Engineering Practices: Complexity—Diversity—Coherence—Meaningfulness

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1 Introduction

During the writing of this chapter, a landmark was passed. For the first time, the total mass of humanly created structures and products exceeded the total biomass on earth (Elhacham et al., 2020). Most of those structures and products are the result of engineering. This chapter looks at the meaningfulness and complexity of engineering practices as a whole and reaches into the complexity that is the actual engineering practice.

Engineering practices are complex, whether they are engineering design, application of engineering and its delivery, or research in the engineering laboratory. This is because engineering involves many aspects simultaneously. As a result, many engineering errors occur because crucial aspects are overlooked or even culpably ignored. This has sometimes been especially true of ethics and responsibility in engineering. This complexity is not a fault or a problem but is inherent in the wonderful reality with which we have to engage and which challenges us to innovation with responsibility—which is at the very core of engineering.

My background lies first in electronics, then for many years in software engineering, leading to knowledge engineering in artificial intelligence. The latter has been in fields related to chemical and civil engineering. This places some limitations on the salience of my reflections in this chapter to other kinds of engineering, and readers should use their imagination to see how these reflections might be helpful in their fields. I cautiously hope they might be useful because I abstract away from my engineering fields to something more general, trying to reflect on the meaningfulness and complexity of engineering as a whole and in most of its kinds.

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2 The Complexity of Engineering Practices in Their Real-World Context

If engineering design starts with requirements, we find these more complex than at first appears. The idea of the design, its purpose, needs to be worked out, often as an iterative rather than logical process. The information must be gathered from clients about what is required, but frequently this is not clear and the good engineer helps them think this out. Requirements are seldom fixed, and negotiation and compromise are often required. A prototype is given to the clients—at which point they change their minds. Then there is a host of other stakeholders to consider, from those who will implement the design, to those affected by it—which moves the engineer into health and safety issues. Even more critical are indirect, long-term impacts of the implemented design on society and the wider world, including biodiversity and climate.

Then a specification must be written, usually to a tight deadline, so much is omitted or so poorly worded as to be misunderstood later. A contract is often needed, which involves lawyers.

The design activity itself has many technical intricacies, which arise only when faced with the actual reality of the medium being designed, whether physical materials, chemicals, ground conditions, electronic components, concepts, information, social relationships or even societal expectations. Each offers their unexpected twists—which sometimes requires investigation or even research. This is complicated by design errors, inconsistencies. Technical information must be obtained and its veracity checked. The thinking processes of the designer can be immensely complex, especially when faced with seemingly intractable problems, so imagination and innovation are needed. Sometimes ideas must be bounced off others or brain-stormed in a group.

Social relationships are essential: working well with colleagues, both in our team and with those elsewhere, with management, with clients, with regulators and many more. Publicity needs to be managed. Sometimes religious faith becomes a consideration. The engineer faces multiple responsibilities—not only to the client (which is often not as straightforward as we might think) but to society and the world, to colleagues, to the engineer's firm or other organizations, to do justice to the design itself, to the engineering profession, and the wider world.

All such complexities are to be taken seriously. And, when what is engineered is a whole system, such as smart grids discussed in Chap. "Towards a Holistic Normative Design", complexity increases even more. So how can we do so?

3 Gaining a Handle on Complexity

What is complexity? Manson (2001) suggests that complexity theory has recognized three main types of complexity, each with its own approach. *Algorithmic complexity* arises because of the difficulty in describing the characteristics of a system (c.f.

an engineering specification). By and large, complexity theory tries to quantify complexity as a single measure. *Deterministic complexity* arises because systems governed by deterministic rules can still be unpredictable because of sudden discontinuities (such as the well-known butterfly effect). He illustrates this by an equation for population growth, ($X_2 = A \times X_1\ (1-X_1)$), where X_1 and X_2 are populations at times 1 and 2 (measured between 0 and 1), and A is the multiplying factor. When A is between 1 and 3, the population reaches a stable amount, but when it is 3.8, population growth is completely random. What he calls *aggregate complexity* arises from the relationships and interaction between system components, learning and the emergence of "higher-level" behaviours.

All three types challenge engineering practices, as does a fourth type that Manson omits: *meeting diverse functional requirements* (El-Haik & Yang, 1999). Functional requirements can be of a wide range of types, such as resistance of electrical contacts, combinations on locks, manufacturing production schedules, space exploration (Suh, 2005).

These are very different spheres of reality, each governed by very different kinds of laws. Yet complexity theory overlooks these differences because it presupposes that "All are built on the same few rules" and so it "can explain any kind of complex system—multinational corporations, or mass extinctions, or ecosystems such as rainforests, or human consciousness" (Lewin, 1992 cited by Manson). As Manson (p. 402) remarks, there had been little progress towards that optimistic outcome; while "exciting academic cross-fertilization" might have occurred, Lewin's over-simplification is "at the expense of potentially false leads."

What is missing from most discussions within complexity theory, but underlies them, is meaningfulness and its diverse kinds. This is most obvious in the wide range of kinds of functional requirements mentioned by Suh, which are meaningful in different ways, for example, economically, technically or morally, but it challenges the other three types of complexity too. Manson mentions "topics ranging from cultural transmission and economic growth to the braiding of rivers" (p. 405). Algorithmic complexity's concern with description is challenged by the question, "Which parameters is it meaningful to include in the description, and which should we ignore?" The same question challenges deterministic complexity, and Manson implicitly recognizes that meaningful variables can be overlooked: "In the population growth example, for instance, where are the variables for culture, the state, or migration?" adding, "characterizing a human system through a few simple variables or deterministic equations is often just too, in a word, simplistic". Aggregate complexity is challenged likewise by which relationships and interactions are meaningful and which are not ("defining the boundaries" [Manson, 411]). On what grounds may emergent properties be identified except by already knowing that certain patterns are meaningful?

So, here, we focus on meaningfulness, both that of engineering practices *in the wider world* and that of what goes on *within* engineering practices.

