Generations of Systems Thinking: Models for Future Learning

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"*In the case of all things which have several parts…the whole is not, as it were, a mere heap, but the totality is something besides the parts*".

Aristotle

Summary

This chapter demonstrates how systems thinking (ST) informs a new language of thought for future curriculum modeling and learning. The problems that beset us in education today are systemic ones that require systemic solutions. Therefore, we must take an ST approach in order to prepare for and adapt to a world that is complex and unpredictable. ST, as quoted above, has its origins in Greek Philosophy through Aristotle's dictum, the origin of which dates back to Aristotle's *Metaphysics*. This chapter also makes explicit ST about learning, emphasizing the importance of relationships rather than reducing the world into separate elements or parts. We trust that this will build the capacity for thinkers, educators, and curriculum designers at all levels to assist in designing more integrated curriculum models that are responsive in real-time in mitigating the effects of the changing demands of lecturers, teachers, and their students.

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QR Code

Scanning the QR code directs you to the word cloud of the chapter that is made up of the words we discussed throughout the whole book in relation to the chapter's keyword, which is intentionally not included in the word cloud. Find the keyword and put it in place in the puzzle according to the clues provided in Chap. 36. The mystery hidden in the puzzle is the quote of *THINKING: Bioengineering of Science and Art.*

Introduction

The author briefly considers the antecedents of systems thinking (ST), in particular, general systems thinking (GST) and cybernetics founded by Karl Ludwig von Bertalanffy and Norbert Wiener, respectively. The origins of ST, which are distinct and interdependent, include considerations of GST, cybernetics, complexity theory, system dynamics, and thermodynamics.

This chapter will delve more into how Karl Ludwig von Bertalanffy's dynamic equilibrium and Fritjof Capra's organismic biology contribute to new contemporary thought for educational modeling and the embedding of sustainability across all curricula. At times, it will differentiate within each context between compulsory education, post-compulsory education, and higher education.

General Systems Thinking

The origins of ST occur in theoretical biology, which led to the development of GST. Specifically, Karl Ludwig von Bertalanffy stated that an organism as a whole possesses a deep connection and openness to the environment [2]. Von Bertalanffy came to reject reductionist science that was void of humanism in favor of science for the benefit of humanity.

Whole ST is a subset of GST. Both focus on the difference between a system and its parts and how it organizes its parts to function. A study of the relationships between the parts is necessary to understand thoroughly how best to cultivate functional sustainability. For example, education curriculum designers are to be cognizant of the relationships of the parts and the whole to create a curriculum that provides an opportunity for sustained learner growth [3, 4].

The origins of von Bertalanffy's idea of an organism are taken from the principles of thermodynamics. He states that "*living systems are open systems, maintaining themselves in exchange of materials with environment, and in continuous building up and breaking down of their components*" [2, p. 23]. It is defined as 'dynamic equilibrium'—a steady-state. It is not an equilibrium in the conventional sense but a continuously changing state while maintaining integrity or form. The application of this open system to various contexts and situations led to the development of GST.

Von Bertalanffy was the first academic of the modern era to apply values and ethics to science through ST, resulting in a more humanistic discipline challenging the prevailing wisdom of empiricism during his early period. As von Bertalanffy gave ST a common language, educators and policymakers need to develop a new language of thinking to inform organismic curriculum design and modeling.

In applying GST more widely, we come to realize structural similarities across a range of entities that are vastly different. For example, the same mathematical laws apply to bacteria, humans, and animals, regardless of causal mechanisms [2].

Cybernetics

Norbert Wiener [5] coined the term cybernetics and published his seminal text in 1948. Cybernetics is from the Greek Kubernetes, to mean 'steersman'—an entire field of control and communication [5, p. 11]. This term was originally applied to an engine governor that controls revolutions per minute in regulating engine operational parameters. Wiener defined cybernetics as two key concepts: control and communication, which are highly related. Wiener stated that these concepts could be expressed as feedback for intelligent systems to self-correct in steering toward intended goals. Cybernetics, therefore, is highly relevant for curriculum designers in responding to student achievement and development feedback within compulsory and non-compulsory education. This feedback becomes very powerful in informing curriculum construction from an ecocentric (ecologically oriented) worldview. Cybernetics is a process of trying, acting, sensing, comparing to the goal and changing. All intelligent systems have such a process, which is a form of self-correction and adaptation [6].

Pangaro et al. [6] describe cybernetics as a systemic language that enables all goal-seeking systems, both biological and mechanical, to adapt and change according to set design imperatives. These attributes, which will be elaborated upon further in this chapter, facilitate self-correction and adaptation. As a language and methodology, it is the conscientious application of cybernetics that empowers us, or any given intelligent system, to operate at optimal levels. Pangaro states that goal-based systems use intermediary feedback to orientate or make course corrections in reaching pre-determined goals.

Pangaro et al. [6] state: "*If systems, then cybernetics—because the interactions and complexity of systems involve humans, we must incorporate goals, feedback, and information, because we are driven by these things. And these are what cybernetics is all about*" [6, p. 23]. This, from an elementary perspective, can also readily apply to educational evaluation. Teachers and educators at all levels can evaluate their lessons, lectures, and tutorials, and students can self-assess their growth over time through positive and negative feedback against their learning goals.

