

Science and Interdisciplinarity: A Treatise on the Philosophy of Interdisciplinary Research

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Abstract: *There is an increasing drive towards interdisciplinarity in all fields of knowledge. The general schema is a necessary and ultimately useful one in generating new ideas and “big picture” conceptualizations of knowledge, yet an impediment to its large-scale adaptation by universities and the Academy is sometimes found within interdisciplinarians themselves. In this manuscript I outline several problems at the core of the “discipline of interdisciplinarity,” many of the questionable arguments used by some proponents of the field to justify their identification and determination of what is interdisciplinary, outline numerous examples of historical interdisciplinarity, and finally propose a New Argument that seeks to encompass all fields of research – disciplinary or otherwise – in a generalized fashion. The New Argument summarized is that if human endeavours are analysable into disciplines, then so too are disciplines into their fundamental components. Observing the parallels between disciplines, they are: 1) the subject, 2) the measure, 3) the method, and 4) the cause. The work draws heavily upon Aristotle, and hopes to clarify the muddied waters of interdisciplinarian debate.*

Keywords: Interdisciplinarity; interdisciplinary research; philosophy of science; Aristotle; classical philosophy

Introduction

An unexpected impediment to the open-ended adoption of interdisciplinary methodologies in the modern research University comes from within the interdisciplinary community itself. Rather than being the impetus for the development of novel methodologies for solving complex problems, free from the trappings of conducting research within the limits of in one’s own field or according to the given methodology of a field, the current state of interdisciplinary affairs teeters towards that facing the disciplines and faculties of the 20th Century. Instead of being a platform for promoting the integration of multiple fields of research forming a singular synthesis, many interdisciplinarians have an academic focus of



how interdisciplinary research should proceed, a focus which dominates the literature on the subject as well as *what* exactly classifies as interdisciplinary, often in direct contradiction to one another. A large contingent of interdisciplinary literature “disciplines” potential adherents as to which catchphrases are necessary to check all the appropriate boxes arbitrarily denoted as hallmarks of interdisciplinarity. That Newell (2001) answers strongly in the affirmative to the question “Will I now have to justify myself every time I adopt an interdisciplinary approach to study a new problem?” is a prime example of the exact issue at hand with the field of interdisciplinarity (Newell, Wentworth, & Sebberson, 2001).

While this may appear as a bombastic, aggressive opening salvo, it is to emphasize that the ongoing debate is needless and counter-productive. Interdisciplinarian terminology can be equally as tart with respect to disciplinarians, where Frank bluntly calls the *discipline* “hoary and antiseptic” in contrast to the “hairy and friendly” *interdiscipline* and further describes *discipline* as cold, uncaring stainless steel opposed to the warm, mutually developing, consultative *interdiscipline – fields* are also linked with cows, mud, and corn, incidentally (Frank, Bailis, Klein, & Miller, 1988). Rather than exposing potential adoptees to clever integrative research methodologies, the waters of the field have been muddied over years of uninspired dialogue (Benson & Miller, 1982). It is not because discourse on a particular subject matter or its respective methodologies are somehow implicitly pointless. On the contrary, the most significant advances in early Greek and frankly the core of Western Scientific thought arose from the dialectical infighting between respective schools of philosophy, competing methodologies for describing an objective reality (Heisenberg, 1958; Schrödinger, 1996). What makes the discourse on interdisciplinarity so irreverent is that in the final analysis the arguments are purely verbal and reflect very little of the actual epistemological issues at the core of knowledge production, resulting in “serious conceptual confusion” (Benson & Miller, 1982).

Reviewing the historical record of human progress for the entirety of the existence of our species, it is demonstrable that we intuitively have been taking information from the environment from multiple sources simultaneously, assessing that information, and eliciting several varied, but with observation, predictable responses. In fact, the most basic and fundamental operations in the brain are those of integration across multiple sensory modalities – including those we are not consciously aware of – and synthesizing their respective information into a coherent unity we refer to as our individual consciousnesses. It is such a deep-seated and natural function of the brain that there is one area in particular, the parahippocampal gyrus, that has been implicated in most major integratory operations (Hameroff & Penrose, 2014; Persinger & Saroka, 2015). The development of language may be the by-product of cross-modal – or integratory – functions of the brain, a trait socially and genetically selected for by early humans (Miyagawa, Lesure, & Nóbrega, 2018). The brain fundamentally both parses out knowledge into localized regional foci and has regions dedicated to the integration of this speciated knowledge (Pestilli, 2018).



We can thus infer that at any point in human history, when asked to give censure on a subject, individuals incontrovertibly have done so with an “interdisciplinary” approach – no human has ever thought, “I can only apply my knowledge of this or that discipline to this problem.” Understandably the idea or concept of the “discipline” in the academic sense is a relatively modern one, however upon taking a wider perspective on the evolution of academia it is apparent that the development of disciplines was not in isolation. Furthermore, even after the more formal inception of disciplines great thinkers and innovators continued to blur the lines between disciplines in their efforts of discovery – consider the voluminous works of various polymaths, who drew upon a wide berth of complex bodies of knowledge to solve problems of their days. On the contrary, it is far more likely that interdisciplinary and integrative approaches to knowledge have always been fundamental, best expressed by the Roman philosopher Seneca to his friend, Lucilius:

That is my habit, Lucilius: I try to extract and render useful some element from every field of thought, no matter how far removed it may be from philosophy. (*Letters*, 58:26, (Seneca, 2004)).

