Transdisciplinary (TD) has evolved over the last 40 years as a way to grapple with the complex, wicked problems facing humanity (McGregor, 2015; Nicolosu, 2014). Elements include health inequity, climate change, unsustainability, loss of diversity, poverty, uneven development, and unequal income and wealth distribution. Trans takes us beyond multi (more than one) and inter (between, among) disciplinary, which are confined to university academic disciplines. Trans means across and beyond to a new space (Harper, 2020) where new knowledges is made from combined disciplinary and life-world knowing (i.e., government, business, and civil society). The transdisciplinary approach to knowledge creation was developed to address social, political, environmental, economic and technological problems that resist resolution using just disciplinary knowledge (Nicolosu, 2002, 2014).

A point of fact – complex transdisciplinary problems cannot be completely solved; they can only be addressed. To address a problem entails directing attention and resources to it so that it can be better understood, preparing people to begin to deal with it (Stuart, 2018). Complexity thinking and complexity logic are needed to reason through and address transdisciplinary problems, because they are complex and wicked (Destois, 2012; Liang, 2017; Nicolosu, 2002, 2014), to be discussed.

This paper teases out this unique type of logic so it will be easier for others to employ – beginning with an overview of complex wicked problems. The thinking and reasoning needed to address these problems will require logic that can deal with complexity. According to logic in general, traditional classical logic and laws of thought are described. Their inability to deal with complexity led to scholarly work on the logics of complexity and the need for a complexity mindset (Liang, 2017; Nicolosu, 2014). The “logic of complexity can be used to understand the problem space (better, the space of possibilities) when addressing seemingly intractable problems and create coevolving enabling environments and more positive futures” (Serrat, 2017, p. 352).

Complex Wicked Problems

This section distinguishes among a problem, a complex problem, and a wicked problem. Conflating them in discussions of transdisciplinarity short circuits people’s appreciation of how they differ and the reality that wicked problems merit a unique approach.

Problem

Problem is Greek terminology, “put forth; that which is proposed” (Harper, 2020). A problem is a question, matter, task, discrepancy or stimulus for which its explanation or how to address it is not immediately known (Costa, 2020). Problems can be solved using high levels of expertise from a variety of fields to apply formulas and standards with the expectation that what worked before will work again with predictable results (e.g., building a bridge) (Stuart, 2018).

In contrast, complex problems (made up of many interwoven, different, parts) can be approached “from multiple, sometimes competing, perspectives and may have multiple possible solutions” (Penn State, 2020, p. 1) to solve them, they need to be approached with formulas or standardized approaches. What worked in one situation may not work again. High levels of expertise can be helpful but are not sufficient. The outcomes are uncertain and are considered to be better or worse rather than right or wrong (Rittel & Webber, 1973; Stuart, 2018) (e.g., addressing inner city poverty and crime).

Complex Wicked Problem

Complex problems become wicked when they are “highly resistant to resolution” (Australia Public Service Commission, 2007, p. 1) (e.g., saving the Amazon rain forest or stopping desertification caused by deforestation or inappropriate agriculture naively thought to ensure prosperity). But “complexity itself is not enough to trigger a wicked problem…” (Liang are driven when) “serious disagreements among stakeholders are combined with complexity and uncertainty (wherein) we have crossed a threshold” (Head, 2008, p. 103). The problem has shifted from complex to wicked, which is Middle English winked, “bad” (Harper, 2020).

Trying to solve wicked problems creates even more problems (some of them wicked), but something must be done. Wicked problems are messy, vicious and aggressive. They are context unique, hard to define and unpredictable with many disparate stakeholders surgery in place for the voice of their intransigent and resolution. These people bring varying different world views and perspectives to the table and tend radically different opinions about possible causes and cures. Consequences of intended or not of any actions considered or taken are not known beforehand (McGregor, 2012, 2019; Rittel & Webber, 1973). At the time of writing, the Coronavirus COVID-19 had emerged as a profoundly complex wicked problem with inconceivable, long-lasting consequences. Never has the whole world been shut down (Berninato, 2020).

Complexity

Complexity is an interesting word. It is more than simple (Latin, “plain and simple”) and complex (Latin, “plaited, interlaced strands, intertwined, embraced”) (Harper, 2020). The opposite of complex is not simple (i.e., few parts or easy to understand) but that which is not; noncomplex means independent and not connected (Alvira, 2014a, b). Complexity is nonlinearity, meaning the interwoven strands are defined in relation to what they are connected. Nonlinearity also means the whole is different from the sum of all the parts (e.g., a cake made from different ingredients). In contrast, linearity means the whole is equal to the sum of the parts (e.g., the cost of the grocery bag of ingredients used to make the cake). Some phenomena exhibit both properties. The cost of buying stockequals to the total cost of all of them added together (linear). But the variation (difference) in those stock prices is often chaotic (nonlinear) (Alvira, 2014b).