Gregory Bateson strived to develop a language of thinking governing information transfer between the two disciplines. It can be defined as transdisciplinary, as he saw commonalities across fields comprising the beginnings of Cybernetics [7]. This is in contrast to Cartesian philosophy, which according to Bateson, corrupted epistemology due to Descartes' partitioning of the physical and mental realms. In contrast, Bateson favored a more unifying perspective. Ramage and Shipp [2] state, "*... this is a call to a new form of epistemology, which understands humanity within its environment, and Bateson's answer to it lay within his conception of an ecology of mind*" [2, p. 14].

Bateson studied the patterns among different mental and physical processes throughout nature to address how entities interact with their environment, ultimately informing his ecological worldview. Bateson's [8] *Mind and Nature*

explores his concept of connective patterns that applies to all living things and, in particular, their inter-relationships, similarities, and differences. These relationships are in a constant state of change: "*a dance of interacting parts only secondarily pegged down by various sorts of physical limits*" [8, p. 13].

A Unifying Vision

Capra and Luigi Luisi's [1] *Systems View of Life* portrays the twenty-first century as having inherited major problems involving the environment, energy, climate change, biosecurity, and financial security. They characterize these as systemic problems in that they are all connected. Historically, a reductionist analysis has been applied to the big problems facing humanity in general by reducing crises such as climate change and poverty and conflict to numerous problems, which represents a poverty of perception and a redundant worldview. These problems appear as one integrated problem or crisis, which we might consider being further exacerbated or impacted in unforeseen ways by the current COVID-19 pandemic.

Any new language of thinking should consider the attributes of systemic integration before action. It ensures that any intervention is compatible with those nested systems and other interdependent nested systems that constitute the macrosystem at work. Capra and Fischer suggest a radical shift in our language of thinking in establishing a sustainable society that supports all life.

Capra's deep ecological view requires a "*radically new conception of life*" and a new understanding of how the world is changing [1, p. ix]. Our planet comprises a series of interrelationships constituting a self-regulating open system. In this concept, the Cartesian mechanistic view of the human body is replaced by an organismic (like an organism), a complex, self-regulating open system.

By taking a systems view of life, we integrate the "*ideas, models and theories into a coherent framework*" [1, p. xii]. A unified systemic vision represents dimensions of biology, cognition, society, and ecology. The author contends that such an integrated view is necessary to solve and mitigate the many crises that plague our global community in serving the common good, not least of which is the current pandemic. This systemic view of life informs a new human ecology and a new ecology of learning.

All living things are complex and non-linear, which can be problematic for conveying ST, given that language is linear. However, language can be applied systemically by employing various systems-based tools such as geographic information systems (GIS), spatial mapping, and visual understanding environments (VUE), which break the linear constraints.

However, any attempt at developing a unifying vision must first consider the evolution of science and the scientific method. Capra and Luigi Luisi [1] state that science has been defined as *knowledge* from the Middle Ages and attributed to the Scientific revolution. The word came from the Latin Scientia and was originally known as Natural Philosophy. Isaac Newton published *Philosophiae naturalis*

principia mathematica, which was to become the foundation of modern science. The modern context uses a scientific method to acquire knowledge. The scientific method came to full fruition during the twentieth century, where empirical science was characterized as a system, which

i. involves the systematic observation of phenomena;
ii. makes connections with the data; and
iii. tests a hypothesis to develop a well-founded theory.

Empiricism and theory building is the very essence of the scientific method. However, science can only provide tentative answers to phenomena. In comparison, ST enables students, teachers, and academics to possess a unifying vision in perceiving, learning, and solving at a very high level of complexity characteristic of our living world.

Science and Society

"*The emerging new scientific conception of life …. can be seen as part of a broader paradigm shift from a mechanistic to a holistic and ecological worldview*" [1, p. 4]. It illustrates a switch from our world's vision '*as a machine*' to a world '*as a network.*' The progression to an ecological paradigm took place in various scientific fields. Capra and Luigi Luisi [1] state that tension prevailed between reductionism (a focus on elements or parts) and organismic or holism (systemic like an organism).

The dynamic of holism and mechanism can be traced through biology. The ancient Greeks saw the world as a cosmos organized and structured and in the sixth century BCE as an organism, not a mechanical system. Their perception was that all parts of our world had a functional purpose, which contributed to an organismic whole, and that elements or objects assumed their functional place. This teleological premise was present within ancient Greek Philosophy and Science. This ancient perspective of the cosmos as an organism also served as an analogy of the interrelationship between the earth and the human body as one, as supported by Plato [1].

Aristotle's treatises integrated the thinking of science and philosophy through to the Renaissance. However, Christian scholars did not recognize Aristotle until Thomas Aquinas during the thirteenth century, who integrated Aristotle's body of work with Christian teaching. Aquinas saw no division between Aristotle's work on nature and the Bible, as the view was that both were authored or inspired by God.

The Renaissance was shaped by philosophy, humanism, and individual expression. I draw upon this cultural shift later in arguing for a new human ecology based on a return to humanism in promoting student self-efficacy within modern education. However, during the Middle Ages period, dogma gave way to a more

secular perspective and an intellectual focus on our human capacity to create art, music, architecture, and literature. Classical Studies, Greek philosophy, linguistic translation, rationalism, and scientific thought became the new intellectual foci.