3.1 The Meaningful Reality of Engineering Practices

First, what is meaningful about engineering practices *in the wider world*? What are its contributions to, and impact on, human life, to "the economy", to medicine, to education, to society's perception of itself, to reality, to God, to our perception of what it means to be human, to the natural world, to history, to our aspirations and so on? What, indeed, is engineering practice as such? And in what ways are the various branches of engineering meaningful: mechanical, electrical, civil and so on? What about social and bioengineering? This first (composite) question is the kind that might not concern those struggling with specific and immediate engineering problems and in the process of learning and gaining experience. Yet this question, of the meaningfulness of engineering practices as such, never leaves us, visiting us when sleepless at night and also returning to haunt those with a lifetime of engineering behind them. It is important at the level of strategy in business, politics and education. Suppose we lack a sound foundation on which to stand while these questions are considered and debated. In that case, we will sink into subjectivism and mere power-oriented corruption, in which engineering practices will become rudderless. Only by the meaningfulness of engineering can we begin to discuss whether it is to be applauded or regretted that engineered product exceeds biomass.

The second question is more immediate: what is meaningful *within* engineering practices? We consider all three practices—design, research, and application in the real world. (The research "lab" could be the domain of application in the world from which generic things are learned.) We may differentiate them most fundamentally, not according to their processes or personnel, but according to the kind of meaningfulness that is central in each. The practice of engineering design involves formative human power at its core. The practice of engineering research in the lab, while it involves formative power, has a human theoretical curiosity about engineering techniques, tools and technologies at its core, the same kind of curiosity found in the sciences. The practice of engineering use (or application) considers other aspects of human life, such as social, economic, artistic, legal, ethical and even sometimes religious, and aspects of physical-biotic reality, such as ground conditions encountered in building.

Each has a meaningful core rather than a boundary because there is overlap between all three. In some labs, design challenges are addressed, and in the wider world of use, design and even curiosity continue. Those engaged in design have their eye on eventual use.

Moreover, around the core of each, all the other aspects of reality are meaningful. For example, is not engineering design usually more successful when one communicates with colleagues and is generous towards them? In the everyday experience of an engineering lab, design and use, we encounter legal obligations, resource constraints, health issues, fun and excitement, courage (or cowardice) and many more, all of which can undermine or support our engineering practices. These all impose functional requirements, some explicitly stated, others implicit and some of them are the issues that unexpectedly determine outcomes.

As explained above, here we do not resort to conventional complexity theories, but to issues of meaningfulness, which underlie them. Both kinds of questions (What is meaningful *within* engineering practices and *in the wider world*) can be addressed with the same approach to meaningfulness and diversity. Thereby they may be linked together if necessary.

Let us clarify what we mean by “meaning” and “meaningfulness”. To some, “meaning” is the signification we give to words, phrases and sentences. To some, “meaning” is what we attribute subjectively to things, such as my father’s special chair. To some, “meaning” is what we find in the world around us by interpreting, for example, the patch of scattered feathers means a bird has been killed and might mean poaching. Yet others are concerned with the meaning of life or of one’s career. The latter verges on what we mean by “meaning” here but does not quite arrive because it is usually centred on the human individual. All four treat meaning as a property. What we mean by “meaning” here is more fundamental, as follows.

All things are treated as meaningful in some way or other, whether or not there is a life or career, a patch of feathers, a chair or words, and whether or not there are humans to think about it. For example, even the smallest atom in the least significant planet of the furthest galaxy, which humans will never visit, is physically meaningful. Meaningfulness is always there, it is like an ocean in which we swim. Metaphorically, all temporal reality exists and occurs by that ocean of meaningfulness, just as it is the ocean that enables fish to swim and even to exist as fish. This includes all engineering practice.

A fuller discussion of these five types of meaning may be found in Basden (2019) and in Chapter 4 of Basden (2020), where they are called signification-meaning, attribution-meaning, interpretation-meaning, life-meaning and “oceanic” meaningfulness, and the philosophical basis is laid out, which argues that the first four arise out of, and depend on, “oceanic” meaningfulness.

By reference to this kind of “oceanic” meaningfulness, we discuss both engineering practices as such and what goes on within them, in that we treat both as occurring within that same “ocean”. We aim to do this in a way that does justice to their complexity.

3.2 Diversity: Fifteen Spheres of Meaningfulness

Just as the real ocean is diverse in what it enables in fish—feeding, respiration, sensing, movement, etc.—so the ocean of meaningfulness is diverse. As engineers, we experience primarily our power to form and engineer things. We also experience distinctions among things that we encounter in engineering practice. We experience sensory feeling, sound or sight as we engage with our materials, some of which are physical, some dynamic, some spatial or conceptual, and usually a sense of quantity in most of them. As engineers, communication and relating to others is important, as are matters of economy. We experience a certain delight and beauty, a sense of doing right rather than wrong, and responsibility. We share the sense of having done a good job, especially when we not only fulfil our brief but give something more. We experience a sense of purpose, commitment and loyalty. All these things go into what makes good engineering practice—and readers will bring many more to mind.

Many aspects cut across all we do in good engineering practice, whether in the research lab, in design or in use. In fact, we find they are more-or-less the same aspects we experience in everyday life. We need a way to understand this diversity of aspects and how they relate to each other.

To understand each aspect regardless of others is the role of science (physics, sociology, psychology, design science, etc. each study their aspect and build up theoretical knowledge about it). To understand the aspects together and how they relate to each other is the role of philosophy, which Strauss (2009) calls "The Discipline of Disciplines". So, in this chapter, we employ philosophy. We do not delve into philosophy as such, but merely apply a philosophy that has an interest in this diversity at its core.

The philosophy we apply and employ is that of the twenty-century Dutch thinker, Herman Dooyeweerd. Sadly, for most of its 2500-year history, philosophy has seldom explored the nature of meaningfulness, let alone its diversity (Basden, 2019), and many philosophers have tried to reduce diversity to one aspect (e.g. materialist or social constructionist approaches), especially since many presupposed theoretical thinking as the only route to true knowledge. By contrast, Dooyeweerd began with everyday life, recognized the importance of pre-theoretical (tacit, everyday) thinking alongside theoretical and refused the seductions of reductionism. Basden (2020) argues that Dooyeweerd is the best philosopher of everyday experience to emerge so far.

By years of painstaking study, both intuitive and philosophical, and set out in Dooyeweerd (1955, II, 1–426), Dooyeweerd delineated fifteen irreducibly distinct, fundamental kinds of meaningfulness, ways in which our experience and indeed the whole of temporal reality can be meaningful. He called them "aspects", "modalities of meaning" and "law-spheres". They are given in Table 1, and can be traced in the list of what we experience, above.