Liang (2017) further distinguished linearity and nonlinearity by the proportionate relationship between cause and effect. With linearity, a small cause always leads to a small effect, for example. Such actions are predictable, objective and orderly. In contrast, nonlinear systems have nonproportional relationships between cause and effect. A small, leveraged action can lead to systemwide change – to a very large effect. This chaotic, disorderly and unpredictable result is amplified by the emotional and subjective human thinking dimension of systems behavior (Liang, 2017; Sensc, 2006).

Complex Adaptive Systems

Complex adaptive systems (CAS), like the stock market, an ant hill or a family unit, defy prediction because they are self-organizing (i.e., able to spontaneously adapt without the need for external control). They “are neither stable nor unstable; but operate at the boundary between the two zones. (They are said to exist) on the edge of chaos” (Darn & Barcley, 2006, p. 22), which is order emerging just not predictably.

The edge of chaos can be a space or a boundary. As a space, it can be both physical (e.g., moving into a tornado-hit region) and mental wherein people are at their highest level of adaptability and innovation. As a boundary, the edge of chaos refers to the edge of things where high turbulence exists with great potential; it is the edge of emergence (Liang, 2017) where things can cross thresholds and transform (i.e., climb up and over to a new space).

In CAS, order and uncertainty can coexist, like in a stock market. There are “continous changes involving high finite dimensionality” (Liang, 2017, p. 562), meaning many variables are constantly changing moving toward some sort of temporary equilibrium. This dynamic is exacerbated by the existence of (a) the known (what they know), (b) the known unknowns (what they know they do not know but can learn) and (c) the unknown unknowns (unexpected and unforeseeable conditions that can appear suddenly creating crippling surprise and total uncertainty and risk). Each person addressing a problem comes to the table with a different take on these three aspects of nonlinear thinking (Appelo, 2010; Liang, 2017) further exacerbating complexity thinking.

Complexity Thinking

Those involved in complexity thinking “work the system, not the people” (Appelo, 2010, Slide 61). They appreciate that with a complicated problem, they can simplify the system to make it understandable. With a complex problem, many interwoven strands (what they know), (b) the known unknowns (what they know they do not know but can learn) and (c) the unknown unknowns (unexpected and unforeseeable conditions that can appear suddenly creating crippling surprise and total uncertainty and risk). Each person addressing a problem comes to the table with a different take on these three aspects of nonlinear thinking (Appelo, 2010; Liang, 2017) further exacerbating complexity thinking.

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A settled, well-established and regular tendency to do something in a particular way (Anderson, 2014); in this case, to think. Nineteenth century American educator Horace Mann said that a “habit is a cable; we weave a thread of it each day, and at last we cannot break it” (as cited in Costa, 2020, para. 1).

**Reasoning**

Applying logic depends on reason, which is Latin ratiocinatio, “consider” (Harper, 2020). Reason is the “power of the intellect to comprehend, reflect, abstract, and draw conclusions” (Rohmann, 1999, p. 337). An unreasonable person is illogical and irrational, meaning their unconsidered actions are not based on reason or logic. Reasoning refers to using the power of the mind to consider, understand and think about things and then form thoughts, opinions and judgements (Harper, 2020; Rohmann, 1999).

Reasoning is a type of thought, and logic is an attempt to describe the rules or norms by which this thinking happens. Logic happens inside a system following a set of rules, and reasoning happens outside the system by working the problem (forward and backward), skipping logical steps, changing the rules, or diagramming things (Hofstader, 1979). Walton (1990, p. 403) further distinguished between “reasoning in logic” (step-by-step process moving from assumptions to conclusions following rules or warrants) and “reasoning in psychology” (actual thought processes involved in exercising the mind). This paper leans toward the latter – mental processes involved in working the problem.

**Inferences**

In addition to reasoning, logic requires people to draw inferences (i.e., conclusions based on reasoning and evidence) (Gensler, 2017; Walton, 1990). Inference is Latin inference, “to carry forward, bring about” (Harper, 2020). Inferences are evidence-based guesses. People read or hear something and then draw conclusions based on what was not said. Instead of depending on explicit statements expressed in words, people draw conclusions based on their reasoning using available evidence. They cannot assume that people express everything needed for another person to construct their intended meaning. Thus, when applying reason to consider another’s comments, people often have to infer (extrapolate) what was meant. Any inference that does not arise from available evidence is mere conjecture or speculation (Flemming, 2013).