Capra states that Leonardo da Vinci (1453–1519) developed the foundation of modern science. Leonardo developed an organismic *systematic observation of nature, reasoning and mathematics*" [1, p. 7]. Leonardo created a unique integration between art and science by organizing a groundwork for understanding the nature and underlying principles of function. He did not study science, engineering, and anatomy to control nature but pursued knowledge and truth for insight and enlightenment. Leonardo saw complexity in living things and that human design was subordinate to nature at every level. He was instead inspired by nature, which informed his ideas and designs, ultimately contributing to an ecological worldview, which we now hold in high regard.

Rene Descartes (1596–1650) categorized life into two realms: the mind and the matter, in that all livings things and the material world were viewed as a machine, which could be understood by reducing it to its smallest parts for analysis. Galileo and Descartes' machine-like perspective saw the natural world as organized and governed by the laws of mathematics, which was developed further by 17th-century Newtonian mechanics. From here, Newtonian mechanics was applied to medical science in attempting to illustrate and understand the human body. However, this simplistic paradigm was superseded in the eighteenth century through developments in chemistry and biology.

The pendulum swung back towards a Cartesian mechanistic view of the natural world and living things. The world like a machine became the new reductionist root metaphor dominated by Copernicus, Kepler, Galileo, Bacon, Descartes, and Newton, responsible for the revolution in physics and autonomy. However, unfortunately, in essence, this reductionist worldview continues to this day–reducing education to that of an industrial age-stratified curricula model so prevalent in the USA, UK, Europe, and Australia.

Modern Biology

The poet William Blake (1757–1827) criticized Descartes and Newton's mechanistic worldview, leading to a shift attributed to romantic poetry and philosophy. This new worldview favored a biological, whole systems perspective that served as an antecedent of modern ST today, viewing the earth as an integrated whole. This organ-like view of the earth and all living things aligns with Leonardo da Vinci and, more recently, James Lovelock's Gaia theory 'mother' earth–to include all living things as a living organism.

A new study of microbiology led, particularly by Louis Pasteur (1822–1895), resulted in a shift from a whole systems view of life to a cellular perspective *which could also now be not simply observed, but placed under human control?* This view dealt with disease mitigation and the formation of biochemistry. At the turn of the

20th-century, microbiology failed to progress in providing a lens for understanding life on earth, and a new worldview was founded in 'organismic biology.' This new view of life as an organism, which began with Aristotle and Goethe, was seen as a living system, which cannot be broken down into separate elements and can only be understood through systemic relationships and interactions [1].

Another perspective of holism came from the Gestalt (organic form) psychologists who directly applied the phrase: "*the whole is more than the sum of its parts.*" This described modern ST, but in a way that has its origins with Aristotle's Metaphysics Book 8 during the fifth century BCE. The ecology field eventually emerged from organismic biology during the late nineteenth century from biologists' study of organisms. It informs the curriculum in terms of considering balance about reconciling education with learning and teaching with an assessment where there are disconnects and imbalance in favor of traditional subjects and high stakes standardized assessment that fails to promote creativity, growth, and complex problem-solving [9, 10].

By the 1940s, ST became consolidated as theory, methodology, and a new view of life, leading to GST and cybernetics, as previously stated. I will now explore this new ecological worldview.

This 21st-century ecological worldview embraced a holistic perspective or deep ecology as previously discussed, recognizing the interdependence of phenomena and that "we are all embedded in the cyclical process of nature" [1, p. 12]. An anthropocentric (human-centered) perspective is exclusively a human ecology and is classified as a 'shallow' ecology, whereas a 'deep ecology' includes the earth and all living things as an inclusive ecology. This informs and has implications for most modern education systems at all levels, which are essentially anthropocentric or human-centered in placing humans at the center of nature and ecological interactions at the expense of deep ecology, which embeds humans into the broader ecology.

Lessons from Australian Indigenous Scholarship—Unlearning the Western Paradigm

Capra states that there is a poverty of perception due to the prevailing reductionist thinking, which goes to the heart of the Cartesian dualism critique–a chasm between contemporary thought and the natural world. This is further illustrated by the disparity of thinking between (predominantly) white Australian (western paradigm) teaching on history and geography and Australian Indigenous culture and continuous lived experience. Australian Aboriginals and Torres Strait Islanders have a deep connection with the natural world, now recognized to extend back in a continuous lineage for tens of thousands of years. Their cultural and knowledge systems are diverse but include the four pillars of Kanyini from northern Australia (connectedness):

i. *tjukurrpa*, knowledge of creation or dreaming;
ii. *ngura*, place, land;
iii. *walytja*, kinship; and
iv. *kurunpa*, spirit [11].

This disconnect between the western paradigm of knowledge and understanding of the world with Indigenous culture can be extrapolated upon within most colonized populations across the globe.

Dark Emu by Bruce Pascoe [12] enlightens us of an ancient agricultural culture in Australia for at least 50,000 years. Contrary to the contemporary Australian narrative, it has always been a sophisticated, ecologically sensitive agricultural society. This emerging Indigenous narrative challenges our 'textbook' view of world history, which states that agriculture emerged 10,000 years ago from the Fertile Crescent "*spanning modern-day Iraq, Syria, Lebanon, Israel, Palestine, Jordan, Egypt, together with the south-eastern region of Turkey and the western fringes of Iran.*" Deconstructing this long-held view of 'civilization' in western teaching is an important process in developing better ST approaches in teaching the humanities, history, and critical thinking.