One may question whether “field of thought” may be interpreted identically to “discipline” as the original Latin, *ex omni notione*, leaves much room for the reader to decide. Even if one should actively attempt to dissuade integration across disciplinary boundaries of knowledge, because of the structure-function paradigm of the brain it would be a physiological impossibility – one will draw inspiration from and realize epistemological connections where they exist – moreover because the biological process behind this conscious effort implicitly involves white matter integratory regions of the brain (Pestilli, 2018). Hence, the argument between whether we conduct research disciplinarily or interdisciplinarily, is, as stated, little more than a verbal distinction and not reflective of any actual reality. It is an argument that stands in direct opposition to traditional disciplines, whose sole purpose is to describe, define, and categorize on the basis of the possession of similar properties our physical universe and the legion entities and phenomena found within (Eddington, 1939).

Some argue that because archival literature on the subject of interdisciplinary research within science & engineering fields is extremely scarce it is reflective of non-committal to interdisciplinary approaches (Borrego & Newswander, 2010). Such an argument is patently not true – there are in fact many examples of interdisciplinarity in the science & engineering fields, some of which are outlined further on, but suffice it to say that to an extent this argument is based upon investigations reviewing literature for the specific keywords of the interdisciplinary community – such as synthesis and integration – and not by merely assessing the epistemology and methodology used to conduct the research (Klein, 1996, 1998). It emphasizes that interdisciplinarians tend to focus on the language used in the literature often more than a thorough analysis of the works themselves. To suggest that the biologist conceives of his research in an isolated silo, away from the influences of chemistry, physics, or even mathematics, places the “physical scientist” in the role of those chained in



Plato's cave, anxiously awaiting the interdisciplinarians to "show him the light" of proper research. A simple thematic analysis of *how* science and engineering research is conducted would render obvious the naturally occurring interdisciplinarity of these fields of knowledge production; that the conclusions of any experiment from any field can always be discussed within the context not only of its own field, but also in reference to state of science as a whole (Morillo, Bordons, & Gómez, 2003). It is a sentiment that is best echoed in the words of Nobel Laureate Paul Lauterbur in his acceptance speech, that "All science is interdisciplinary" (Lauterbur, 2003).

Checking Boxes

Often to qualify one's research as being interdisciplinary there are several caveats, points, markers, *etc.* that, depending how dogmatically one adheres to the theories of the field, one incorporates into the research. This notion itself is not obtuse – to conduct biology, one must observe biological subjects with deference and acknowledgement to the language of the field of biology in order to facilitate the economic and efficient transfer of accurate information. However, there is no literal *Biology Research Oversight Committee* policing potential research, looking for terminology and specified *modii operandi* – although those are some of the functions of Academic Journals. It is ultimately a difference not of degree, but of kind, between the function of disciplinary and interdisciplinary peer review, as one is often recommended several articles providing actual checkboxes/steps to perform for one to justify or classify their work as interdisciplinary (Klein, 1990; Newell, 2007; Newell et al., 2001; Repko, 2008; Szostak, 2007; Szostak, Wentworth, & Sebberson, 2002). For those unable to determine the level of "interdisciplinarity" contained within their research project, Mansilla has been kind enough to provide an "assessment matrix" one can use to determine the "unique interdisciplinary qualities" in their own work, and a similar 'manifesto' exists in the more philosophical literature on the subject as well (Mäki, 2016; Mansilla, 2005; Politi, 2017).

What are we talking about? or Basic Definitions

One of the checkboxes often found within an interdisciplinary discussions is to provide operational definitions of *inter* vs *mono* vs *multi* vs potentially a number of other *prefix*-disciplines, as Szostak emphasizes, "Foremost, it is important to define what is meant by disciplines and interdisciplinarity" (Szostak, 2007). Frankly, this should be a simple and closed discussion. In the context of the university, academia, and knowledge, discipline refers to a body of literature or a grouping of information around a particular or centralized topic. The central topic forms an axis or focal point around which the language of the field will revolve in its attempts to describe the physical universe or human experience, chosen as the subject of study. The discipline of biology is all knowledge associated with biological subjects – living things – as the Greek βίος referred to an "essence" possessed by living



entities. The discipline of sociology is all knowledge pertaining to societal patterns and group behaviours, *etc.*

If a (*mono*)discipline is thus defined as a “singular organizational knowledge concept” then interdisciplines are simply organizations of research without such singular, centralized concepts – they are between or among (*inter*) the disciplines – etymology being the first and clearest way to define any term (Danyluk, 2013; Szostak, 2007). Similarly, Aristotle comments, “A single science is one whose domain is a single genus (subject), viz. all the subjects constituted out of the primary entities of the genus.” (*Posterior Analytics* I.28, (Aristotle, 2009)). There is also the separation of interdisciplinarity from multidisciplinary; the latter term defines research incorporating the perspectives, methodologies, and theories of one or more disciplines but lacks the integration and synthesis of the former term (Frodeman, Klein, & Pacheco, 2017). Transdisciplinary research is that which goes beyond any one discipline or methodology, frequently utilizing associations with government and other non-academic sources of knowledge or information. Essentially, interdisciplinary research is still within a framework of traditional academic settings while transdisciplinary research is not (Nicolescu, 2002).