Other sets of aspects have been offered, for instance in Maslow's (1943) "hierarchy" of needs and especially by systems thinkers like Wilenius, but they are largely subsets of Dooyeweerd's aspects and, in the main, lack the sound philosophical grounding worked out by Dooyeweerd (see Chapter 9 of Basden, 2020). Though Dooyeweerd's suite of aspects is probably the best available, Dooyeweerd was still adamant that it is only a best guess, because:

> "In fact the system of the law-spheres designed by us can never lay claim to material completion. A more penetrating examination may at any time bring new modal aspects of reality to the light not yet perceived before. And the discovery of new law-spheres will always require a revision and further development of our modal analyses. Theoretical thought has never finished its task. Any one who thinks he has devised a philosophical system that can be adopted unchanged by all later generations shows his absolute lack of insight into the dependence of all theoretical thought on historical development." (Dooyeweerd, 1955, II, 556)

Table 1 Dooyeweerd's aspects

Aspect	Kernel Meaning	Good
Quantitative	Amount: more and less	Reliable quantity and sequence
Spatial	Continuous extension, space	Simultaneity, continuity
Kinematic	Movement: "flowing and going"	Dynamics
Physical	Forces, energy, matter	Irreversible persistence and causality
Biotic	Life	Flourishing; organisms sustained in environment; reproduction according to kind
Sensitive	Feeling, response, emotion	Interactive engagement with world
Analytical	Conceptualising, clarifying, categorising and cogitating	Independence from the world; theoretical thinking
Formative	Formative power (deliberate shaping)	Achievement, innovation; technique, history, culture, technology
Lingual	Symbolic signification	Articulation of intended meaning
Social	Social interaction	Togetherness, institutions
Economic	Frugal management of limited resources	Sustainable prosperity
Aesthetic	Harmony, surprise, fun	Delight that seems non-necessary
Juridical	Due; appropriateness; rights, responsibilities	Justice for all
Ethical	Self-giving love	Extra goodness, beyond the imperative of due
Pistic	Vision, aspiration, commitment, creed, religion	Courage, loyalty, perseverance, hope; openness to the divine; change in direction of society

For full treatment, see "http://dooy.info/aspects.html" or "http://dooy.info/aspects.smy.html"

Dooyeweerd's aspects have proven to be an excellent conceptual tool to aid analysis, especially (a) where it is necessary to understand clearly what things mean and (b) to ensure that things often overlooked are given due regard. Many examples of this may be found in Chapter 11 of Basden (2020).

The mutual irreducibility among aspects is that the meaning of each cannot be reduced to that of others, even in combination. None can be explained in terms of others and, when we try to do so, we find our explanations thin and unsatisfying. Theories based on reductions ultimately get undermined and rules based on reductions tend to mislead.

One common reduction is to mathematics. Chapters "Economics, Regulatory Aspects and Public Policies", "Statistics and Engineering", "Analytical Optimization Applied to Social Aspects and Public Policies", and "A Multi-aspect Dynamic System Model to Assess Poverty Traps" in this book introduce algebra, statistics, calculus and simultaneous equations as tools for evaluation and decision-making in various fields. Dooyeweerd maintains, however, that functioning in each aspect works according to different laws, which cannot be reduced to each other. Expressing each meaningful issue as a quantity presupposes quantitative laws govern it. Though this is attractive because the laws of the quantitative aspect are easy to reason about, it can lead to distortion and, often, misleading results. So engineers in each field, qualified by a different aspect, must always be critically aware of how they use mathematics and be careful about treating its calculations as truths. There is always something in the laws of other aspects that cannot be fully expressed numerically. Chapter "Statistics and Engineering" recognizes this explicitly when it says, "each problem … must be treated differently from the others. … it is extremely important to understand deeply what is the problem being solved", and among experienced engineers this recognition is implicit and tacit and pervades their practice. Chapter "A Multi-aspect Dynamic System Model to Assess Poverty Traps" tries to bring multi-aspectuality into a complex mathematical model of poverty by defining many variables, but even it ignores things like ethical self-giving, pistic inspiration and aesthetic purchase of, or refusal to purchase, issues non-necessities, which the Covid-19 pandemic has brought to our attention.

3.3 Possibilities of Good

Each aspect is a sphere of meaningfulness and a sphere of law (in fact, meaningfulness implies goodness and law). Each aspect makes possible a different kind of good, ranging through things like strength of materials, health, clarity, working together, frugality, justice and courage. These and the others are shown in column 3 of Table 1.

Many of the kinds of good early in the table above we take for granted—for example, that the quantity 5 will always be more than 4—but a little imagination shows that reality would not work well if such laws were transgressed. That they are reliable makes mathematics the excellent tool it is for helping engineers think and evaluate.

Dooyeweerd's view is that all temporal reality strives towards the good in each aspect; for example, plants want to flourish. From the biotic aspect onwards, the laws can be transgressed, allowing dysfunction, for example disease rather than health, and we see that as something to be avoided, because it harms and disrupts overall flourishing. So are things like deceit, enmity and injustice, and indeed the negatives in all aspects.

All temporal activity is a functioning in all aspects simultaneously, for good or ill, and engineering practice is no exception. From Dooyeweerd, therefore, we may form the hypothesis that engineering practice works best when all those involved function well in all aspects. This has been called the Shalom Hypothesis or Principle (Basden, 2018, 83), from the Hebrew word *shalom* and the Arabic word *salaam*, denoting a broad kind of peace, prosperity, well-being, etc. In each aspect, good functioning leads to good, dysfunction leads to harm or evil. So, for example, any engineering project can be harmed by (respectively from biotic to pistic aspects) pandemic, sensory deprivation, confusion, laziness or lack of innovation, miscommunication, enmity, waste, fragmentation, injustice, self-centred attitudes and disloyalty.

Some of the good or evil are direct, perpetrated by one individual on others. However, much good and evil is indirect, especially in the social and post-social aspects, because entities respond and the response spreads. For example, when there is miscommunication, information does not flow and, as we see below, this can lead to engineering disaster. In the ethical aspect, a self-centred, cynical attitude spreads throughout a group or society, eventually pervading it. Conversely, a self-giving attitude of willingness to sacrifice ("go the extra mile") also spreads. The benefit of that often does not return to its perpetrator except very indirectly, but rather helps to set the tone of the group and society so that things in general work better.

It is the ability to differentiate the distinct meaningfulness and laws of each aspect that gives us a handle on the complexity we encounter in temporal reality—and especially that of engineering design, research and application. The laws and norms of aspects offer a conceptual tool with which to explore and understand complex normativity. They can guide engineering practice and can also be used to predict engineering outcomes. The laws of the quantitative to physical aspects are largely deterministic (except at the quantum scale), but the laws of the biotic to pistic aspects are increasingly non-deterministic. Despite non-determinism, Dooyeweerd believed we cannot escape the "retribution" that each aspect affords for good or ill.