Pascoe's [12] narrative challenges conventional thinking about aboriginal life and culture on the Australian continent. He cites empirical evidence from explorer and colonist journals of the eighteenth and nineteenth centuries, which Pascoe uses to dispel the hunter-gatherer myth in demonstrating that Australian Aboriginals were, in fact, farmers with a highly developed practice of agriculture to include irrigation technologies, the production of cropping and aquaculture systems. Pascoe's work demonstrates the emergence of a highly ecocentric Indigenous economy, potentially extending back at least 50,000 years ago as an ancient culture that has practiced systemic agriculture in-tune with the earth as a living entity. Pascoe makes references to the Indigenous building of "*dams and wells; planting, irrigating and harvesting seed; preserving surplus and storing it in houses, sheds or secure vessels as well as examples of... (ecologically) manipulating the landscape*" [12, p. 2], such as through the use of fire, as examples of sustainable land management practice.

The Australian Indigenous have a systemic perspective embedded in their belief system through their emu story stemming from the dark space evident in the Milky Way: "*The emu is inextricably linked with the wide grasslands of Australia, the landscape managed by Aboriginals. The fate of the emu, people, and grain are locked in step because, for Aboriginal people, the economy and the spirit are inseparable. Europeans stare at the stars, but Aboriginal people also see the spaces in between where the Spirit Emu resides*" [12, np].

This quotation clearly illustrates the systemic, organismic connection between Aboriginals, flora, fauna, the earth, and their spiritual dimension. This, it would seem, is in stark contrast to their European counterparts, who view the cosmos from a more astronomical perspective.

The Aboriginal belief system illustrates a consciousness of dynamic equilibrium and an ecocentric, reciprocal relationship based on deep ecology and a spiritual connection with the country. This Indigenous perspective, in turn, nourishes all living things, not just themselves, through reciprocity. This is the antithesis of our current predominant paradigm that places humans at the center of the earth's ecology, aligning with a Cartesian mechanistic view of nature.

*Europeans saw Terra Australi*s as a golden opportunity for a new market through the agency of cheap convict labor. Colonists saw this ancient Australian continent as a land ripe for exploitation. This object was achieved from a European perspective, resulting in increased wealth to include new towns/cities being built to embrace a growing industrial expansion in serving those colonists and their countries of origin. Gold mining and resource extraction attracted Asian cultures from the middle of the nineteenth century.

Europeans afforded themselves an innate superiority in the sciences, economics, and religion, which informed a destiny over non-European inhabitants and ancient cultures. This was partly attributed to Darwinian theory, leading to the domination over the 'beast' in favor of a Eurocentric view of civilized man. This extended to religious domination by Christianity based on the precept of *Terra Nullius:* land deemed to be legally unoccupied or uninhabited. This was based on the Roman definition of a civilized society comprising a walled city. In particular, the British entitled themselves to a natural authority ordained by their Christian God.

It was unfortunate that 18th and 19th-century colonists not always sought empiricism over pre-enlightenment. The legacy of *absolute truth* ordained by God was still playing out during the colonization of Australia, regardless that Aboriginal cultural practice was aligned with the principles of ST (holism).

Australian Indigenous agricultural systems went well beyond that of their European counterparts and have done so for over 50,000 years in context and harmony with Australia's ecology. For example, advanced aquaculture was observed and dismissed by colonists based on their prejudicial agenda of cultural erasure and displacement. Australian Aboriginals have a common language of ST and know that it innately aligns with earth systems and organismic (organ-like) biology.

The farming of yams (Indigenous potatoes) serves as an excellent example of systemic and sustainable practice by Aboriginals. However, the introduction of cloven-hooved animals and European agriculture was highly reductionist and destructive, resulting in yam scarcity and flora decimation in general. This incursion failed to align with the fragile Australian ecology, destroying ancient systems of sustainable Indigenous practice, which evolved over thousands of years.

Indigenous systemic thinking extended to the trading in seed with relatives with sensitivity to earth systems as a reciprocal ecological process. These practices also serve as evidence of Aboriginal tribes as the first bakers, preceding Egyptians by 15,000 years. "*If we look at the evidence presented to us by the explorers and explain to our children that Aboriginal people did build houses, did build dams, did sow, irrigate and till the land, did alter the course of rivers, did sew their clothes, and did construct a system of pan-continental government that generated peace and prosperity, then it is likely we will admire and love our land all the more*" [12, np].

Australian Indigenous rice was systemically cultivated by Aboriginals in such a way that they were cognisant of biosecurity. This is in contrast to Asian rice, which was becoming less resilient to an emerging disease. These practices also align with cybernetics in that Australia's first peoples were mindful of feedback mechanisms to inform systemic intervention. These practices were evident from the diversity of flora and the ecological interdependence that evolved alongside the Indigenous population, making the entire ecology of pre-colonial Australia biosecure. Furthermore, long-term grain management and food production techniques developed did not require intensive irrigation, nor poisonous fertilizers and pesticides so detrimental to soils, crops, and fauna. These ancient cultural practices impacted very little upon the environment.

'Long term cereal production systems' were also developed by Indigenous peoples. This was achieved by making changes to the 'genomes and habits of plants' through the ongoing intervention of growth cycles and seed selection strategies, establishing a continuous cereal production. This systemic innovation developed a perennial integrated pasture that included a grain crop [12, p. 43–44]. This is an ancient innovation of global significance to inform biosecurity and food production throughout the world. In summary, pre-colonial Australia was a magnificent large-scale garden: *Hortus Magnificum Australis*—tendered by Aboriginal stewards through a culture of reciprocity.