Language derives a large component of its meaning by the context in which words are found, and contrary to our desire that words have concrete meanings unchanged by the impermanence of time, a sentiment best echoed by our attempts to catalogue language in lexicons, much confusion arises over these subtle nuances of semantics (Wittgenstein, 2010). When viewed in the context in which the word occurs – *e.g.* the academic *discipline* of biology – little confusion seemingly arises. However, despite the Latinate word being etymologically related to concepts of *learning*, *instruction*, and being a *pupil* in the sense of education, the word originally entered the English language through French during the Catholic-Christian dominated Middle Ages (Dalton-Puffer, 1996). Resulting from this indirect importation, the word, particularly in Romance-language speaking countries, also has the connotation of “a *disciple* of Christ.” Stated alternatively, in this interpretation of the word, to be “disciplined” is to follow a pre-defined path or systematized pattern of behaviour, and particularly in the Middle Ages to fall off the path required a form of correction – punishment – often in the practice of self-flagellation, from whence we garner the meaning of disciplinary action (Asad, 1987).

Chettiparamb also notes the Medieval Latinate origin of the term *discipline* in the manner presented here, emphasizing a meaning of “the instruction given to a disciple” and in particular makes the connection between the first Universities of Bologna and Paris and the beginnings of formal education – where Bologna, founded in 1088, has the honour of being the oldest continually operating University in the world (Chettiparamb, 2007; Sanz & Bergan, 2006). Education was grouped in the seven traditional *artes liberales* or liberal arts: music, arithmetic, geometry, and astronomy composing the *quadrivium*, or higher arts, and the lower *trivium* of grammar, rhetoric, and logic (Castle, 2001). Both Cicero and Seneca



independently discussed the *artes liberales* – which are potentially the first distinctions of education into what are equivalently “disciplines” – where the former presents the term in an educational treatise on rhetoric and oratory, and the latter nestles the *artes* within the *physics* of Stoic philosophy (Cicero, 2006; Kimball, 1995; Seneca, 2004). One may question the equivalency of “liberal arts” with “disciplines” in the modern sense, but each had their own teaching methods, fields of focus in knowledge, methodology, and in that sense they are equivalent although there was less rigid “control” over the educational disciplines in Cicero’s time compared to the modern disciplines.

The many “alternate meanings” of interdisciplinarity are why Klein has argued the problem with interdisciplinarity is not an absence of meaning, but rather that the term and its associates are imbued with layers of conflicting meaning (Klein, 1996; Repko, 2007). As an example of “layers of meaning,” one criticism of the discipline-structured academic university has arisen from the “punishment” context of the word. Michel Foucault in both *The Order of Things* and *Discipline and Punish* argues that the modern academic institutions arose from the same societal systems and political necessities that brought about changes in the French penal system (Foucault, 1995, 2012). While Foucault agrees with the definition of a discipline to be a system for classifying and characterizing around a centralized focus, he also stresses that through the systems there are norms that are implied, instituted, and ultimately enforced. As a direct consequence of this conception is the creation of the dichotomy of “the normal and the other,” which enables the invalidation, disqualification, and elimination of the “other.” In short, it suggests that the production of knowledge is controllable (Foucault, 2012). Nor was Foucault the first to strike upon this difference in meaning, as John Milton conceived of discipline as “the regular practices [a group] collectively follows,” which implies the interpretation of discipline as “a submission to a set of practices, a sense of imposed self-ordering of life and thought, body and mind” (Chandler, 2009; John, 1820). These latter “disciplinary practice” interpretations of the term discipline have been used by some in the interdisciplinary community to buoy their arguments; or as Newell may phrase it, it is one trick the interdisciplinary community has used “to be perceived as basic or fundamental and distinctive in their approach” (Newell, Szostak, & Repko, 2008).

Using proper terminology to enforce a particular perception by the reader – in this case to be basic, fundamental, or distinctive – is straightforwardly the skill of Sophists. Knowledge is ultimately unimportant, but *how* you say things becomes of utmost importance – it is using rhetoric to mislead and misinform your audience (Plato, 2004; Poulakos, 1983; White, 1987).

