge to explicit knowledge. Proverbs provide learning models for co-creation with other people to deliver factual ecological knowledge (Kim et al. 2017). Educators can bridge traditional technical knowledge gaps with cultural expressions for sustainability (Kim et al. 2017). Improving community wide ecology and sustainability proverbs helps deal with climate crisis.

An object at higher level of great chain metaphor has all properties of lower level in addition to properties of its level (Krikmann, 1996). Proverbs understanding and reasoning is complex

extending beyond great chain, conceptual, stereotype and metaphoric integration theories individually; combining the theories into theory nexus overcomes several limitations of individual theories (Lemghari, 2021). The combination of the theories is application of TRIZ inventive merging principle.

BIOINSPIRED DESIGN, ARTIFICIAL INTELLIGENCE AND INVENTIVENESS

Nature is a rich source of novel creative ideas that can be leveraged to create inventions (Keshwani et al. 2017). The fact that groups of organisms are working together doesn't mean they working effectively to achieve a common goal, they have to be designed to do so, for example a group of ants are designed to work together towards a common goal but a group of pigeons are not (Ratnieks, 2008). When using BSD, it's important the organism is well understood to be able to know its good designs to use and accidental ones not to use. Similarly, a group proverbs and their relationship should be designed to work as system towards a common goal. BSD is a fruitful path to innovation (Katherine et al. 2014). Bioinspired proverbs transmit factual knowledge derived from observation promoting co-creative intergeneration learning by young students interacting with older people (Kim et al. 2017) connecting generational innovation trajectories.

BSD requires designer to decide degree replication faithfulness of biological model (Mahmoud and Plebe, 2022). Bioinspired solutions faithfulness to biological model varies from 0 to 100 percent. For example, if brain writing method is used to generate biological ideas, initial biological idea could be transformed in a way that leaves no biological trace or even contradict biology resulting with 0 percent faithfulness to biological model. However, if final generated idea is useful bioinspiration is still credible idea generating or product development method. Turning a single cell organism into a DNA computing system is 100% faithful to biological model.

Nature of biological proverbs is due to human biological nature, observing nature and environmental influence (Di Sciullo et al. 2010). Observation, visualization and mind-set management are foundations of I4R (Ajaj et al. 2024) that biological proverbs can help align with societies aspirations and I4R biological pillar. Large language models (LLM) are creative from perspective of AI based on passing Turing test, but the models cannot be used as linguistic language model because they don't replicate, identify or account for creative aspect of language (Carchidi, 2024). Transdisciplinary social machine enables transdisciplinary sense making by diverse users combining multiple pieces of knowledge from multiple sources similar to way Wikipedia combines knowledge pieces (Lebow, 2018). Wikipedia is among very large knowledge systems. A transdisciplinary social machine can drive innovation (Lebow, 2018) for sustainability. There is need for policy integration with indigenous knowledge including biological proverbs for education and transdisciplinary collaboration of academia, professional practitioners and indigenous practitioners for technology development (Maiwong, 2025). Transdisciplinary collaboration will enable creating synergy between global knowledge and biological proverbs.

Exploration of Information technology (IT) proverb application was used to develop professional identity and to complement IT culture understanding (Kenzhebulatova et al. 2024). Some derived proverbs and saying that help understand IT culture are: without code is like without hands derived from proverb, hurry without code will make people laugh created by symbol substitution of proverb haste makes waste (Kenzhebulatova et al. 2024). The pattern for deriving these proverbs can be used to transform other proverbs into biological computing proverbs.

BSD is an IS research method that supports innovation, research and development by applying BSD principles: evolution, emergence and fitness (RD) (Kaufmann and Portmann, 2015). Proverb inventiveness and innovativeness can be advance IS (Iyamu, 2021). BSD used as RD experimentation method can discover ways of applying biological proverb inventiveness and innovativeness to advance IS. Proverbs are invention heuristics (Polya, 1985) that if improved can catalyse society innovation and become invention principles. Proverb inventiveness and innovativeness can be diffused in more areas. Engineering and computing development techniques start as heuristics that are refined gradually over time to become principles (Shaw and Garlan 1996), a pattern that research can use to turn proverb heuristics into principles.