What Is Broken Now?

The Earth, by Humans? This new deeper ecology, as previously stated and informed by Indigenous Australians, challenges us all to question the old reductionist paradigm that characterizes the western industrial worldview. This has implications for our human interactions and relationships within a wider ecology in seeking and identifying solutions to our complex problems. However, as a species, humans have fractured the connections between living entities and their environment. This is evident from the destruction of our wider ecology and the reductionist educational modeling. One only needs to cite the systemically closed Australian, US, and English curricula [13, 14]. This is not surprising given that these countries' educational systems function as closed systems [9, 15, 16].

Bateson tells us that closed systems do not allow matter and energy to pass through their boundaries. Therefore, in extrapolating from a curriculum modeling perspective, closed systems are highly constrained in catering to educational needs due to a disconnect with natural systems. Closed, homogenized systems, whether they be populations of living things or social models, are unsustainable because they are estranged from their ecological environments. A systemically closed entity destroys both itself and its environment. This further relates to our western modeling and, more specifically, curriculum modeling and educational systems in general that do not align with their environmental ecologies [1, 9, 16].

"*If an organism ends up destroying its environment, it has in fact destroyed itself. And we may very easily see this process carried to its ultimate reductio ad absurdum in the next 20 years. The unit of survival is not the breeding organism, or the family line, or the society*" [2, 7, p. 15]. This proposition is analogous to the AC, as the AC fails to display the attributes of an open, ecological system and fails to adhere to the ecological principle of subsidiarity. This suggests that we need to go beyond the current economic paradigm and traditional cognitive constructivism in favor of ST-based social constructivism to inform a deeper ecology. It is important, therefore, to recognize that humans are integral to natural systems and therefore dependent upon nature to exist, function, and survive. To differentiate the human species from the rest of nature is ecologically flawed [1, 17].

New Ways of Knowing and Learning

ST more effectively connects students with their prior knowledge and new knowledge. This is how meaningful learning is constructed. By applying ST, students are actively engaged in learning at all levels and are provided with options in contributing to their community of practice [18].

For example, Robson [19] suggests, in navigating social media spaces, we need to be mindful of embedded ideals that exist within all social contexts. Therefore, we share social norms, behaviors, and ways of thinking and being. This includes approaches to relating to people within a whole social system. Embedded 'ideals' are also 'particular discourses that inform knowledge and identity. Within education, this can be understood concerning 'ideal identity.' Ideals are embedded within complex systemic technological contexts and are nested within complex social systems and environments. Gatekeeper hierarchies and power structures curate dominant discourses about knowledge production, practice, and identity, informing powerful agendas. Engagement with these embedded ideals is either aspired to or rejected.

We must go beyond conventional discourse about online engagement within the education profession and also consider our underlying assumptions of technological determinism. Furthermore, there needs to be more systemic thinking within the critical discourse about the embedded social nature of online social familiarities and wider social issues. Embedded ideals and associated structures require greater critique to moderate bias and prejudice of the inherent power structures, ultimately affecting student knowledge construction within compulsory, post-compulsory, and higher education.

There is also a need to identify and regulate the online gatekeepers from a systemic perspective to make explicit to users: students and communities engaging online to surface hidden agendas. Students of all levels (age-appropriate) should also be equipped to identify ideals and the overall design in terms of how it constructs user engagement.

By applying organismic biology and being cognisant of dynamic equilibrium, we see the world through fresh eyes: a world of ecology and ecologies within ecologies or systems within systems. ST is a metasystemic methodology that enables us to perceive, understand systems, and intervene to manage goal-based open systems that characterize living things and closed systems that define non-living material things.

This mosaic lens is a powerful way of knowing and learning. This is because it connects with the earth's many systems and is sensitive to the life cycle of all fauna and flora. ST is supported by sound ecological and organismic biological theory, which I will elaborate upon later.

ST also aligns with being group smart in that innovation comes from collaboration with others by drawing upon the natural world. Smart Swarm by Peter Miller [20] conveys how nature teaches us how mass collaboration serves better organization to inform functionality. Miller goes on to teach us that historically our (educational) institutions have 'defaulted to traditional hierarchies.' Smart Swarm transforms how we see our world and others as reciprocal agents for learning, knowing, change, and problem-solving intervention.

Tapscott, who wrote the forward to Millers' text, states that Smart Swarm challenges the 'tenets of hierarchical control' in collaborating across organizational silos. He also challenges us all to rethink power through people rather than over people. "*This model has worked well as a way of systematizing work, establishing authority, deploying resources, allocating tasks, defining relationships, and enabling organisations to operate*" [20, np]. This comes from a more organismic approach to organizational hierarchies in allowing systemic self-organized networking and interconnection to form collaborative teams globally. This informs educational curriculum modeling in exploring and sharing best learning design practices to employing connective ST-based social principles such as subsidiarity, solidarity, and the common good. Now I will delve more deeply into curriculum modeling.

Current Curriculum Modelling

The problem with current curriculum modeling is that we are not cognisant of 'dynamic equilibrium' and systemic thinking in general and tend to overreact to the dynamic peaks and troughs within our education systems. Closed systems such as the Australian Curriculum (AC) [21] administered under the Australian Curriculum, Assessment and Reporting Authority (ACARA) mitigate reductionist curricula by implementing patch and mend strategies or short-term symptomatic remedies. The natural world further illustrates this in that change and fluctuation is natural phenomenon, requiring actions that are sensitive and mindful of the dynamics of fluctuation and change. By way of analogy, it is akin to moving house in the advent of a one in a one-hundred-year flood. It poses the question; how do we mitigate such flooding and keep the integrity of our waterway systems?