What led to the creation of the modern University system is well documented, but Foucault’s link with the French penal system and his meaning of “discipline” is at odds with some other narratives on the subject. For example, Foshay states that the modern university was founded upon enlightened and democratic ideals, albeit women were not admitted to German institutions until 1909, though arguably “democratic and enlightened” for its time (Clark &



Clark, 2008; Foshay, 2011). It remains an important to also note Humboldt's ideals of the university as possibly undemocratic – he argued for the involvement of the State in the external organization of universities, such as the filling of academic posts, because the State as interests in the success, direction, and types of research engaged within the hallowed halls of academia (Östling, 2018). Humboldt himself desired a kind of “governmental border control” pertaining to who had access to university and higher institutions of knowledge, despite his insistence on the freedom in lecture halls and seminars – *Lern- und Lehrfreiheit* – seemingly a distant move from his earlier defense of individual self-fulfillment and against unrestricted State power (Östling, 2018). If Humboldt's ideal was upheld, the University would be much closer to Foucault's description than we might first acknowledge.

It is here that one may also lay the charge against the “physical scientist” or any follower of the scientific method that their adherence to the “code of science” is no different from the proposals for specifying the procedures for interdisciplinary research. However, the justifications for the utilization of the scientific method are on genuine epistemological grounds. We have copious amounts of data to support the notion that to *not* follow the scientific method leaves open the conclusions of any hypothesis to severe attack, not just based on the data alone, but also based on logic, epistemology, and the rationale behind the experimental design. Interdisciplinary often cannot state the same in defence of their proposed methodologies – there is no inter-observer agreement as to what interdisciplinarity even is yet. Furthermore, the physical scientist would be able to rest upon propositions whose truth-value lie in empirical evidence, while much of the interdisciplinary armaments are little more than semantic affairs.

But what are we actually talking about? or Operational Definitions

The second such necessary checkbox for prospective interdisciplinary rests on clarifying the definitions provided above operationally, given the waywardness with which language is interpretable (Wittgenstein, 2010). It is here, in the more technical operational definitions, that much of the confusion in the field arises to which Benson spoke (Benson & Miller, 1982). Such definitions include interdisciplinarity as “a methodology, a concept, a process, a way of thinking, a philosophy, and a reflexive ideology” which is itself a non-defining definition, leaving the term as vague as ever (Hankard, 2013; Klein, 1990). Perhaps with an actual purpose in mind for their definition, Salter and Hearn emphasize that interdisciplinarity is “an interaction between two or more disciplines”, however it is hard not to see how closely this parallels the etymological definitions above (Salter & Hearn, 1997). Much of the discourse on the definition of interdisciplinarity could conclude with an agreement that it is essentially “a combining in some fashion of two or more disciplines” (Nissani & Lohani, 2008). A concise definition of the term has been provided by Hankard as “the synthesis of information from two or more disciplines to produce original knowledge that cannot be produced by a singular discipline” (Hankard, 2013).

In this, Hankard would find agreement with the NIH Funding Roadmap's terminology, which describes interdisciplinary research as that which (key points reproduced here): a) integrates the analytical strength of two or more often disparate scientific disciplines, and b) engaging seemingly unrelated disciplines helps to bridge traditional gaps in terminology, technology, approach, and methodology (Huerta et al., 2005). Aboelela *et al.* seemingly stamp their feet in opposition to such clear-cut descriptive terminology, stating “descriptive statements and lists... lack the precision needed to determine whether a given research effort is truly interdisciplinary.” (Aboelela et al., 2007). The word originates in *inter*, meaning “between,” and *discipline*, referring to an organizational group of knowledge; thus *interdiscipline*, or an organizational group of knowledge that exists “between” traditional groupings. Aboelela almost restate the NIH Funding Roadmap's definition of interdisciplinary research verbatim, recommending it over that given by the NIH – perhaps because the NIH is not an authority on interdisciplinarity, while Aboelela *et al.* are; there are no fundamental differences in the definitions, only more (unnecessary) stipulations, requirements, *etc.* in Aboelela *et al.*'s (Aboelela et al., 2007).

Holbrok surmises that the most popular view endorsed of interdisciplinarity appears to be the presupposition that the end result of the process is a consensus reached through integration, what he terms the Habermas-Klein Thesis (Holbrook, 2013). Although there is a strong consensus among interdisciplinarians that the work produced through an interdisciplinary approach must, in some way, integrate and synthesize the theories and perspectives of two or more disciplines by “creating common ground”, often lauded as “the hallmarks of interdisciplinarity”, it is also potentially the weakest aspect of the entire field (Newell et al., 2001; Repko, 2007). The weakness is best characterized by Repko who stated “[It] has been the Achilles' heel of interdisciplinarity all along: the lack of clarity on precisely *what* to integrate and *how* to integrate” (Repko, 2007). It is a weakness that has gone largely unanswered despite a vast multiplication of interdisciplinary programs and communities, as the dialogue instead focuses on the freedom from the constraints imposed by disciplines (Nowacek, 2009). Repko's argument, however, is one of overall support for Newell in that the terminology of “creating common ground” illuminates what makes integration possible through the “black box of interdisciplinary integration” (Repko, 2007). Strangely, Repko acknowledges interdisciplinarians may face the potential for no differences or conflict between disciplinary perspectives when trying to create common ground, and yet still provides strategies for integration (Repko, 2007).