Turing test determines machine intelligence by a person communicating with a machine through text concluding that he or she is communicating with a person. A similar proverb test for proverb behave and look alike expression test is if an experienced proverb user, concludes an expression is a proverb with same likely hood as when user is presented with unfamiliar foreign proverbs conclude they are proverbs. Proverbial economies are systems of acts of speech and action that are valuable, make a difference in judgment and action, the economies are applied in engineering, sciences and medicine (Shapin, 2001). Proverbs should be skillful, intelligently, systematically and economically applied.

Creativity AI manifesto supports human and AI creative collaboration for transformational creativity (Vinchon et al. 2023). The authors asked chatGPT to write a manifesto for creativity and AI, the results returned were useful and included points the researchers had not considered. Generative AI tools like chatGPT are suitable for human AI collaboration because humans can ask questions or request to improve human solutions or it to perform tasks like to writing a design fiction for technology. ChatGPT is an AI tool developed by OpenAI.

AI as discovery, invention and experimentation tool, learning from failure and ability to foster AI application innovation and creating competitive advantage (Abbas and Al-Lawati,2025). This makes AI is a meta-circular tool that can help improve itself. AI, BSD and proverbs are meta-circular tools that can be used to improve the other and themselves. The main focus of study is on proverb as tools for leveraging and improving AI and BSD adoption, invention and applications. Minor focus is given to doing the reverse for proverbs. Figure 3 show circular learning from other and self of the three domains.

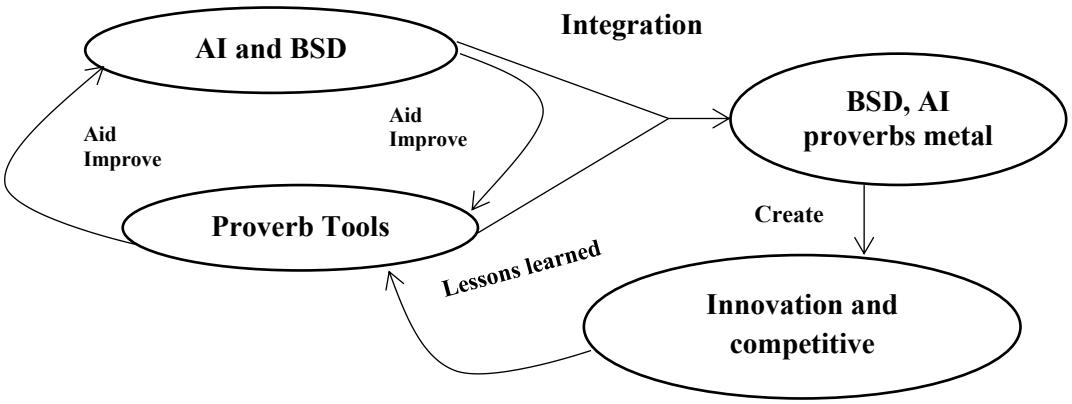


Figure 3: Proverbs, AI and BSD circular learning from each other and self-learning

Creativity and artificial intelligence manifesto can be integrated Africa science, technology innovation manifesto (Urama et al. 2010). The continent can benefit by turning proverb into a field providing opportunities for region to become a proverb innovations world technology leader (Wamuyu and Mambo, 2025). Africa pioneered Orature discipline enabled by its long history of passing literature through spoken that gave continent a competitive advantage. Human and chatGPT co-creativity can be used to create innovative proverbs by for example asking chatGPT how methods like lateral thinking can be used to create novel proverb applications. Biological proverb research and practice can be situated in science technology and innovation manifesto to catalyse industrial revolution (Urama et al. 2010). The manifesto could be foundation for biological technology proverb research.

TRANSDISCIPLINARY SCHOOLS

Transdisciplinary aims to unify knowledge based on four principles: searching for unity, participatory research and development, transcending and integrating disciplinary paradigms and relating to socially relevant issues (Pohl, 2010). Transdisciplinary schools are groups of people who share similar methodologies and perspectives. Schools are coherent thought systems with shared internal logic and diffuse boundaries; they compete and collaborate with each other, overlap but also have distinct elements (Negru, 2013). A paradigm may have several schools of thought. Transdisciplinary work can be classified into following overlapping schools:

Knowledge co-creation school (Nicolescu) – co-creation of knowledge by industry, academia and society based on multiple levels of reality (McGregor, 2023) and principles of crossing, exploring between and beyond bounded regions (Nicolescu, 2010). These boundaries are porous allowing knowledge to flow.