Curriculum modeling is not dissimilar in that contextual change (such as the COVID-19 pandemic) poses a shock, but we are still human, and we are still part of the natural world, requiring a sensitivity for the moving parts or ecological variables. To overreact by closing ourselves off to the wider ecology through autocratic policies and models results in a fracture between policy and curriculum [13, 22]. I will now address how ST may address systemic problems with systems solutions.

Can ST Fix This?

Bateson and Capra suggest drawing upon the natural world through biology to build more resilient systems of knowing and learning. This can be constructed by unifying our thinking in creating stronger links with our natural systems. Humans are self-regulating open systems, just like the entire earth's ecology. We regulate our bodies but have the power of choice that sets us apart as a species. This is a clue in considering how to mitigate the problems that beset us and how to live sustainably in allowing our entire ecology to flourish as a whole system.

Policymakers could integrate this ecological worldview into our education systems, policy settings, and curriculum modeling. Pangaro et al. [6] suggest utilizing feedback from our actions through the employment of cybernetics in that we can course-correct in real-time to reach our set goals.

This ecological worldview is similar to organismic biology and also links to von Bertalanaffy's [3] Dynamic Equilibrium by being cognisant of both negative and positive feedback mechanisms that assist us in self-regulating at every ecological level. In applying this as a language for curriculum modeling and learning, teachers and academics must also consider our collective imperatives in progressing a new educational ecosystem [23].

Teachers today generally regard themselves as facilitators of learning in a complex environment [10]. If this is the case, then learning will be our key educational goal. Then we must ask, what is learning, and how do we measure growth and success? In simple terms, education, Curriculum, learning, and teaching are not easily defined. For example, the funding of an education system, the communication of a curriculum, and teaching practices do not always mean that learning is taking place. In some instances, quite the contrary. For learning to occur, a creative process culminating in producing a cultural artifact may have been necessary that is useful to the student(s) and their community. A goal must be made explicit, and the journey negotiated with the learner researcher to be measured within a continuum of development and growth without the fear of standardized grading. The assessment then becomes a collaborative goal-based narrative by both the educator and student.

ST Curriculum Modelling

In drawing upon my curriculum models [24, 25], I will further demonstrate how ST informs Curriculum and pedagogical innovation by mitigating traditional schooling effects. In the western tradition, the 'schooled mindset' served 19th and 20th-century industrialism for occupations that no longer exist or are in the process of being overtaken by roles fit for a digital society. Educators and students are left with a production model legacy in the twenty-first century characterized by an age-stratified education system compounded by a subject-based curriculum structure [25].

In contrast, an ST approach to curriculum modeling and pedagogy favors interdisciplinarity and returns to a village model of the classroom or age mixed environment. This approach reinforces social connection and is mindful of how students are socially and intellectually situated. Other attributes of ST include the promotion of student self-efficacy and agency in fostering resilient, independent learners.

Organismic Biology Informs Compulsory Educational Modelling: Open Systems

Organismic, open system education modeling promotes increased flexibility. For example, by applying disciplinary lenses as threads in gathering real-world elements in forming thematic curricula modules. This creative synthesis embeds traditional disciplines within meaningful, relevant contexts that resonate with students. This process emulates an organism, which is evident through its connection seeking and consolidation/defense attributes. This mitigates the constraints of the current divisions of knowledge as defined by traditional subjects.

This transdisciplinary thematic focus provides much-needed stimulus and scope for creative, virtual worlds curricula and problem-solving simulation development. Chow [26] states that being present in a virtual world learning environment promotes more effective learning for students. Robinson [9] states that we live in a virtual world of ideas, which align with this approach as it connects to our enormous creative capacity. Furthermore, this virtual environment also allows students to connect with and model behaviors for real-world applications to include cultural artifacts useful to themselves and their communities.

This form of systemic learning is applied engagement within a collaborative ecology instead of the listening and absorbing learning model, which is highly passive. The role of the teacher undergoes changes to that of a mentor and co-learner with the student. It is a shift from reductionist schooling to a higher emphasis on student self-efficacy. This new paradigm also enhances the systemic UX (user experience) design, allocating students as agents of their own education construction, design, and synthesis. Such a model can also be informed by vertical curriculum modeling in mitigating the adverse effects of age-stratified design and

learning. This is reinforced by positive psychology that provides greater agency for users in strengthening this UX focus.

Students, as agents of change, can potentially progress such educational modeling through this systemic UX focus as an ongoing organic process in collaboration with teachers, academics, and specialists. This challenges the Cartesian machine-like approach by developing an ecology of systemic practice. The emphasis here is ecology and holism, which contrasts with the prevailing deficit approach that seeks to view students as being educationally deficient in need of homogeneous schooling or treatment [27].

Ivan Ilich [27] critiqued the role of schooling, noting that within its traditional/industrialized western form, it has confused substance and process in promoting the view that clinical, educational treatment leads to a well-educated person and, ultimately, to success. Ilich also states that this also disenfranchises the individual and his/her communities of practice. Within traditional schooling, imagination becomes schooled to include a severe decline in creativity. Robinson [8] states that there is a negative *corollary* between a child's school life and a decline in creativity. This is a travesty because creativity is of paramount importance for students and young adults to become innovative, independent, collaborative learners.