In such ways, Dooyeweerd enables us to go beyond a mere numerical balancing of good and bad, to understanding its various kinds and the relationships among them. These relationships are discussed in the next section.

3.4 Coherence: Inter-aspect Relationships

In engineering practice, reductionism is harmful in that it tries to deny rather than face real complexity. In reductionism, we overlook or even ignore aspects that prove essential to good engineering. When we ignore an aspect we often go against its laws, so our practice becomes dysfunctional according to that aspect and jeopardizes the success of the whole, especially in the longer term. So, in both engineering and science and everyday life, it is advisable to take all the aspects together, even though we might give one more attention than others. This is because the aspects exhibit an inherent coherence.

Together the aspects form what we have called the "ocean of meaningfulness," which Dooyeweerd called "coherence of meaning" (Dooyeweerd, 1955, I, 4). Just as the ocean lends a coherence to the various functions that fish perform and their entire experience as fish, the "ocean" of meaningfulness lends coherence to all temporal reality, human and non-human, to engineering, to science and to everyday life. This does not arise from human thinking but from the very structure of meaningfulness itself. All aspects relate inherently to other aspects, and do so in several ways that are important in engineering practice.

Multi-aspectual simultaneity. All things, activities and situations exhibit all aspects simultaneously. The idea of multi-aspectual functioning will be important throughout this chapter.

No conflict. Dooyeweerd held (1955, II, 3) that there is no conflict among aspects, all contributing to the full actualization of others. This is the basis of the *Shalom* hypothesis/principle. Apparent conflicts (such as "Being virtuous jeopardizes economic success!", as expressed in Mandeville's *Fable of the Bees*, suggesting a conflict between the ethical and economic aspects) arise from aspectual dysfunction, from misunderstanding the kernel meaningfulness of an aspect (e.g. that of the economic aspect as profit-maximization rather than frugality) or from reducing one aspect to another, and all three problems can be avoided.

Inter-aspect analogy. Each aspect contains analogical echoes of all the others. For example, causality is physical but logical implication and historical bringing-about resemble this; see Dooyeweerd's own account of many analogies (1955, II, 118ff). (Inter-aspect analogy is not to be confused with the concrete analogies that we make between things, such as "She is a peach"; rather it is what enables metaphors to "work".) Inter-aspect analogy can be useful in engineering practice to stimulate fresh ideas, though too much reliance on analogy can mislead because the laws of one aspect cannot be reduced to those of another. Example: The organic metaphors of growth, health and survival have been unquestioningly applied to businesses and nations, and some argue that this has led economics astray (Pilling, 2018).

Inter-aspect dependency. Each aspect depends on other aspects (Dooyeweerd, 1955, III, 91) for the fulfilment of its meaningfulness, but differently in the two directions. *Foundational dependency* (or *retrocipatory dependency*) means that functioning in an aspect depends on good functioning in an earlier aspect. The earlier aspects provide a substratum or foundation, for example most social activity depends on good lingual functioning, and much engineering practice depends on physical functioning. *Transcendental dependency* (or *anticipatory dependency*) works in the opposite direction. An aspect's full meaningfulness cannot be opened up without anticipating later ones; for example, our lingual functioning would be limited to making notes for ourselves if not involving the social. Anticipating the social aspect introduces new issues into linguistics (and into engineering specifications!) such as agreement over word meanings. For example, in engineering practice, much civil engineering, governed primarily by spatial, physical and formative laws, anticipates the functioning of the economy.

Order of aspects. Inter-aspect dependency gives the aspects an order, not lower to higher, but earlier to later, which is shown in Table 1.

Targeting. Our actual functioning in any aspect often targets another. Examples: When we count pebbles or pronouns, we function in the quantitative aspect, targeting physical and lingual, respectively. When I utter "This rose is red" I am functioning in the lingual aspect, targeting the biotic (plant) and psychical (colour). Aspectual targeting helps define different kinds of engineering; see Table 2.

[These inter-aspect relationships are not so clearly distinguished in Dooyeweerd's own writings as is needed here for clear understanding below, but follow Basden (2020, 52–55)].

Table 2 Kinds of engineering and their target aspects

Engineering discipline	Target aspects
Mechanical engineering	Physical, spatial
Chemical engineering	Physical, kinematic (e.g. fluid and heat flows)
Aeronautical engineering	Physical, kinematic (air flow)
Civil engineering	Spatial, physical, some social
Bio-engineering	Biotic, physical
Electrical engineering	Psychical, organic[a], physical, analytical
Acoustical engineering	Physical, kinematic, spatial, aesthetic
Software engineering	Analytical (variables and instructions)
Social engineering	Social, lingual
Telecommunications engineering	See below

[a] The organic aspect (another name for biotic) is understood by some as organs and components maintaining their functioning, the psychical as analog signals, and the analytical as digital signals. Not all agree

In the multi-aspectual functioning that is engineering practice, most of these inter-aspect relationships are experienced, but especially those of simultaneity, targeting and dependency (in both directions), as will be seen below. In interdisciplinary practice especially they are important, and understanding of how each aspect relates to others can make this more fruitful. Chapter "The Interdisciplinary Nature of Engineering Education and Practice" discusses the interdisciplinary nature of engineering practice and education, and the above might help us understand the complexities therein. Basden (2021) discusses how aspects can help us understand and integrate a wide range of disciplines or fields of research.

What inspired Dooyeweerd towards his taking diversity and coherence seriously (and not seeing them as mutually exclusive) was his Christian faith. Just as it was his Christian faith that opened Faraday's mind to the possibility of magnetism being a force that acts at a distance (Russell, 2000), so it is Dooyeweerd's idea that temporal reality is Created, rather than just happening to be, and thus is meaningful, which opened his mind to the possibility that meaningfulness can be taken seriously and explored philosophically (Chapter 5 of Basden, 2020). However, just as it is not necessary to be a Christian believer to use or study magnetism, so nor is it, in order to benefit from Dooyeweerd's ideas and especially from using his aspects. This is why they are recommended here.