**Fallacies and Paradoxes**

Logic also involves fallacies and paradoxes (Cantini & Bruni, 2017). Fallacies are flaws in reasoning that deceive or mislead people. Also called errors in logic or fallacious reasoning, an example of a fallacy is distracting a person from the claim being made by introducing another topic that is easier to argue – called a red herring. Another example is making someone else’s argument look weaker and easier to dismiss than your own claim – called a strawman (McGregor, 2018b, Chapter 17).

Paradoxes contrast two normally unassociated ideas to create a provocative idea (e.g., ‘Less is more’ and ‘it is kind to be cruel’). They serve “to arrest attention and provoke fresh thought” (Editors of Encyclopedia Britannica, 2020, para. 1). A paradox combines contradictory elements to the point of being seemingly absurd and contrary to accepted opinion (“Paradox,” 2020). “The point of a paradox is to point out a truth, even if the statements contradict each other” (Examples of paradox, 2000).

**Logical Thinkers and Sound Reasoning**

Logical thinkers have several habits of mind that distinguish them from illogical thinkers. Foremost, they try to arrive at the truth of things; both what is real (ontological truth) and statements about it (logical truth). They get their facts straight and make sure their articulated ideas match the facts. They constantly test their ideas to make sure what they are saying reflects what they are seeing and thinking about. They are attentive to and aware of the whole situation. When making a rhetorical and logical claim, they communicate using clear and understandable language geared to their audience (McInerny, 2005).

Logical thinkers capable of engaging with complex problems are aware of their own thought processes (metacognition) and have a questioning attitude, always looking for problems to solve. They think flexibly (i.e., look at things in different ways), which helps them to generate novel ideas and strategies. With an adventurous spirit, they take intellectual risks and are prepared to experience awe and wonder as they seek truth. They strive for accuracy, are thoughtful and deliberative (i.e., think before they act) and are willing to admit when they do not know something (Costa & Kallick, 2000). Their application of logic and reasoning leads to convincing, valid arguments (i.e., a set of reasons given in support of something) (Walton, 1990).

**Traditional Laws of Thought (Exclusive Logic)**

Classical Linear Logic (Simplicity and Duality) Reinforces Tension between A and Non-A

**Axiom of Identity:** A is A.
- Everything is itself.
- Whatever is, is.

**Axiom of Contradiction:** A is not non-A.
- No thing having a given quality also has the negative of that quality.
- Nothing can both be and not be (e.g., be true and false at the same time).

**Axiom of the Excluded Middle (Third):** There exists no third term T that is at the same time A and non-A. This T cannot exist in contradiction. No reconciling third possibility is logically foreseeable.
- Everything must either be or not be – dualistic.
- Everything either has a given quality or has the negative of that quality (e.g., it is either this or the other but not both).

Contemporary Nonlinear Logic (Complexity and Nonlinearity) Frees Tension between A and Non-A

**Axiom of Identity:** A is A.
- Everything is itself.
- Whatever is, is.

**Axiom of Contradiction:** A is not non-A.
- No thing having a given quality also has the negative of that quality.
- Nothing can both be and not be (e.g., be true and false at the same time).

**Axiom of the Included Middle (Third):** There exists no third term T that is at the same time A and non-A. This T can coexist in contradiction, because actualized, non-A is potentialized without disappearing entirely - a reconcilable foreseeable.
- Things can remain distinct separate (e.g., mind and body nondualistic).
- Things can (a) both be the one or (b) both be neither other one.

Exclude is Latin excludere, “to shut, keep out, hinder” (Harper, 2020). People applying exclusive logic (i.e., the logic of the excluded third) would reason that there is no possibility for anything to be true and false at the same time. Suggesting such a thing is illogical. For example, the mind is one thing, and the body is another. Based on this premise, Western medicine has evolved based on empirical science and controlled
experiments (e.g., the body) with no room for intuitive, spiritual or transcendental ways of knowing (e.g., the mind). Nicolescu (2014) framed this as the huge divide between technoscience and spirituality. Excluded logic assumes that people can say something is true or false, but they cannot say it is neither true nor false or it is both true and false. They are denied access to this conclusion, because ambiguity cannot be tolerated (i.e., not clear, undecided). Things either are or they are not. There is no middle ground, which is why this is called the logic of the excluded middle. This logic assumes that knowledge cannot evolve if there is ambiguity (Nicolescu, 2014). The damage caused when using exclusive logic to address complex wicked problems is that it rules out too many things that might be fundamental to addressing the problem. And, it negates the possibility of contradictions and antagonistic ideas coexisting with the potential to generate something new by resolving the tension between them (Nicolescu, 2002) (to be discussed).