From a purely epistemological point of view, this is not the state of affairs for any academic discipline or interdiscipline upon which to rest its laurels. The final analysis of developing a new methodology should not reveal, “we do not really know what happens” or “we are not sure what we did,” which is the meaning of “black box” in the context of a process. The result of academic pursuits should be the revelation of reality, the description of the physical universe and the relations of things within or some greater understanding of things, but descriptions in a way that allows for replicability and the independent verification of those



results in the “Court of Appeals for Science” – *i.e.* the interobserver agreement (Eddington, 1939). If interdisciplinarians cannot point to what they did, how can they begin to assess the power of their methods in creating accurate descriptions of reality? Moreover, are they even needed to “create common ground” when disciplinarians have been able to share information for generations without the “interdisciplinary perspective” (Peterson, 2008)? Furthermore, there are instances of interdisciplinarity observable and reported in the literature in which integration played no significant role (Grüne-Yanoff, 2016). If this is possible, then integration is not fundamental to interdisciplinarity, and much of the current literature directs towards a straw man.

Justifying Interdisciplinarity, or Why We Should Care

The implication is that somehow disciplines are unable to come to these common grounds without interdisciplinarian assistance, a notion reflected in the latter part of Hankard’s definition, “...knowledge that cannot be produced by a singular discipline”, and which seems to be at the core of the weightiest discussions on interdisciplinarity (Hankard, 2013). It reflects the third and final checkbox and requirement that must occur within interdisciplinary work – the raw justification for its own existence. Consider that for a new methodology to be crucial to solve a problem the pre-existing methodologies must be somehow insufficient or incapable of doing so – otherwise, the problem would not exist. Perhaps to be taken with a grain of salt, Newell proposes that those wishing to conduct interdisciplinary research should outline why traditional disciplines were or are incapable of solving the problem at hand – it comprises the entire introduction of his *A Theory of Interdisciplinary Studies*, for example – essentially arguing for what might be termed “justification clauses” (Newell et al., 2001). Newell’s influence within academic interdisciplinarity is not so strong that this is a “needs-must” occurrence within the literature, but it serves to emphasize the point which many interdisciplinarians perceive as essential to defining what is or is not interdisciplinary research, that is the evaluative or critical assessment of some level of synthesis or integration within and amongst the disciplines.

Justification clauses might be as simple as including “interdisciplinary” in the title or elaborating on the varied disciplines synthesized and integrated for the present work (Kolodny, Feldman, & Creanza, 2018; Leonhardt & Kronenberg, 2016; Liritzis, Preka-Papadema, Antonopoulos, Kalachanis, & Tzani, 2017). However, this also may be because one of the “features” of interdisciplinarity includes reflecting on the choice of methodology (Szostak, steps 7-10, (Szostak et al., 2002)). Justification clauses often contain additional phrasings that often must be included or at least given some deference – *e.g.* that one requires interdisciplinarity when studying “complex systems”; when complexity is absent interdisciplinary approaches are not required; that disciplines only study single-faceted systems; that interdisciplinarity integrates and synthesizes information from across disciplines, to name a few (Newell et al., 2001). To an extent, Szostak and Repko produce these models for prospective students learning about interdisciplinary research and wanting to



conduct their own efforts within the field as opposed to established researchers. However, if future professionals are inculcated into the field via this method, it is to be expected that to an extent these steps and checkboxes will remain as part of their methodology within the subtext of their efforts, if not overtly described and discussed in the works they produce. Students are not taught specific methods simply for them to disregard them after graduation – they serve a purpose in the *training* of future scholars. Note that the complex systems clause – that interdisciplinarity is required by complex systems and *vice versa* – is a legitimate source of contention within the interdisciplinary community itself (Repko, 2007).

The larger phenomenon at hand is the need to justify the use of interdisciplinary approaches in deference to disciplinary approaches, and the suggestion that disciplines are insufficient at solving particular problems (*e.g.* complex ones). Although many would argue that disciplines remain equally as important as their own interdisciplinary field, the dialogue is rife with implications of the superiority of their methods (Nowacek, 2009). Szostak uses the less politically charged phrase “*advantages* over the disciplinary researcher” when providing his justifications (Szostak, 2013):

- 1) The interdisciplinarian can compare and contrast insights generated across disciplines;
- 2) The interdisciplinarian can ask to what extent the discipline’s insights reflect its disciplinary perspective;
- 3) A disciplinarian knows a theory or method well; the interdisciplinarian knows the strengths and weaknesses of many theories or methods;
- 4) Interdisciplinarians are capable of studying and mapping complex systems; doing so places disciplinary insight in context.