Pragmatic school (Zurich) Approaches science, research and politics pragmatically based on mode 2 knowledge and product innovation and post normal science (McGregor, 2023). Mode 2 innovation is transdisciplinary involving moving between practical and theory, fundamental

and applied research spaces to catalyse knowledge flow between disciplines (Gibbons et al. 2004). Post normal science combines natural, social sciences, lay persons and local communities' efforts to co-create knowledge for sustainable development and dealing with climate crisis (Luks and Siebenhüner, 2007). Knowledge driven transdisciplinarity between disciplines spaces is transformed to novel knowledge.

Holistic view school (Brazilian) – studies the whole based on duality of synthetic and analytic methods creating applied knowledge and understandings of reality (McGregor, 2023). It combines reductionist and systems thinking. The school shares duality with knowledge co-creation school. Duality is based on including the excluded middle (Nicolescu, 2010).

Synthesizing school - applies transdisciplinary philosophy to unify local philosophies for technology development (Mambo, 2020). Some regions like western world have a single philosophy while some other regions have multiple competing philosophies. The school enables collaboration, competition and integration between different local philosophies through transdisciplinarity.

Each of these schools provides insights for transdisciplinary technology development. For example, transdiscipline unifies best practices from intersecting disciplines to aid knowledge and technology development activities. Nexus of disciplinary schools would create a meta-transdisciplinary that creates synergy and hybridizes schools' efforts. Each school or nexus can present trajectories for bioinspired proverb systems evolution.

Proverbs encapsulate systems of local knowledge and methods forming paradigms (Easton and Local researchers, 2004). A technology and knowledge paradigm is an outlook, for studying and solving relevant problems by modeling and inquiry (Dosi, 1982). Proverb meanings are highly interleaved connecting many things forming frameworks for reasoning and collaboration between international development community and local beneficiaries (Easton and Local researchers, 2004). A transdisciplinary social machine for collaborative sense making for transdisciplinary literature review was implemented (Lebow, 2018). The machine can be extended for collaborative sense making for technology research and development by basing it on sense making design science co-evolution theory (Ralph, 2015). It can be combined with BSD RD method (Kaufmann and Portmann, 2015) to create a BSD method nexus. Design science research methods are used for innovation research and development (Hevner et al. 2004). The design science machine can be used to create innovative transdisciplinary artefacts that require research review, innovation, research and development.

Artificial intelligence and bioinspired design revolutions are radically transforming industries, organizations, disciplines and individuals. Similar to interaction between quantum computing and artificial intelligence that are revolutionizing industries and disciplines, they are likely to yield innovative solutions that can solve complex problems facing society (Usman et al. 2025), so can AI and BSD applied to biological proverbs. The resulting revolution should not be ignored as countries that pioneer such areas could become technology leaders and generate a lot of wealth. Every country is a technology and knowledge leader in their local knowledge

and technology (Wamuyu and Mambo, 2025) which can increase a country's confidence to build capabilities in other areas.

ADAPTING DESIGN SCIENCE RESEARCH METHOD

BSD model can be used to create engineering methods (Adriaens, 2019). BSD is based on technology push where a biological discovery is used to create a solution in another discipline and the more widely used technology pull that uses BSD as a problem solving process (Adriaens, 2019, Graeff et al. 2020, Technical Committee, 2020). In this section bioinspired model is used to adapt a design science method widely used in IS and less in other computing disciplines.