**Transdisciplinary Logics**

Transdisciplinarity was conceived partially to stave off the inadequacy of classical linear logic to address complex wicked problems. In particular, Nicolescu (1985, 2002, 2014) respected but took issue with linear logic’s triadic structure: A, non-A and the excluded middle T (see Table 1). Indeed, “very few would try to maintain that [traditional logic] is adequate as a basis for understanding … everyday reasoning” (Smith, 2017, para. 5). “Even Aristotle considered the law of the excluded middle somewhat shaky” (Rohmann, 1999, p. 236). “Reason is contradictory in its own nature” (Nicolescu, 2014, p. 132).

Nicolescu (2002, 2014) is a theoretical quantum physicist who is especially concerned with the global trend of relying on exclusive logic to address the problems facing humanity. He challenged the traditional tertiary approach and formulated a new one (see Table 1) along with a totally new methodology for creating knowledge that bridges disciplines and the life world (i.e., governments, businesses and civil society). As with conventional methodologies for producing or creating new knowledge (i.e., empirical, interpretive and critical) (McGregor, 2018a,b), Nicolescu’s (2002) methodology is based on three philosophical axioms: ontology, epistemology and logic; axiology (values) is also an axiom but not so for Nicolescu’s approach. Axioms are self-evidently true principles – no need to explain, question or demonstrate; their truth is obvious. If someone says something is so, you can take their word for it (McGregor, 2018b).

In more detail, first, transdisciplinary reality (ontology) exists along many levels (TD-Subject [perspectives and consciousness] and TD-Object [facts, evidence, statistics]). Respectively, examples include individual psychology and philosophy, history, and political ideology (TD-Subject) and economics, technology, and environment (TD-Object). Interaction among these seemingly contradictory realities is mediated by the unifying force of the Hidden Third (such as art, drama, music, culture, spirituality). People meet in a mental zone of nonresistance to each others’ ideas to create new knowledge. Second, transdisciplinary knowledge (epistemology) is complex, emergent, embodied and cross fertilized. These two axioms are described elsewhere with deeper and broader coverage (McGregor, 2011, 2018a; Nicolescu, 2002) with the remainder of this paper focused on the third axiom – logic (see Figure 1).

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**Figure I – Using Inclusive Logic and the Logic of Complexity When Creating Transdisciplinary Knowledge**

With the advent of the new sciences about 100 years ago (i.e., quantum physics, chaos theory, and complexity theory), challenges to linear logic appeared. A key champion of this effort, Nicolescu (1985, 2002, 2005) formulated two logics: (a) the logic of the included middle (inclusive logic) and (b) the logic of complexity. The former deals with reconciling contradictory and antagonist ideas so new facts, thoughts and insights can emerge, and the latter helps people to weave these new disparate strands of thinking into a complex new whole. In short, inclusive means including integral elements whose absence would be notable, and complex means embraced, braided and intertwined (McGregor, 2018a).
In summary, Nicolescu (1985, 2002) contributed two new logics to augment traditional laws of thought, which are valuable but not privileged. He formulated (a) the means intertwined (Gélalian, 2018). By complexus, Nicolescu (2010) meant the unification of different types of complexity, what he called economics: classical, ecological, feminist, behavioural).

Types of complexity

consists of many small, ever-changing regions. Therein, space and time are not definite but fluctuate in a foam-like manner (Wilczek, 2010). When addressing complex problems, these small bubbles could represent complexity in cyberspace-time.

They cannot occupy the mind at the same time because they push against each other. This means that when dealing with complexity, people cannot create new knowledge that is aware of the ignorance that it brings” (Nicolescu, 2014, p. 134).

Generalized complexity

with “the generalized interdependence of everything and everyone” (2005, p. 21). This means that when dealing with complexity, people cannot create new knowledge unless they “try to comprehend the relations [emphasis added] between the whole and the parts” (Nicolescu, 2014, p. 134). This is why the world is totally predictable” (p. 87). “Morin recommends the adoption of open thinking, negotiating with the unknown, and a knowledge that is aware of the ignorance that it brings” (Nicolescu, 2014, p. 134).