Discussion

An Existential Threat in All Its Dimensions

Utilitarianism has been the main object of the West at the expense of the Common Good and Human Flourishing. The litmus test is, are we thriving or just surviving? The connection between education and socio-political objectives remains the prominent driver of education policy and the resultant curricula of many countries. Of particular issue is the socio-economic underpinning of access to and participation in education, regardless of the relative wealth of nations.

Herman and Chomsky [28] state that poverty is 'by design' and is a socio-economic construct that structurally allows developed nations to create wealth, privilege, and power over others. This ethos has corrupted political systems and education. For example, Chomsky states that in the US, democracy as a lexicon has been emptied of its original meaning to an exploitative end driven by a neo-liberal super-rich elite who represent less than 1% of the US population. The US corporate Politcal Action Committees dictate policy and shape legislation in dividends and invested interests after funding targeted politicians to get elected. From a functional structuralist perspective, education is unavoidably affected and shaped by this through a nationalistic narrative taught in schools, for example, Truth, Justice, and the American way, a well-known American slogan. Unfortunately, this culture of money-for-policy exists throughout developed countries to the detriment of the democratic process financed by large corporations. One way of

mitigating this is to apply ST principles in creating a level playing field by capping political donations and promoting subsidiarity and more equitable community access and representation.

Integrating ST throughout education, within both compulsory and non-compulsory sectors, potentially empowers students to interact and make decisions and contributions in ecologically sustainable ways. As our future policy advisors, from social justice to mitigating climate change to living in balance, I think if ST was embedded in our education systems globally, we would not have, for example, exploitative policies rendering 1 billion people in a state of poverty worldwide. Developed countries live at the rate of three planets earth, while the rest struggle to live healthy, equitable lives.

Education here has a very important role to play in educating our population to be engaged, ethical citizens at all levels. It requires that educators, learning designers, and policymakers think anew by drawing upon ST, Indigenous belief systems, wisdom traditions, and philosophy to instill an ethical dimension and a moral purpose in student graduate attributes at all sector levels. This could also include employing, for example, ST in promoting a critical frame of mind in ultimately mitigating manufactured consent as perpetrated by the popular 'media propaganda machine' as identified by Herman and Chomsky [28]. Unfortunately, critical thought has been subsumed by manufactured truths based on the tenet of a protectionist narrative, whereby the instruments of government and media censor truth and reality. Unfiltered truth becomes a threat to the corporate culture, foreign policy, and therefore the western power base: 'power is the right to dictate reality.'

We learn stability from living organisms. However, unfortunately, neo-liberalism, compounded by an anthropocentric worldview, has little empathy for our declining earth, particularly given the corporate control of the earth's resources. Indeed, there is a proposition for a new language of thinking. Indigenous ecocentric cultures are a long way from Wall Street, where the earth is viewed as a resource to be exploited regardless of the consequences, which is in stark contrast to the Indigenous, who view our earth as an organism and a living entity that must be respected. I will expand more on this by exploring the Australian Indigenous culture later in this chapter.

Embedding Sustainability Across All Curricula

The knowledge divisions are at odds with ST because they reflect a Cartesian industrial construct, not a socioecological one. For example, by adopting a more systemic, age-mixed transdisciplinary education model worldwide, we enhance our capacity to adapt to changing contexts and environments. As humans, we are self-directed systems wired for change and adaptation to new environments and contexts. Therefore, it is important to be cognizant of this disposition and align our learning and curricula accordingly, but with a sensitivity of all ecologies that we are nested within. This respects the earth as a valued entity that we are dependent upon for our survival and the survival of all living species.

We need to bridge the Cartesian gulf between the mind and the physical realm by employing circular systemic problem-solving in addressing root causes. The proposition of a 'circular economy' may be one positive example, although this too has its critics as an example of 'shallow ecology.' This can be achieved by reflecting, modeling, and acting in proposing ecocentric approaches. This then informs preventative, sustainable solutions that appreciate the earth as a living organism that provides an indispensable life support system. Cybernetics is also relevant here by applying positive and negative feedback in correcting our course of action against goals.

The human body serves as an instructive metaphor in illustrating this proposition further. The body requires stimulus, food nourishment, social interaction, and exercise for mind and body to maintain the human person in all its dimensions: emotional, physical, cognitive, intellectual, and social. These are also interdependencies in that any singular weakness potentially creates a systemic breakdown and dysfunction. This human system is nested within a myriad of ecological systems that we, humans, are dependent upon to survive.

Change, Our New Constant

Our world is never static, but most western countries educate their populations as if it was. We live in a world of change and interconnection. Predicting our future is fraught with misconceptions and a denial that we have progressed from the Enlightenment period given our industrial education paradigm. For example, in the history case study exemplars in the Australian Curriculum, one can only be impressed by the paper-based colored pencil illustrations. Some insightful work seems to be an absence of contemporary artifact examples reflecting new modeling and digital literacies. Well done to those students and their efforts—valid study here, no intention to disparage. However, it is produced with 60 s technologies.

Today we need a new way of thinking that requires a web of diversity, not convergence—exploring many answers to those complex problems that beset us. Traditional schooling prescribes answers and formalizes our thinking and modeling by applying a patch and mend addressing today's symptoms. As educators, we should instead deal with the root causes attributed to an outdated legacy of thinking perpetuated by neo-liberalism.