3.5 *Things; Types of Engineering*

Though all things function in all aspects, we notice that in some things one aspect is more important than others in defining its meaningfulness, and how it relates to other things. For plants, the biotic aspect is most important, for animals, the psychical, for words, the lingual, for institutions, the social, and for faiths, the pistic. Dooyeweerd called this the qualifying aspect. Qualifying aspects define main types of things.

This includes types of activity. The scientific enterprise is qualified by the analytical aspect, in its guise as theoretical thought. The mandate of science is to separate the laws that govern our functioning in each aspect so that humanity's bodies of knowledge may be clear. This generates theories—though it requires lingual functioning to express and communicate them.

Engineering practice is qualified by the formative aspect, since it wishes to form things and enable humans to achieve more.

This idea of qualifying aspect can prevent dominance by an inappropriate aspect—as found also in Chap. "Key Concepts for Frameworks: Values, Aspects Normativity and Enkaptic Structures". For example, whereas engineering can help a firm make money (economic aspect), if its practice is dominated and constrained by money-making, it becomes corrupted and impoverished as engineering. Ironically, the firm can then gradually become less profitable, as we see in one of the cases of engineering failure discussed later. Understanding which aspects are most important and being aware of all aspects can help guide engineering practice.

While engineering is qualified by the formative aspect, different kinds of engineering are defined by a secondary aspect, which the formative aspect targets, as shown in Table 2.

Taking into account the target aspects of the formative functioning that is engineering helps to clarify which kinds of issues, concepts and theories are likely to be useful in that kind of engineering, and hence which disciplines the engineering activity should involve in its interdisciplinary working.

I have included social engineering above, even though many would see "engineering" as only metaphorical there, to indicate why the metaphor is appropriate, namely the formative power over social relationships and institutions. This, perhaps, also clarifies why social engineering may be an inappropriate occupation if we believe the social aspect should not be formed in such ways.

In Chap. "Smart Telecommunications: The Catalyst of a Social Revolution", on telecommunications engineering, many aspects may be detected: the spatial (distance and area), the physical in transmission medium, the biotic in organs like eyes, ears, the psychical in channels and analog signals, the analytical in digital signals, the linguistic in the meaning of signals, the social in agreed protocols and the difference between formal, informal and unofficial "channels".

Everything involves a coherence of all the aspects. Together they define or determine what the thing is, what it can become, what it should (and should not) be in the real world of actuality rather than merely the rarified world of theory or philosophy. The very meaningfulness of a thing is its coherence of meaning. So, in the next section, we seek to understand the overall meaningfulness and mandate of engineering in terms of its qualifying aspects.

4 Engineering in an Ocean of Meaningfulness

What is the meaning of engineering practice: Why bother with engineering research, design and use? Is it to be applauded or regretted that engineered product exceeds biomass? And what is meaningful within engineering practice, as we undertake it? Those questions, introduced at the start, are questions about meaningfulness. They will now be examined by reference to Dooyeweerd's aspects, as ways in which things can be meaningful.

4.1 What is Meaningful About *Engineering as Such?*

"While I'm worth
my room on this earth …"
The Proclaimers, *Sunshine on Leith*

In Britain, especially England, there has long been a problem, that scientists and artists look down on engineers. Why? And what can be done to overcome that disdain? One reason is that scientists and artists tend to take an aristocratic view, in which they are superior to, separated from, everyday life, whereas engineers are necessarily engaged with reality.

Recognizing the meaningfulness of each function in terms of aspects can help us understand and perhaps overcome the disdain. Disdain is a dysfunction in the social and/or pistic aspects, and many artists and scientists do not succumb to it. Where they occur, different kinds of disdain have a different root, in what Dooyeweerd called the qualifying aspect of their role. This is the aspect that most makes an activity meaningful and worthwhile, and it defines their responsibility within Creation as a whole. For art, this is the aesthetic aspect, of which snobbery is a common dysfunction. For science, the qualifying aspect is the analytical, of distinction-making. Dooyeweerd argued that distinction-making is the necessary core of theoretical, abstractive thinking found in science, and is of two kinds (Geerstema, 2021, 116–7): separation of an aspect from the others as a focus of study, and separation of the thinker from the world being studied. This can become disdain—though it need not do so.

Both art and science—and all other kinds of human activity, including engineering—are given a valid role and responsibility by their qualifying aspects: to make reality more beautiful and to understand it theoretically. The formative aspect gives the role and responsibility of engineering: to innovate, to form, to achieve. These activities necessarily require engagement with the world, with the realities of the materials being formed. Though these are of different kinds, as indicated in Table 2 above, the formative aspect is common to all. It is the formative aspect that makes engineering practice worthwhile globally and is the qualifying aspect of engineering. It is engineering practice that creates tools and technologies that enable people to achieve more within the world they engage in. This is why, in engineering courses, a considerable amount of attention is given to developing good formative functioning in students, especially in the form of skills learned by practice—whatever the target aspect of the kind of engineering. All these things—skills, tools, techniques, technologies and planning, executing, constructing and achieving, and "work" discussed in Chap. "The Engineer in the Face of Social Changes: The Cases of Health and Sustainability at Work"—are qualified by the formative aspect. The formative aspect gives engineering as such its mandate and importance.

Heidegger is famous for emphasizing immersion in the world, and Dooyeweerd works this out more fundamentally. He argued that, scientific theorization, rather than giving true knowledge of reality, leads to narrow, partial and distorted knowledge. So, because of its wider engagement with the world, might it be that engineering understands reality better than either science or art?

It is usually expected that the norm that primarily guides something is that of its qualifying aspect. However, Schuurman (1980), exploring this in some depth, including philosophically, concluded that technology should not be guided only by the norm of its qualifying formative aspect but by the norms of all other aspects. The formative functioning of engineering should serve other aspects, to enable their functioning to be more effective. Readers might have noticed that the definition of engineering and technology offered in Chap. "Introduction", of meeting needs and wants and fulfilling needs and desires, does not specify whether those wants or desires are just or unjust; that is because justice is of the juridical, not formative, aspect. Both aspects must be considered together when considering the whole of reality. So, for example, electrical engineering serves the juridical aspect of just distribution via electrical grids (including local grids and renewable energy) (Verkerk et al., 2018). Chapter "The Engineer in the Face of Social Changes: The Cases of Health and Sustainability at Work" likewise may be understood as discussing the importance of the social aspect alongside the formative. But when engineering is guided only by the formative norm (e.g. "technology for technology's sake"), we find the engineers' equivalent of the disdain of artists and scientists—a dysfunction particular to the formative aspect.