Proverbs are similar to design patterns and some proverbs are design patterns (Mambo, 2024). Personal construct theory (Kelly, 1955) is used to create proverbial expressions (Boose, 1984) which proceed to next maturity level to become proverbs and mature to highest level becoming principles. Extending Kelly (1955) definition of personal theories, proverbs are community theories. Computing principles start as proverbial expressions (Shaw and Garlan 1996). Design science research methods (DSRs) are used to create theories and principles (Vaishnavi and Kuechler, 2015). Proverbs support design oriented methods: design science and design thinking (Quarshie and Poku, 2025). Vaishnavi and Kuechler, (2015) used DSR method to create design science patterns and organize them as a system of patterns. One pattern divide and conquer with balancing is a proverb. Similarity between design patterns and proverbs; and proverbs being personal theories and evolving into principles, supports adapting a DSR method for biological short expressions creation. Design patterns capture best practice in professional domain enabling reuse (Schadewitz, 2009), while proverb capture best practice in everyday domain for community wide reuse. Patterns are interrelated, cross referenced and organized as collections enabling discovery of problems and solutions (Schadewitz, 2009). Biological proverbs lack such organization making them more difficult to discover and relate them. A DSR method adapted for proverb toolkit application can aid in introducing creativity, innovation and diversity thinking; and proverb management

Problems and solutions are repeated in different disciplines and domains (Domb, 1999). Design patterns are one technique used to capture solutions in different disciplines including computing, design and others. A design pattern is general technique for solving class of problems that are similar to other problems that have been solved before (Vaishnavi and Kuechler, 2015). Proverbs like design patterns serve the same purpose for communities that use them. A commonly used DSR method variant will be adapted for creating short expressions like proverbs. The DSR method (Vaishnavi and Kuechler, 2015) adapted for BSD short expression creation steps are:

Awareness of problem: search for specific class of problems that lack or have in sufficient proverbs or proverb like and behave like expressions

Suggestion: refine problem to one or more objectives and determine feasibility of answering or meeting objectives. Use analogy to biological with similar objectives. Identify relevant mechanism generate from mechanism suggestions of solving problem.

Development: perform research and experimentation using BSD to create a short proverb like short expression.
Validation: validate the short expression
Conclusion: diffuse short expression widely in society.
Most metaphoric proverb reasoning only transfers a small fraction of total transferable knowledge and solutions from biological source to target. For example, the cow is a bank proverb, only a small fraction of bank knowledge and experience is leveraged because of commonly used routine thinking while innovative thinking using adapted BSD method would enable transfer more knowledge. There is much knowledge about banks that can help improve livestock farming. BSD RD method combined with adapted design science method would create a method nexus for improving biological proverbs as tools.

DISCUSSION

Proverbs analysed in this study are tools that can synthesized into toolkit system by combining them to create a coherent whole. A proverb tool consists of best practices, knowledge and theory and techniques. An adapted design science method was adapted for proverb management. BSD research experimentation method (Kaufmann and Portmann, 2015) can be combined with adapted design method to complement their strengths and counteract their weaknesses. Both methods are bioinspired and support research design, innovation and development.
It was found that different proverbs are different types of tools for dealing different aspects of artificial intelligence and bioinspired design. Biological proverbs serve multiple functions like strategy, motivation and others that help dealing different aspects problem solving and decision making. Ordinary people are able to turn their observations of nature into solutions that solves the problems they face, which can be aided by methods.
Creating powerful and sustainable predominantly proverb oriented based technology applications should be based on selecting the best proverbs available worldwide, basing applications only local proverbs will limit potential adopters to mostly local people. The proverbs should be grounded on knowledge structures based best practices from creativity and science technology manifestos.
The transdisciplinary social machine is an example of how system for transdisciplinary research can be created. There are advantages transform transdisciplinary literature review method to a transdisciplinary design science method like using same method based on same paradigm for research and innovation.

CONCLUSION

Biological proverbs are tools for navigating and directing bioinspired design and artificial intelligence two on going technological innovation revolutions changing the world. Systematizing proverbs creation and practice makes them more knowledge driven. Proverbs use metaphoric system, concept substitution reasoning mechanisms for creative and innovative thinking. A design science method was adapted for bioinspired research,

development and innovation to be used for generating new knowledge, creating, improving and innovating proverb artefacts.

Future research should explore how generative AI tools like chatGPT can aid in creating innovative biological proverbs and applications. Research and experimentation can help improve proverbs to remain competitive relative to other tools created through RD. Research on how computing innovation styles: visionary, experimenter, modifier and explorer (Miller et al, 1993) can apply biological proverbs to software innovative development based on science technology and innovation manifesto (Urama et al. 2010), would contribute to strengthening culture of innovation. Transdisciplinary driven proverb collaboration, co-creation and innovation will enable all members of society to be contributors of BSD and AI.

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