The four points provided above, while taken from Szostak, reflect some avenues of thought carried by what might be termed a “North American clique” and emphasized by some scholars in the field – these are their justifications for why their use is necessary over the methods of disciplinarians, one more trick “to be perceived as basic or fundamental and distinctive in their approach” [27]. When assessing the justification clauses of independent interdisciplinary research articles, they essentially are personalized versions of the four bullets provided by Szostak. Taken at face value, it is easy to see how the disciplinarian may riposte, “Why can I not integrate across disciplines? Why can I not reflect on the extent to which my training colours my perspective of research? In what discipline does the researcher know *a particular* theory but not the strengths and weaknesses of *many* theories?” The answer appears to be “because interdisciplinarians say you do not and that you cannot,” a clear attack from authority which many of the interdisciplinarian theorists wage against the old paradigm of disciplines.

Stanley Fish critiqued the field in a similar way, defending against the interdisciplinarian charge that followers of disciplines adhere to an abstract authority in demarcated fields of knowledge, and that the university structure is a political body with independent motives dedicated towards a repressive agenda (Fish, 1989). Fish's outline of the anti-disciplinary clause reflects how the philosophies of Milton and Foucault, discussed above, form fundamental corners of many interdisciplinary theories, and taken together emphasize how interdisciplinarians view their field as being necessary to free knowledge from the shackles of authoritarian disciplinary thought. However, one can see the position is hypocritical because there is an abstract authority that dictates what is or is not valid interdisciplinary research. Many argue for almost the prescription of the method one follows in order to be interdisciplinary, such that those without the proper training are somehow at a *disadvantage* in the insights reached through their research. Fish closes his attack on the entire field by asserting that the reason interdisciplinary discussion focusses on this untenable political position arguing in favor of their existence is that the epistemological considerations refute all their justifications. The political position is an epistemological non-starter because of its inherent hypocrisy (Fish, 1989).

It is not that the notion of integrating and synthesizing data and information from across disciplinary bodies is epistemologically unsound. Rather it becomes apparent that if integration and synthesis are a) natural functions of the human brain, and b) a superior problem solving technique, it can be concluded that the methods espoused and enshrined in interdisciplinary theory are already in existence, the "borrowing across boundaries" being conducted academically for years (Fish, 1989; Peterson, 2008). The essence of what interdisciplinarity demands of new adherents has already been utilized hundredfold times, and is innate to any serious academic – or any human being in fact. The hunter-gatherers were integrating and synthesizing; they must have been, if our brains naturally integrate environmental stimuli in order to make temporal predictions about regularities and patterns, as empirical evidence would suggest (Assaneo & Poeppel, 2017; Maniscalco et al., 2018; Persinger & Saroka, 2015). As Benson aptly stated, "There is nothing special about this import/export business across disciplinary lines; and it has not occurred to anyone to call this process integrative or interdisciplinary [prior to interdisciplinarians]" (Benson & Miller, 1982).

The development of the field of quantum mechanics/electrodynamics is a fantastic example of inherent interdisciplinarity in action. It is strange, then, to find the *inter*-disciplinary efforts of CERN, though focussed on questions pertaining to "Modern Physics," being viewed as a "typical mono-discipline research institute," despite CERN's own self-promotion as an interdisciplinary institute (van Raan, 2000). Interdisciplinarians such as van Raan thus continue a hypocritical stance – disciplines are at a disadvantage because of the silos they create and the authorities protecting them; but claim here is our silo, and we are the authorities of it. It should come as no surprise, then, that Albert and Laberge conclude that many interdisciplinary efforts are not erasing, but rather reproducing, disciplinary boundaries



– the same as expressed by Jacobs and his prediction of fractionation (Albert & Laberge, 2017; Jacobs, 2014).

The example of quantum physics highlights another glaring omission in the literature on interdisciplinarity – the idea that there is not some incommensurable divide between disciplines trying to explain a particular phenomenon, but rather that simply “joining methodological forces” not only expedites but enhances the accuracy of results. Commenting on the development of integration systems biology, MacLeod and Neressian observed that the complex problems being tackled were best approached using epistemic values that favoured *precision* and *exactness* (emphasis added, (MacLeod & Neressian, 2016)). There was no further justification required – *it is better for knowledge production*. Politi develops this idea in his recent paper while acknowledging that there may exist some instances where specialisation is driven by incommensurability between paradigms (Politi, 2017). However, within the philosophical literature this position – exemplified by the concept of ‘needing common ground’ – is not considered a necessary aspect of interdisciplinarity (Mäki, 2016). Consequently, this body of literature takes a physical science context of interdisciplines – elucidating the necessary emergence of virology and bacteriology from pathology, for example – and argues that interdisciplinarity arises from collaborations where those involved possess complementary and interlocking skills from different specialties. No mention occurs of “needing common ground” or tackling specific questions or problems disciplinarians are incapable of handling. Interdisciplinarity arises from the epistemic dependence from multiple specialties, not an intractable, incommensurable divide between gate-kept disciplinary knowledge (Andersen & Wagenknecht, 2013). The language implies the opposite, in fact; complementary and interlocking would seem to indicate a level of overlapping bounds of epistemic dependence.

