Bio-Inspired Learning for Management -A Review for Designing A Taxonomy

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Abstract
Bio-mimicry as a deep observation-based subject serves as the input of knowledge and wisdom for human activities. Management as an interdisciplinary subject connecting human activities can draw pearls of wisdom from nature. Applying wisdom and knowledge from nature bio-mimicry can open a new treasury for management innovation. This paper attempts to articulate what to learn and apply through bio-inspiration. Through a brief literature review, a bio-inspired taxonomy is created. There are enough spaces to accommodate bio-mimicry-based knowledge and wisdom for management needs more rigorous discourse and concept development.

Keywords: Bio-Inspiration, Eco-Knowledge, Leadership, Workspace Design, Human Technology, Bio-Sensor, Flexible Leadership

Introduction

Bio-mimicry, the imitation of models and systems from nature to solve human problems, has been applied successfully in various fields such as engineering and human-computer interaction (HCI) [1] [2]. In the context of HCI, principles derived from biology can greatly benefit the development of more naturalistic interactions [3]. Mimicry is not only a biological phenomenon but also has connections to human experiences of misperception, imitation, and artistic creativity [4]. Human mimicry, which occurs without awareness, has been found to have a broad impact on social interactions and beyond [5]. It is influenced by social, motivational, and emotional conditions. The ability to mimic is supported by a cognitive architecture that enables individuals to imitate others' behaviours. Mimicry is innate, but the behavioural response may be influenced by learning or associations. Mimicry has downstream consequences, including increased prosociality and effects on cognitive processing, attitudes, and self-regulation. Overall, bio-mimicry and human mimicry have implications for various fields, including engineering, HCI, anthropology, and psychology.

Bio-mimicry, the practice of imitating nature's designs and processes to solve human challenges, has gained significant attention in various fields, including engineering, architecture, and sustainability. However, its potential applications in employee engagement are often overlooked. By understanding and applying the principles of bio-mimicry, organizations can create a work environment that fosters employee engagement, productivity, and well-being.

Bio-Inspired Meaningful Works

Nature is a treasure trove of bio-inspiration, and when it comes to setting meaningful goals, the animal kingdom offers a wealth of wisdom. Here are some ways to draw inspiration from specific creatures for different aspects of goal-setting:

Table-1:Bio-Inspiration for Meaningful Work as the Adapted Skills

Creature	Activities	Roles
Bees	Pollinate plants	Play crucial roles in their ecosystems, contributing to pollination, seed dispersal, pest control, and nutrient cycling
Dung beetles	Decompose waste	
wolves	regulate prey populations	
Cleaner fish	Remove parasites from larger fish	Engage in mutually beneficial relationships with other species, contributing to each other's survival and well-being
clownfish	Live among the stinging tentacles of anemones for protection	
The above examples are the engagement of animals in activities that could be considered "meaningful" from an external perspective. Animals are primarily driven by their instincts and basic needs, their actions geared towards survival, reproduction, and fulfilling their natural roles within their ecosystems		

Clear Expectations

Animals, though lacking human-like expectations and goals in the technical sense, do exhibit strong instincts and drives that propel them towards specific outcomes. Some fascinating examples of animal behaviour showcase remarkable focus and purpose, suggesting complex decision-making and even rudimentary planning.

Table 2: Bio-Inspiration Clear Expectation for Goal Setting

Aspects	Animals/ Creature	Activities	Roles for Short and Long-Term Goals
Clear Goals and Expectations	**Ants**	Gathering food,	Demonstrating a clear goal of acquiring and transporting food back to their colony.
	Humpback whales	Bubble-netting for Feeding Strategy	This technique showcases a deliberate plan and understanding of prey behaviour.
Navigation and Migration	**Monarchs butterflies**	Undertake an epic annual migration, spanning thousands of miles across generations	Inheriting the navigational instincts and utilising celestial cues by using sunlight and Earth's magnetic field
	Salmon	Return to their natal streams after spending years at sea	Showcasing a remarkable goal-oriented journey
ToolsUse	**Chimpanzees**	Uses sticks to extract termites from mounds, crack nuts with stones, and modify leaves to soak up water.	Use their intelligence in all actions with a clear, immediate goal in mind.
	New Caledonian crows	Clever birds bend sticks into hooks to pull grubs out of holes,	Demonstrating an understanding of tool function and adaptation for a specific goal.
Animals may not set "clear goals" in the human sense, but their impressive behaviours display a fascinating blend of instinct, adaptation, and even some elements of goal-oriented action.			