The word "guided" is important. Our formative functioning in engineering should serve the norms of other aspects, but never be dominated by them. When an engineering project is dominated by other norms, such as the pistic-juridical norms of politics, the lingual-pistic demands of the marketing department or the economic-pistic demands of management, it often fails. Notice the prevalence of the pistic aspect there, the aspect of belief and ultimate meaningfulness. In its right role, it enhances engineering practice with motivation, commitment and courage, but when others function pistically to impose their own hidden agendas on engineers, the result is often failure and harm, especially in the longer term. This aspectual approach enables us to distance ourselves from the view that sees engineering as only and merely in the service of business; such a view would replace the formative aspect of engineering with the economic, and an impoverished version thereof, at that.

The aspectual approach also throws light on the difference between engineering research, design and application in aspectual terms. If engineering research aims to discover ways to achieve things, then alongside its primary formative aspect is the analytical aspect that also governs scientific research. Engineering design and application might be seen as more purely formative in its meaningfulness, but with different manifestations of the formative aspect. The meaningfulness of engineering design is to form products or systems. The meaningfulness of engineering application is to help humanity achieve more good through using those products or systems, which is meaningful in the ethical aspect.

To understand the meaningfulness of engineering practices fully, however, calls us to understand also that of the activities and issues that occur *within* them.

4.2 What are the Meaningful Activities and Issues **Within** *Engineering Practice?*

Now we look at the activities within engineering practice from an aspectual point of view, remembering that the overall mandate of all engineering practice is meaningful primarily by reference to the formative aspect, but which serves and opens up the norms of other aspects. For the practice of each of engineering research, design and application, we consider our functioning in each aspect, as individuals, as teams, companies, etc. Space prevents full discussion, so we focus on just a few aspects in order to demonstrate how such understanding may be fostered. Reference to several engineering failures will provide illustration.

4.2.1 The Multi-aspectual Functioning of Engineering Research

The functioning during engineering research in the laboratory is similar to that which occurs in the sciences, which is discussed aspect by aspect in Chapter 10 of Basden (2020), to which readers are referred. The following is a summary tailored to engineering research.

The qualifying aspect of the sciences is the analytical, the overall aim being to crisply identify pieces of (theoretical) understanding about the laws of the core aspect of that science. In engineering research, this is accompanied by the formative aspect in that the research is intended to crisply identify good ways of engineering. (Though philosophers might discuss whether analytical or formative leads, here we take both together as leading.)

In software engineering, for instance, this would include new algorithms, data structures and software engineering techniques. These take into account the laws and meaningfulness of target aspect(s): spatial for geographic information system algorithms, quantitative for those that discover prime numbers, economic and juridical for block-chains and so on.

With the formative and analytical, all the other aspects constitute, together and simultaneously, the multi-aspectual functioning that is engineering research. The engineers' psychical functioning is the feelings they have and their mental activity.

Their lingual functioning is in communicating and recording, for example in documentation, in communications with colleagues, with clients, with the public, etc. Publicity is a lingual functioning.

Of the post-social aspects, most are similar to that of the scientist. For instance, the economic is to do with management of resources guided by the norm of frugality—not only money (budgets), but time, patience, components, materials, information storage or anything that is limited.

Two aspects are particularly worth our attention in engineering. The research engineer's pistic functioning is, as with the scientist's, exhibited in their motivating ideological or religious basic beliefs and commitments as the answer to "Why do I/we research?", whether such beliefs are declared openly or are hidden (including hidden agendas). Commitments are to their research topic, to quality engineering research, which makes them persevere when faced with difficulties, to colleagues, institutions and the research project (many projects have failed when key people left), and may be seen in the personal courage of individual engineers in the face of disinterest or opposition, and also, negatively, in idolatry (elevation of something to absolute status to which other things are sacrificed), in stubbornness, in disloyalty and so on (Basden, 2020, 222–3).

The research engineer's aesthetic functioning is exhibited in their harmonizing of all aspects of their research rather than ignoring any or artificially setting one against another, and in harmonizing their research with the outside world, whether the academic world of other theories, or the world of application and practice—this leads into their ethical functioning of putting the needs of others before their own—and then also in the excitement and satisfaction encountered during research, and so on (Basden, 2020, 227–8).

These two aspects must suffice to show how each aspect manifests itself in multiple ways in the activity of engineering research, all of which constitute the real, lived experience of the research engineer. Yet other ways will be found by the engineer who reflects on what they are doing. Sadly, too little is written on such "down-to-earth" issues (Ahmad & Basden, 2013).

In learning engineering research, it is the formative and analytical aspects that form the core, especially in techniques of both research and engineering (of the relevant type). Good engineering research learning, however, will cover all the other aspects, often inculcating them by the culture that permeates the research group. This, perhaps, is what distinguishes a good from an ordinary research group.

4.2.2 The Multi-aspectual Functioning of Engineering Design

Likewise, engineering design is a richly multi-aspectual human functioning, though perhaps led more purely by the formative aspect. Designers might not need to learn so much about research, for example, but a good design school is still distinguished from ordinary ones by the way it teaches and especially inculcates all the other aspects of engineering design.

The techniques of the formative aspect of engineering design will be given priority, with practice and development of skills rather than just learning of theory. Readers will well know what these engineering activities and skills are—planning, analysis prior to design, design itself, construction (programming in software engineering), testing, etc.—because they are given explicit and detailed attention, so here I will turn to some other aspects, especially some of what Chap. "Industrial Innovation Practices Breakthrough By Process Intensification" calls the "soft" issues of design, which are crucial for success but too often sidelined. The discussion of each aspect in Chapter 10 of Basden (2020) is still relevant, though perhaps needing some imaginative reinterpretation.

The pistic aspect of engineering design is exhibited in ways similar to those of engineering research (commitment, etc.), and so is the aesthetic aspect, except that what is harmonized, enjoyed, etc. is design rather than research. How will the designed product harmonize with the context in which it will be applied? The answer is not necessarily to fit snugly therein, but to act as stimulant (compare to instruments in a symphony). The aesthetic aspect is also manifested in the beauty of the finished product; I particularly appreciate, for example, the beauty of well-engineered steel, especially on steam locomotives. Even computer programs produced by software engineering can exhibit aesthetics, as Knuth (2001, 130) remarks,

> I got hold of a program from IBM called SOAP, written by Stan Poley. That program was absolutely beautiful. Reading it was just like hearing a symphony, because every instruction was sort of doing two things and everything came together gracefully. I also read the code of a compiler that was written by …: that code was plodding and excruciating to read, because it just didn't possess any wit whatsoever. It got the job done, but its use of the computer was very disappointing. So I was encouraged to rewrite that program in a way that would approach the style of Stan Poley. In fact, that's how I got into software.