Are the boxes checked?

The overall claim of the present paper is that some avenues proposed by several interdisciplinary scholars, such as they are, are self-defeating and ultimately unnecessary to achieve the aims and goals it sets forth. The claim rests not on suggesting that integration and synthesis are impossible, nor is it contended that the current omnipresent existence of disciplines will or should forever dominate and demarcate the bounds of knowledge and information. The problem lies in that many within the interdisciplinary community cannot agree on what their field accomplishes or produces which disciplines are inherently incapable of yielding without their assistance. Within this community it is the result of a process referred to as the “black box” of integration (Repko, 2007).

The apparent primary responsibility of the interdisciplinarian is to carve out their own niche from the scores of other fields – to define interdisciplinarity in contradistinction to disciplinarity, discussed previously. From this arises the second requirement, an elaboration of the operational definitions of interdisciplinarity in order to emphasize the “black box” of



integration and synthesis unachievable through ordinary disciplinary approaches. The third requirement appears to be rooted in the disciplinary action interpretation of the word – that there is a prescribed method or perspective to conducting research given from an authority – and thus the interdisciplinarian has advantages through the implied non-constraints of their methodological approach, free to integrate and synthesize across disciplines. These latter requirements I have also referred to as justification clauses. The interdisciplinarian then naturally accepts and concludes that disciplinary approaches are inferior and that they, as interdisciplinarians, have inherent advantages over disciplinary researchers – integration and synthesis being something that is “inherently interdisciplinary in character” and thus by such language cannot be disciplinary (Bailis, Wentworth, & Sebberson, 2001). This is in spite of the fact such notions of interdisciplinary are purely semantic, and within the philosophical community held to be insignificant justification for requiring interdisciplinary methods (Andersen & Wagenknecht, 2013; Mäki, 2016).

Reflective Justification

Up to this point, the discussion of the processes and methodologies of interdisciplinary research was in the abstract and the theoretical. However, while the first two of the three interdisciplinary checkboxes can remain somewhat abstract, one must present the final checkbox – the justification clause – reflexively and reified with respect to an individual’s actual or proposed research. It does not suffice for an interdisciplinarian to justify the existence of their field and integratory perspective, but one must also clearly indicate to the interdisciplinary authorities how *exactly* one’s own work *is* interdisciplinary (Klein, 1990; Szostak, 2007; Szostak et al., 2002). The minimum requirement from definitions of interdisciplinarity in order to justify one’s work as being interdisciplinary would appear to be the “integration and synthesis from two or more disciplines” (Frodeman et al., 2017; Hankard, 2013; Szostak, 2013). Within the conception of many experimental designs and interpretations of the results of those experiments are the sources of integration and synthesis across varied “disciplines”. Many scientists could thus paraphrase Descartes, “I integrate and synthesize perspectives from across multiple disciplines, therefore I am an interdisciplinarian”, with some added commentary from Aristotle, who would argue that one who does interdisciplinary things in an interdisciplinary way should be considered an interdisciplinarian (*Nicomachean Ethics*, II, 4; 24-27) (Aristotle, 2009).

Interdisciplinarity essentially arises from the incorporation of conceptual languages between two or more disciplines; this may be perceived by some as the keystones of integration and synthesis, but these two factors are not of the utmost importance to defining interdisciplinary (Grüne-Yanoff, 2016). Most of human knowledge is better understandable and digestible when analyzed – from the Greek *ανάλυσις*, to break up or loosen apart – that is, despite any *a priori* integration and synthesis of knowledge that may occur, we as rational creatures can better understand various aspects of that knowledge when analysed *a posteriori* observation – or broken down into its component parts. Such reasoning is the primary cause for individual



disciplines, because “knowledge” as a fundamental noun encompassing everything and anything possible under that category is *impossible* to comprehend indefinitely as “one giant whole.” Disciplines are knowledge analysed into related conceptual circles, not demarcated boundaries reflecting aspects of colonial membership – despite the collegial and inclusive feelings that naturally arise from being “a part of” a discipline.

While arguing that due to the physiological reality of the brain and its processing abilities any knowledge produced by a human is integratory, it is possible this does not entail interdisciplinarity (Grüne-Yanoff, 2016). Much interdisciplinary research stems from mixed methods – qualitative and quantitative – but Klein concedes as well that multiple interdisciplinarity exist, which permits the possibility of interdisciplinarity that does not integrate, synthesize and heavily biases towards quantitative methods (Klein, 1996). Here a strong epistemological critique of some approaches to interdisciplinarity becomes apparent. As the author and principal investigator of study, I might indicate where my perspectives for my research arise from, state that I integrated and synthesized in their conception and interpretation – is the knowledge forthcoming of this hypothetical study “interdisciplinary” now? Had I not overtly stated my disciplines and used the words “integration” and “synthesis” would the knowledge produced then be *non*-interdisciplinary, or somehow *non*-integratory from all aspects of my academic training? What is the measure by which we can objectively rate the “level of integration and synthesis,” and, once found, what levels of integration and synthesis are necessary for interdisciplinarity? A recent discussion by Huutoniemi *et al.* references works attempting to assess “degrees of integration”, none of which are empirically based (Huutoniemi, Klein, Bruun, & Hukkinen, 2010). Without an empirical measure for “integration” interdisciplinarians bent on assessing its levels face the problem inherent with all verbal scales of behaviour; there is no standardization or objective basis in physical reality for what they purport to measure. Aristotle would perhaps argue that such divisions are not to be the subject of deliberation, akin to asking “whether this bread has been baked as it should” because such divisions are “matters of perception” and impossible to analyze to a finality, “going on to infinity” (*Nicomachean Ethics*, II, 3; 34-38)(Aristotle, 2009).