Motivation: Bio-mimicry sustainable innovation training programs have been found to intrinsically motivate employees and promote creative thinking and engagement [6]. The emotional inclusion of employee engagement is an important factor to consider, and a typological model of emotional inclusion has been developed [7]. Job requirements and job resources have a positive effect on employee engagement [8]. Managing older employees is crucial for companies, and creating a work environment favourable for all generations can increase the work engagement of older employees [9] [10].

Designing Workspace

Animals certainly contribute to a positive workplace atmosphere, it's unlikely you'll find any species specifically "expert" in workspace design. Their talents lie in other areas! However, let's explore some ways animals can influence workspace design and how their natural abilities might inspire our work environments:

Table 3: Bio-Inspiration for Designing Workspace

Animals	Activities	Bio-Inspired Learning and Inspiration
Birds	Nest-building skills	Could inspire modular, adaptable furniture and flexible spaces
Beavers	Dam construction	Showcases impressive engineering and resource management, suggesting efficient workflow layouts and sustainable building practices.
Spiders	Web-weaving	Demonstrates intricate organization and efficient connections, potentially inspiring collaboration tools and communication networks.
Dogs	Keen sense of smell	Inform air quality optimization and even stress detection systems.
Horses	Natural flow and movement	Could inspire dynamic, flexible workspaces that encourage breaks and physical activity.
Monkeys	Playful climbing and swinging	Suggest incorporating playful elements and adaptable working levels to encourage social interaction and movement.

Designing workspaces inspired by nature has been shown to have numerous benefits. Nature-inspired design principles can lead to energy-efficient buildings with high levels of thermal comfort that are sustainable and buildable [11]. Incorporating natural elements into workspaces, such as plants or views of nearby nature, has been associated with increased productivity, creativity, and positive emotional and physical health outcomes for workers [12]. Workers perceive natural outdoor spaces as highly flexible and appropriate for diverse workplace activities, and they rate these spaces as more fascinating, relaxing, open, bright, and quiet compared to constructed indoor spaces [13]. By integrating nature into workspaces, designers can create environments that promote well-being and enhance performance in various workplace activities [14].

One of the key applications of bio-mimicry in employee engagement is the design of workspaces inspired by nature. Just as natural environments have a profound impact on our well-being, the physical environment in which employees work can significantly influence their engagement levels. By incorporating elements such as natural light, greenery, and natural materials, organizations can create a workspace that mimics the calming and rejuvenating effects of nature. This can lead to increased employee satisfaction, reduced stress levels, and improved overall well-being, ultimately enhancing engagement and productivity.

Nature's Strategies for Team Building

Nature provides numerous examples of effective teamwork and collaboration. By studying these strategies, organizations can apply them to their team-building activities. For instance, ants work together in a highly coordinated manner to achieve common goals. By incorporating team-building exercises that encourage collaboration, communication, and shared decision-making, organizations can foster a sense of unity and purpose among employees. This can lead to improved teamwork, increased trust, and enhanced engagement within teams.

Table 4: Bio-Inspiration for Team Building Cooperation and Social Strategies

Animals/ Creature	Activities	Roles for Short and Long-Term Goals
Honeybees	The colony's well-being is communicated through complex dances and pheromones. ensuring synchronized efforts in hive maintenance, foraging, and defence.	Teams can learn from this by establishing clear communication channels and fostering mutual understanding.
	Adjust their behaviour and hive structure to respond to changing environmental conditions	Emulate this by embracing flexible approaches, readily learning new skills, and bouncing back from challenges.
Dolphins:	Playful interaction, Problem-solving, Mutual aid and support	Playful and social nature, forming strong bonds through games and physical contact
	Readily assist injured or vulnerable members of their pod, demonstrating strong social bonds and a sense of community	Exhibit remarkable intelligence, and collaborative problem-solving skills, working together to hunt, navigate obstacles, and communicate with each other
African Wild Dogs	Meticulously plan hunts, strategize together and utilize swift flanking manoeuvres to bring down prey	Exceptional communication and synchronized efforts make them a formidable force
Grey Wolves	Pack members hunt together, care for pups, and defend their territory as a unit	Well-defined roles, clear communication, and adaptive hunting strategies make their resilient social groups.
African Elephants	Led by experienced matriarchs, elephant herds navigate, solve problems, and raise young cooperatively.	Their strong social bonds, empathetic nature, and collaborative foraging strategies ensure the collective well-being of the entire herd.
Penguins	Group dynamics	Might inspire collaborative spaces and encourage team-building activities.
Animals may not set "clear goals" in the human sense, but their impressive behaviours display a fascinating blend of instinct, adaptation, and even some elements of goal-oriented action.		