Thinking about the juridical aspect of engineering design brings to mind doing justice to the design specification, to clients, to colleagues, to management, to the profession, to society and the world—justice includes speaking truth to power. It is also especially manifested in doing justice to the design and the eventual product; corner-cutting is a juridical dysfunction and, as such, can lead to problems that emerge only in the longer term. The ethical aspect of engineering design is the attitude of the engineer, their team, their company and their profession. Many in the UK construction industry, for example, maintained an attitude of self-protection (ethical dysfunction) that led, via other functionings to the Grenfell Tower disaster. As I write, the Grenfell Tower Inquiry is ongoing, and the company that supplied combustible insulation rigged their testing (just within the law!) to show that their products were no more dangerous than non-combustible products. That testing itself is, of course, part of the main formative functioning of engineering design of a product, but the way it is carried out is influenced by the engineer's functioning in later aspects like the ethical.

Chapters "Social and Economic Implications of Electricity Generation Sources" and "Amazon Region Power Plants and Social Impacts" contain detailed discussion of hydroelectric engineering responsibilities towards many aspects, including the biotic ("environmental"), lingual (ensuring views are heard), social, economic, juridical and pistic (cultural beliefs) aspects. Chapter "Scalability and Normativity—System Requirement Definition based on Social and Philosophical Consideration" contains a more general discussion of the need for engineering design and application to consider all aspects, and which expands on what is discussed here.

Engineering design often takes place during use, especially in civil engineering, when the two must be considered together.

4.2.3 The Multi-aspectual Functioning of Engineering in Use

If the primary mandate of engineering applied in the real world is to enable human beings to achieve more than we could before, which is meaningful in the formative aspect as discussed earlier, then the second most important aspect may be the juridical, the aspect of responsibility. This because the "more than we could before" is something new, and which might impact its wider stakeholders (the world, people, especially those who have no control of the engineering) in ways unexpected and unforeseen, whether for good or ill.

Looking into the juridical aspect of engineering application more closely reveals a multitude of responsibilities—to clients, to society, to the world, and, internally, to colleagues, to the project, and the engineering institutions. However, from a Dooyeweerdian understanding of juridicality, responsibility extends further than we might expect. Responsibility to clients, for example, extends beyond "What does the client want?" to what is justice for the client, so it is the engineer's responsibility, and part of their remit, to help the client understand what is needed rather than what is wanted, and also help the client to recognize their own wider responsibilities in the world.

True juridical functioning means listening to those who have no voices as well as those who do. It means listening, for example, to the requirements of the poor and the requirements of the non-human world, especially in relation to biodiversity and climate, doing justice to animals and habitats, and of course, these closely intertwine with the requirements of future generations. These are what would be called "stakeholders" in Chap. "Key Concepts for Frameworks: Values, Aspects Normativity and Enkaptic Structures", where a fuller discussion may be found for engineering of energy systems. Chapter "Amazon Region Power Plants and Social Impacts" contains a useful discussion of them in relation to hydroelectric systems.

The legal frameworks within which engineers operate—globally, nationally and locally—may be understood, not as the total of responsibility in themselves, but as lingual expressions of some portions of the whole responsibility. This is why merely keeping within the law is not enough—as has become clear during the Grenfell Tower Inquiry.

Responsibility should be tempered by attitude: the ethical aspect of engineering in the world. Good engineers see themselves as serving the world rather than expecting the world to serve the engineer—even in employing the engineer since employment for its own sake has little meaning. When the engineer's employment is in the service of something else, it becomes much more satisfying and meaningful.

Wider justice and responsibility is to think in terms of every aspect of the functioning of the engineered product or system in its situation. A good engineer will consider all these things. To discuss this, we will examine several failures as examples. Many engineering failures can be seen as arising from transgressing the laws of various aspects. CWRU (2020) briefly lists *5 Disastrous Engineering Failures Due to Ethics*, which it is instructive to analyse by aspect.

The failure of the Ford Pinto car arose from dysfunction in the ethical aspect, namely selfishness and self-protection. Late into its development (during the 1970s) engineers discovered that the fuel tank could easily be punctured, leading to fire risk, and suggested a solution that would add $11 to the cost of the vehicle. The Ford management, however, decided to continue with the design as it was, to maintain their competitive position and not delay the launch. As a result, people died when the car caught fire. The company resisted efforts to change the design until bad publicity forced them to do so. Ironically, trying to save $11 per car cost them many millions of dollars.

The Love Canal is listed as the USA's first environmental disaster. Constructed before 1900 but never completed, it was sold to a chemical company in 1947, who lined it with clay to be a dump for waste and chemicals. In 1953, filled and covered with soil, it was sold again and houses and an elementary school were built on it. In the construction of these, the clay seal was broken, so chemicals leached into the surrounding ground, causing many health problems. In choosing the site, the Board of Education had ignored strict guidelines, a juridical dysfunction.

Juridical dysfunction of failing to follow guidelines was one reason why the New Orleans Levees failed during Hurricane Katrina. The engineers who did so also relied on false information about heights and ignored information about ground sinking (pistic dysfunction). The authorities failed to fund and maintain the system (economic dysfunction). A total of 1800 people died, and the disaster cost $100 billion. This combination of aspectual dysfunction means that "No one single decision led to the disaster, but rather systemic failures were the cause."

Dysfunction in the lingual aspect, "lack of proper communication," caused the Hyatt Regency Hotel Walkway disaster in 1981, when suspended walkways collapsed, killing and injuring many. A design change, which resulted in suspension rods supporting twice the load they should have done, was not communicated to be properly analysed.

Many dysfunctions led to the Titanic disaster, including use of low-quality iron in the rivets so the ship broke up too easily, and not properly sealing the supposedly watertight cabins (physical, formative aspects). However, one above all was disastrous: insufficient lifeboats being available to serve all 2200 passengers (economic-juridical dysfunction). This occurred partly because the owners had asked for the number to be reduced because it made the ship look unsafe and too crowded—a pistic dysfunction in giving more importance to aesthetics than to safety.