Useful here is Morin’s (2005) notion of generalized complexity. Quantum science respects the principle of universal interdependence (Nicolescu, 2005, 2014) thereby enabling Morin to equate generalized complexity with “the presence of gaps and interruptions, the appearance of everything and everyone” (2005, p. 21). This means that when dealing with complexity, people cannot create new knowledge unless they “try to comprehend the relations [emphasis added] between the whole and the parts” (Nicolescu, 2014, p. 134). This is why the world is totally predictable” (p. 87). “Morin recommends the adoption of open thinking, negotiating with the unknown, and a knowledge that is aware of the ignorance that it brings” (Nicolescu, 2014, p. 134).

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In more detail, complex problems manifest when people experience dilemmas, a situation when they have to make a difficult choice between alternatives when the decision may bring negative or undesirable consequences (Costa, 2020). Inclusive logic and the logic of complexity are designed to help people to negotiate their way through a dilemma where many varying voices are present. These logics create disruption leading to interruption (stopping a process) and the opening of a liminal space where threshold crossing is possible (Preiser, 2012). Wicked problems exist when thresholds have been crossed (Head, 2008). Liminal spaces are temporary zones of nonresistance (zone of nonresistance) so any limiting factors can be identified and inhibited so collective learning and knowledge generation can proceed. To that end, in a process rife with contradictions that have to be held in limbo, Senge (2006) especially lauded the principle of leverage wherein the best results come from holding the system in the zone of nonresistance (slowing down), (d) stability is an illusion and impermanence is the essence of continuity and (e) every in-process answer becomes a knowledge springboard. People are urged to (f) convert doubt into knowledge – that people have a way to weave these new emergent lines of knowledge together using logic other than exclusive logic.

Learning Organization Logic

Senge (2006) coined the term ‘learning organization’ into the working world. This complex adaptive system is self-organizing, much like working in the zone of nonresistance to create new transdisciplinary knowledge via simplicity. They take on the inner voice of their own that is not dependent on external steerage or leadership. The latter emerge from within. Like Niclosceu (2014), Senge (2006) believed that ‘communities of inquiry’ creates learning organizations. And like Morin (2005), Senge (2006) was concerned with interactions as a whole rather than people as a whole. He conceptualized that learning organizations nurture new and expansive patterns of thinking, set free collective aspirations, and learn to see the new, emerging whole, together. They approach the learning enterprise (i.e., creating new knowledge) with complexity thinking so that people can envision connections that have not yet materialized.

In this learning environment (what Niclosceu, 2002, called levels of Reality interfacing in the zone of nonresistance), Senge (2006) claimed that people come with their own mental model of the world (see also Preiser, 2012); that is, their internal pictures, assumptions, perceptions, meanings and stories. Using what Niclosceu (2002) called inclusive logic, members of the learning environment come up with a shared vision, an internalized picture of a desirable future that pulls them forward in the same direction. Inspired by this vision, they think together in dialogue enabling them to receive insights that were not available to individuals alone. Ideally, people will tap into their ability to handle creative tensions or be open to learning how to do this so group learning can continue (Senge, 2006; see Preiser, 2012).

Similar to Appelo’s (2010) notion of working the system not the people, Senge (2006) felt that people should manage the commons not the people. This involves gaining insights into the system’s behaviour (e.g., the zone of nonresistance) so any limiting factors can be identified and inhibited so collective learning and knowledge generation can proceed. To that end, in a process rife with contradictions that have to be held in thought, he advised against diverting resources to one of two deserving things, opting instead to ensure both can flourish until something new emerges (i.e., confront dualism, resist nondualism). Instead of pushing hard for success, resist factors that are inhibiting success. This way, new things can emerge with less tension involved. Senge (2006) especially lauded the principle of leverage whereby the best results come from small, well-focused actions instead of large-scale efforts, especially if they are at the right place at the right time. The latter is more feasible if people are paying attention to the commons and dynamics.

Conclusion

This paper teased out Basarab Nicolescu’s transdisciplinary logic axiom – the logic of the included middle and the logic of complexity. His philosophical and theoretical approach was briefly augmented with some Pithy examples from Desbois’ (2012) work include (a) act like a thinking person and think like an acting person, (b) gaps identified are precious resources, (c) create opportunities by using the potential of contexts at hand, (d) to paraphrase John Muir, “When we try to pick out anything by itself we find it hitched to everything else in the Universe” (John Muir as cited in Gifford, 2006).

References