Nature's strategies for team building involve utilizing the natural system and its services, understanding the surrounding system, and considering the potential impact on social and environmental systems. It is important to establish the effectiveness of team-building solutions on a larger scale and assess their suitability in addressing regional-scale issues. Successful pilot projects may not always guarantee wider applicability and broader applications may involve dilemmas related to the environment, policy, and legislation [15]. Organizations rely heavily on expert, innovative work teams to navigate the complexities of the modern work environment. These teams evolve and develop in stages, requiring leadership strategies tailored to each stage of team development [16]. Effective team-building initiatives should consider the characteristics and dynamics of effective teams, as well as the factors influencing interpersonal interactions within a team. Various strategies can be employed to improve team effectiveness [17].

Embracing Diversity and Collaboration

Ecosystems flourish through the presence of various species, wherein each individual plays a distinct role in upholding the equilibrium and efficiency of the system. Similarly, organizations can reap advantages by embracing diversity and cultivating collaboration amongst their employees. By acknowledging and appreciating the diverse talents, viewpoints, and backgrounds within their workforce, organizations can establish a culture of inclusivity and collaboration. This can result in heightened levels of creativity,

innovation, and problem-solving capabilities, ultimately enriching employee engagement and enhancing the overall performance of the organization.

Table-5: Bio-Inspirations for Diversity & Collaboration

Animals	Activities	Bio-Inspiration for Diversity & Collaboration
Cleaner Fish	Remove parasites and clean the skin of their hosts, forming a symbiotic relationship	Inspires collaborate despite their size and physical differences, mutually benefiting from each other's strengths.
Hummingbirds, Warblers, and other Small birds	Often form mixed flocks when foraging for food	Inspires for the use of the power of diverse perspectives and collective intelligence in overcoming challenges.
Coral reefs	Countless species interact in complex and mutually beneficial ways	Their intricate dance of diversity could inspire how different organisms can rely on each other for survival and success.
Biomimicry of the above may inspire innovation from nature and has the potential to foster diversity and collaboration in various fields.		

By observing and replicating the processes and structures found in nature, biomimicry allows for the development of more sustainable and strategic approaches to manufacturing and design [18]. It can guide the transition towards a Circular Economy (CE) by inspiring technological and organizational innovation, leading to restorative and regenerative outcomes [19]. Biomimicry also offers solutions to address challenges such as climate change and biodiversity loss, by learning from nature's mechanisms for carbon absorption and adaptation [20]. In the context of architecture and urban planning, biomimicry initiatives in France have contributed to a paradigm shift towards regenerative cities, driven by individual efforts rather than public policies [21]. Furthermore, the integration of biomimicry with nanotechnology has shown promising results in various fields, including medicine, robotics, and energy solutions [22]. Overall, biomimicry provides a framework for embracing diversity and collaboration by leveraging the wisdom of nature to drive innovation and sustainability.

Nurturing Resilience and Adaptability

Determining the "most" resilient and adaptable animals is a tricky endeavour, as every species faces unique challenges and displays resilience in its way. However, certain characteristics and behaviours shine in this arena, making some creatures worthy of special mention:

Table 6: BioInspiration for Resilience and Adaptability

Animals	Activities	Bio-Inspired
Polar Bears	Endure extreme cold, hunt on shifting sea ice, and navigate vast distances.	True resilience lies in their flexible hunting strategies, scavenging abilities, and even venturing onto land when necessary.
Honeybees	Face unpredictable weather, disease outbreaks, and habitat loss	Their resilience shines in their adaptable social structure, where every bee contributes to hive survival. Could inspire communication for strong warnings and demonstrate incredible collective intelligence and resourcefulness.
Desert Lizards	Collect dew on their spiny scales, burrow to escape the midday heat, and switch diets based on prey availability.	They could inspire adaptations for water conservation and adaptability to harsh conditions to become the masters of desert survival.
Monarch Butterflies	Embark on the most awe-inspiring migration journeys	They inspire us to acquire incredible navigation skills, adaptability to varied environments, and reliance on collective experience.