The dynamics of our interrelationships could benefit from a group smart systemic culture of thinking. The Age of Paradox by Charles Handy tells us that unemployment from companies and institutions removes the shackles that stifle our initiative by allowing a channeling of a new collective potential for a new business ecology, as we become consumers of each other's goods and services within a reciprocal economy. This poses a more collaborative ecological economy that is more disposed to social justice and the common good through interdependence [29].

Systems Thinking and Digital Virtual Worlds

To further enhance our new systemic language of thinking, Digital Twin Technology (DTT) can be employed to inform education modeling and simulation from real-world scenarios. DTT virtually replicates a given environment, system, or program for future modeling, simulation, redesign, critique, and problem-solving. This could theoretically help build a new human ecology that values individual self-efficacy, interdependence, and collaborative learning.

A systemic DTT application has particular relevance if Virtual World learning environments are being considered and developed, as it becomes a developmental bridge for UX (user experience) design. This approach also informs simulations to teach cause and effect and long and short-term consequences of human actions. For example, as previously stated, embedding sustainability across a school and university Curriculum mitigates the effects of climate change and promotes graduate attributes that foster sustainability in all its dimensions in living within the limited resources of our planet earth. Systemic thinking informs us that we live within a materially closed system and that where possible, these materials need to be recycled or ecologically offset.

These Virtual World environments align very effectively to how humans systemically function in that we already live in a virtual world of ideas. For example, our ability to dream, imagine, and create and construct our mental world. Senge [30] tells us of a mental model that informs our thinking and reality and that new experiences alter these states of being by being engaged in new learning experiences.

A systemic DTT approach assists educators in designing, building, and operating new education models. Furthermore, this new thinking and modeling inform ST Cybernetics and student goals in constructing innovative Curriculum and learning to reflect student learning priorities within compulsory and non-compulsory education.

At a higher education level, systemic collaboration can lead to the development of incubators of innovations by students and academics. It is evident given the Advanced Teaching and Learning program at Warwick University and the *Systems* and Environmental *Sciences* Department at Open University UK, where transdisciplinary programs flourish through students practicing their own production, creativity, and systemic problem-solving.

Narratives in Sound Art

ST can be illustrated by arts collaboration. In further developing a systemic approach to Virtual Worlds by employing sound and graphic art composition, provides an immersive experience, rich UX experience for academics, teachers, and students at all levels. By exploiting sound, graphic, and animation art through contemporary narrative, students can construct their own worlds and provide collaborative case studies and artifacts as integrated learning outcomes to be published in the public domain. It enables students as knowledge producers and consumers within a reciprocal learning community.

Through an augmentation of verbal phonics, we can access an entire sound resource that reflects at many levels, both semantic meaning, literary device, and narrative soundscape composition. This represents the employment of the human system as a creative resource. For example, a soundscape composition based on the word Lamenterra, which I composed in 1995, was a term created to reflect a lamentation and celebration of the earth (see Appendix I). By augmenting or reducing the spoken word frequency: Terra (earth) to produce a percussive phonic effect, I created an entire soundscape narrative from both a literary and sound art perspective. This was conceived and defined as a creative aesthetic system as an element of this art installation. Search for Australia Felix also portrayed the earth as an organism [31].

Search for Australia Felix

Search for Australia Felix was a systemic process that involved a diverse group of artists, including composers, graphic artists, choreographers, and communities from various cultural backgrounds to include an Aboriginal College with the local townspeople of Benalla, Victoria, Australia. This project included Indigenous stories, dance, and music, which contributed an aesthetic dimension to the creative, collaborative methods. This Indigenous contribution provided fresh, insightful perspectives on creative expression through their belief system.

The Aboriginal input also brought a contrasting value system to this project, reflecting connections with the earth and its inhabitants. "*A western understanding of* '*dreaming*' *is as a timeless state of being and believing. The aboriginal tradition traces cultural journeys from their ancestral past and assists in reinstating our web-like organismic relationships through realising the creative and celebratory bonds that still exist between people and the earth. By amplifying the strengths of these relationships, we serve to disseminate issues of awareness and provoke questions of past, present and future*" [31, p. 6].

Conclusion

We must develop a new language of thought that disenthralls us from the old industrial, educational model. As humans, we are self-correcting, goal-based open systems that function best within a social climate informed by an ecological ST worldview. However, unfortunately, an anthropocentric education model has predominated since the introduction of mass education in the nineteenth century. This education model has been characterized by reductionist industrialism and commodification for an era that longer exists [10, 15]. "*The most ethical thing we can do is increase the choices of others*" [33]. By establishing and developing ST as a new language of thought, we empower all to serve the future needs of our communities.

Core Messages

- There is a need for a new human ecology in education that aligns with our earth's ecosystem.
- Adopting an ecological worldview through curriculum and learning models helps mitigate the multitude of crises we face worldwide.
- Moving from an anthropocentric education paradigm towards an ecocentric one is imperative for sustainability.
- Indigenous curricular perspectives, inform learning and teaching with greater ecological sensitivity.
- The principles of ST in education are quite promising in promoting social justice, human dignity, and the common good.

Art Performance

Search for Australia Felix (*Lamenterra Project Production Film by Spain, S., Power, M., Pollard, M. and Balla, T., 1996;* https://bit.ly/30oUBsV)

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