CWRU emphasizes the importance of "leadership". Two aspects are most important in leadership, the final two aspects, ethical and pistic, because our functioning in them deeply influences our functioning in all earlier aspects. Ethical dysfunction is clear in the attitude of the Ford company refusing to sanction the necessary design change and the owners of the Titanic putting the marketing of their ship above the interests of passengers and crew. Pistic dysfunction is often found in what owners or project leaders most deeply believe, commit to and treat as of ultimate importance, and especially in project choices, as seen in the Titanic, and in deciding that guidelines do not matter in the cases of the Love Canal and the New Orleans Levees. Lower-level pistic dysfunction occurs among mid-range engineers, for example when relying on false information.

In most cases of failure, closer examination reveals further aspectual dysfunction, often rooted ultimately in ethical and pistic dysfunction. For example, the lingual dysfunction of lack of proper communication is actually more complex, as the source document (ASCE, 2007) makes clear, being multi-aspectual functioning by several people, with aspects inserted that make each failure meaningful:

> The engineer of record further contended that it was common practice {soc-pis} in the industry for the structural engineer to leave the design {fmv} of steel-to-steel connections to the fabricator {soc}. The original design provided in the structural drawings was intended only {pis} to be conceptual {anl}. When the fabricators found that design to be impracticable {fmv}, they requested approval {lng} of the double-rod system by telephone. The structural engineer verbally approved the change {lng}, with the understanding {pis} that a written request for the change would be submitted {lng} for formal approval {jur{. This follow-up request was never honored {pis}. In fact, the fabricators had just begun work on the shop drawings when a sudden increase in workload {eco} required them to subcontract {soc} the work to an outside detailer. That detailer, in turn, mistakenly believed {pis} that the double-rod connection on the shop drawings had already been designed and therefore {anl} performed no calculations on the connection himself.

In such ways, we see the ability of aspectual analysis to help us tease out the complexity of engineering in the real world, and the pervasiveness of the pistic aspect even at the level of the engineers, in assumptions made, which affected all other functioning.

Yet it can take us even further when we ask about the inter-aspect relationships, especially dependencies in both directions. Dooyeweerd denied there was any causality between aspects, in that our functioning in one aspect never absolutely requires, and certainly can never justify, our functioning in another, but instead Dooyeweerd points to inter-aspect dependency. So, "a sudden increase in workload {eco} required them to subcontract {soc} the work to an outside detailer" does not imply deterministic causality but rather just one manifestation of the way the economic aspect depends on the social. This can be fulfilled in several ways, so there were other options. It is management pistic functioning that is choosing between them.

Chapter "The Need of Normative Technologies for Smart Living Cities" discusses sectors of society and which technologies might make them "smart". The sectors mentioned happen to be qualified by different aspects: communications (lingual), energy (physical), food (biotic), healthcare (biotic, psychical), safety (juridical), transportation (kinematic, economic), waste management (economic, analytic), water (physical, biotic). Different technologies support good functioning in each aspect. However, Dooyeweerd's aspects might prompt us to ask whether other sectors should be considered for the missing aspects, such as ethical and aesthetic.

Thus far we have discussed aspects of how engineers impact the world. In reverse, the world impacts engineering and technologies in each aspect. Chapter "The Socio-economic Implications of the Coronavirus Pandemic: A Brazilian Electric Sector Analysis", for example, discusses in some depth how the biotic aspect (a pandemic) affected electricity systems. Similar discussions are called for about the impact of all other aspects, from physical (e.g. earthquakes) to pistic/faith aspect (e.g. both morale and religious commitment can either restrict or stimulate innovation).

An understanding of inter-aspect dependency can help engineers work out more precisely what is needed and perhaps justify it—and more fully, so nothing needs to be overlooked. Anticipatory dependency along with inter-aspect analogy can broaden and stimulate the engineers' imagination and foster innovation. Foundational dependency is about how this might be realized in practice.

5 Conclusion

This chapter has introduced a way of understanding the complex meaningfulness of engineering practices, in design, research in the lab and in the application. It has reflected on the meaningfulness of these three engineering practices in the wider world: what is their role, mandate? This was followed by a discussion of the complex nature of the activities of engineering practice. To do this, we employed the ideas of Dooyeweerd, who is arguably the best philosopher of meaningfulness and everyday experience yet to emerge. Dooyeweerd studied meaningfulness as such, not just meanings in signification, attribution, interpretation or even the meaning of life, but meaningfulness in its full diversity and coherence. His suite of 15 aspects offers us a conceptual tool with which to get a handle on both the meaningfulness of engineering as such and also the complexity that is engineering practice. We have looked at how each aspect may be relevant in this and briefly looked at inter-aspect relationships.

With this, we can understand the complexity that is engineering practice, and perhaps to offer direction for guiding it, at each of the strategic, tactical and operational levels. And it gives us norms by which we can evaluate it in a complex yet structured way, taking into account all the norms of all the aspects.

This chapter can perhaps serve the other chapters of this book in two ways. Its way of applying Dooyeweerd's ideas to engineering design, research and application, across many kinds of engineering, can act as a philosophical underpinning. Then, with this, the proposals made by other chapters might be affirmed, critiqued and perhaps enriched. Many chapters (especially "The Engineer in the Face of Social Changes: The Cases of Health and Sustainability at Work", "Sustainability and the Responsibility of Engineers", "The Socio-economic Implications of the Coronavirus Pandemic: A Brazilian Electric Sector Analysis", "Social and Economic Implications of Electricity Generation Sources", "Amazon Region Power Plants and Social Impacts", "Scalability and Normativity—System Requirement Definition Based on Social and Philosophical Consideration", "Microgrid Operation and the Social Impact of Its Deployment") emphasize the importance of "social" aspects in addition to technical ones, so Dooyeweerd's distinguishing of social to pistic aspects can bring clarity and fresh insights.

For example, Chap. "Sustainability and the Responsibility of Engineers" provides an excellent discussion of the social aspects of sustainable energy, taking into account many of the later aspects, especially the formative, social, economic, juridical and faith aspects, and does so in insightful ways. Recognizing this, however, reveals an aspect that is given less attention, the ethical aspect of self-giving attitude. In its suggestion of a co-construction stage, for example, the chapter emphasizes the need for social agreement about visions (faith aspect), but how may this be achieved except by when an attitude pervades society of willingness to give up one's vision in favour of others? Adding this to the discussion of co-construction would enrich and strengthen it.

In such ways, Dooyeweerd's suite of aspects can offer useful critique of what is proposed in most chapters, accompanied by suggestions for how their proposals may be enriched.

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