Nurturing resilience and adaptability is important in various fields, including healthcare, climate change adaptation, and pain management [23] [24] [25]. In healthcare, interprofessional education programs can enhance adaptability and resilience skills among pre-professional healthcare workers [26]. For climate change adaptation, community-led engagement is crucial in understanding the needs and cultural practices of communities at risk [27].

Nature is resilient and adaptable, constantly evolving and responding to changes in its environment. Organizations can learn from nature's resilience and apply it to employee engagement. By nurturing resilience and adaptability in employees, organizations can help them navigate through challenges and changes with greater ease. This can be achieved through providing opportunities for growth and development, fostering a growth mindset, and encouraging employees to embrace change as an opportunity for learning and personal growth. Resilient and adaptable employees are more likely to be engaged, motivated, and productive.

Bio-Inspired Animal Communication

Effective communication is a fundamental aspect of animal life, and research on animal communication can provide insights and inspiration for effective human communication. Animal communication systems share basic elements with human communication systems, and there are more similarities than differences between non-human and human communication [28]. Animal communication research often focuses on the role of the signalling environment and quantification of receiver responses, while human communication research emphasizes relationship building between signalers and receivers and quantifies aspects of the receiver's psychology [29]. The study of vibrational communication in arthropods, such as insects and arachnids, has provided evidence of its use as a source of information from the environment and its involvement in various behavioural roles [30]. Deceptive communication is also prevalent in the natural world, and studying deceptive systems can shed light on the evolution of complex behaviour and social cognition [31]. Understanding the mechanisms and adaptive value of synchronization among animals can further enhance our understanding of the functional complexity of animal collectives [32].

Animal communication systems are highly efficient and effective, allowing individuals to convey information and coordinate actions seamlessly. Organizations can draw inspiration from animal communication and apply it to their communication strategies. By promoting open and transparent communication, active listening, and clear feedback channels, organizations can create a culture of effective communication. This can lead to improved collaboration, reduced conflicts, and increased employee engagement.

Empowering Leadership Inspired by Nature

Nature provides numerous examples of effective leadership, where leaders empower and support their followers. Organizations can learn from these examples and apply them to their leadership practices. By adopting a leadership style that empowers employees, encourages autonomy, and provides support and guidance, organizations can create a supportive leadership culture. This can lead to increased employee engagement, motivation, and loyalty.

Table 7: Bio-Inspiration for Leadership

Animals	Activities	Bio-Inspired Leadership Knowledge
African Painted Dogs	Masters of teamwork, meticulously plan hunts, utilizing coordinated flanking	Could inspire democratic leadership, shared decision-making, and synchronized efforts making them formidable hunters and examples of collaborative excellence.
Chimpanzees	exhibit diverse leadership styles depending on the situation	Inspire flexible leadership structure and social intelligence offer valuable insights into adapting
Honeybee Queens	their power lies not in force but in their vital role as egg-layers.	Motivate and energize worker bees, encourage them to perform their necessary tasks and contribute to the collective good. They are chemical-based leadership with the power of effective communication and inspiration.
Elephants	Empathetic Power with deep knowledge of resources for informed decision-making	Their matriarchal leadership serves as a testament to wisdom, compassion, and shared responsibility, prioritizing the group's well-being and survival.
Grey Wolves	They guide the hunting pack through strategic hunting, selecting migration routes, and maintaining their social order.	Their hierarchical leadership emphasizes clear roles, teamwork, and coordinated action.
Meerkat Mobs	These vigilant sentries actively scan the environment, vocalize warnings, and alert the mob of danger.	Their distributed leadership ensures the safety and productivity of the entire group, highlighting the importance of shared responsibility and collective vigilance.
Narwhals	Lead in migration and foraging expeditions.	They inspire the experience and resilience guide the group, offering valuable lessons in the power of accumulated knowledge and leading by example.

Empowering leadership inspired by nature is a concept that has gained popularity in contemporary work settings. It involves leaders promoting followers' creativity and innovation [33]. Nature has been a source of inspiration for various fields, but its leadership potential has been largely untapped [34]. The Empowering Leadership Project aims to improve management students' understanding and practice of empowering leadership [35]. This approach, called Empowering Leadership, fosters bottom-up dynamics and can achieve success in business and social entrepreneurship [36]. Additionally, a nature-based training program has been found to increase authentic leadership, suggesting that immersion in wilderness can foster leadership change [57]. By extracting principles from nature, empowering leadership can offer new insights and effective strategies for leading in complex and unpredictable environments.

Integrating Sustainability and Corporate Social Responsibility

Nature operates sustainably, with ecosystems maintaining a delicate balance between resources and consumption. Organizations can learn from nature's sustainability and apply it to their business practices. By integrating sustainability principles and corporate social responsibility initiatives into their operations, organizations can create a positive impact on the environment and society. This can enhance employee engagement by aligning their values with the organization's mission and purpose.

Biomimicry holds the promise to contribute to sustainability by integrating sustainability and corporate social responsibility (CSR) [42]. It is shown that biomimetics is further integrating sustainability to contribute to real problems in this context [43]. The transition to equitable and sustainable societies requires

new firm practices and approaches that encompass corporate sustainability issues and dimensions [44]. Corporate social responsibility (CSR) emerged as a tool for linking the priorities of business companies with the priorities of citizens and society [45]. Companies can bring important benefits to society by being responsible for the quality of the goods and services they produce and developing new goods or services that generate economic growth [46]. The implementation of CSR can vary among contractors, but it can be a model for governing common resources and promoting sustainability. The concept of the "Biophilic Organization" aims to counter the bio-cultural disconnection of many organizations and tackle sustainability in a holistic and systemic sense. By integrating biomimicry, sustainability, and CSR, organizations can contribute to sustainable development and address global challenges.

Findings and Discussion

Bio-mimicry offers numerous applications in employee engagement and people management. For designing and developing a bio-inspired management concept, a taxonomy may be derived to fit the different contexts of people management.

Major Aspects	Bio-Inspired Taxonomy for Management
Goal Setting	Instinctive Goals, Survival Goals, Actions Gearing, Natural Roles, Mutual Benefits, Unconscious Eco-System Balancing Goals
Clear Goals	Bringing Back, Colony Well-Being, Community well-being, Bubble Netting, navigational instincts, Celestial Cues, Goal Oriented Journey, Immediate goal, Adapted Goals
Workspace Design	Nest Building, Flexible Space Design, Web Weaving, Spce Optimisation, Smell Sensitivity, Natural Flow, Playful Swinging, Adaptable working
Team Building	Complex Dancing, Synchronise Efforts, Communication for the Colony's well-being, Playful Interaction, Learning New Skills, Resilience Communication, Obstacle Navigation, Swift flanking, Resilient Social Groups, Herd Navigation, Collaborative Spacing
Diversity and Collaboration	Collective Intelligence, Collaborative, Intricate Dance, Symbiotic relationship
Resilience and Adaptability	Flexible Hunting, Venturing on to Land, Collective Intelligence, Migration Journey, Collective Resources, Adaptability
Leadership	Collaborative Excellence, Flexible Leadership, Social Intelligence, Chemical Leadership, Matriarchal Leadership, Hierarchical Leadership, Distributive Leadership, Leading by Example, and Leading by Experiences.

Bio-mimicry can be a source of innovation and new systems design for management. The entire nature can contribute to the design and innovation of new knowledge and techniques for human management in an organization. We analyzed only a few nature-inspired knowledge contextualized for management innovation. A rigorous study may be initiated in future to design a detailed taxonomy from bio-inspired learning for management.

Conclusion

By understanding and applying the principles of bio-mimicry, organizations can create a work environment that fosters engagement, productivity, and well-being. From designing workspaces inspired by nature to embracing diversity and collaboration, nurturing resilience and adaptability, and fostering creativity and innovation, bio-mimicry provides valuable insights and strategies for enhancing employee engagement and organizational performance.

Ecosystems thrive on diversity, with each species playing a unique role in maintaining the balance and functionality of the system. Similarly, organizations can benefit from embracing diversity and fostering

collaboration among employees. By recognizing and valuing the diverse skills, perspectives, and backgrounds of their workforce, organizations can create a culture of inclusion and collaboration. This can lead to increased creativity, innovation, and problem-solving capabilities, ultimately enhancing employee engagement and organizational performance.

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