Empiricism is not without its own critiques; however, evidence for using empirical approaches to produce knowledge manifests in our modern technological world. That the average human being today is likely to be healthier and longer-lived than any ancestor in human history is a testimony to the efficacy of empirical approaches and goes without further hyperbolization, and is evident following the clear shift in human progress when empiricism was embraced during the Scientific Revolution (Heisenberg, 1958; Schrödinger, 1996). As briefly discussed, one might subject the Scientific Method to some of the same attacks from authority wrested against the interdisciplinary community. The difference lies in that although referred to as the “scientific method,” the methodology is one used by *every discipline*, academic or otherwise, and centers on the operational principles of logic and analytical reasoning.



These basic principles for logic and reasoning were identified by Aristotle in his *Organon*, and have been the basis for practically all human rationalization since (Aristotle, 2009). It may not be apparent in a discipline such as music, but logic and analytical reasoning are present. Notes are objective – an A is 440 Hz or a harmonic of it – though experience of them subjective; patterns of notes have expected phrasings and expressive capacities, learned through experience and the application of logical rationale. Aggregates of notes lead to predictable chords, harmony being an empirical physical property. Moreover, there are empirically “good” and “bad” performances, the former accurately express the intent of the author or artist, the latter miss the mark entirely. The verbal labels for particular subjective events may change, but the basis in logic and reason is consistent – a logical and rational creature cannot be expected to perform otherwise (Aristotle, 2009; Aurelius, 2006).

Disciplines Simplified

While this work has been highly critical of several interdisciplinary theories, approaches and methodologies outlined within, I explicitly state that interdisciplinary research clearly exists and is highly beneficial to the Academy. The critique has been against those members of the interdisciplinary community who prescribe ways to conduct research, acting analogously to gatekeepers in the Foucauldian sense. The argument against the heavy focus on *how* to conduct interdisciplinary research can begin with Aristotle. In the *Nicomachean Ethics* (III, 3; 13-20) (Aristotle, 2009), he writes:

We deliberate not about ends but about means. For a doctor does not deliberate whether he shall heal, nor an orator whether he shall persuade, nor a statesman whether he shall produce law and order, nor does anyone else deliberate about his end. They assume the end and consider how and by what means it is to be attained; and if it seems to be produced by several means they consider by which it is most easily and best produced, while if it is achieved by only one they consider how it will be achieved by this and by what means this will be achieved, till they come to the first cause, which in the order of discovery is last.

At first reading, it seems this passage is in support of the interdisciplinarian obsession with methodology – “We deliberate not about ends but about means” – means being a synonym for method. However, Aristotle goes on to provide clarification of this position, resting upon the notion that the vocations he lists all “assume their ends” – all know what it is their actions produce, and they thus can deliberate on how best to achieve their respective ends. However, what can the interdisciplinarian identify as their end? “Integrated knowledge”? Epistemologically, the qualifier “integrated” reflexes back onto the process of interdisciplinarity – the “black box of integration” –, which is ill defined and nebulous, and thus the end of interdisciplinarity, too, must be ill defined and nebulous. If we refer to it as



“interdisciplinary knowledge,” then we must ask what makes it interdisciplinary, which leads us essentially to the start of this manuscript.

Agreed, interdisciplinarians all integrate and the knowledge produced reflects this. However, if one integrates disciplines A-B-C-D and another W-X-Y-Z their resultant respective final products may be qualitatively different from one another. Does it then stand to consider them from the perspective of interdisciplinarity as opposed to whatever main field their research problem is attempting to address? That is, interdisciplinary biology and interdisciplinary sociology may both integrate and synthesize perspectives and methods and knowledge from across disciplines – but are their final products **not** biology, **not** sociology, if their respective research questions are heavily biased towards these fields? We may venture again into Aristotle as he would seem to address this directly, who states “A man will be a grammarian if he does something grammatical and does it grammatically, and this means doing it in accordance with the grammatical knowledge in himself.” (*Nicomachean Ethics*, II, 4; 24-27) (Aristotle, 2009). Consider the context of grammarian and Aristotle’s purpose of using it – it is a profession with a clearly defined aim, methodology, and purposeful end. Thus, one should understand and know their end before the means to achieve it is subject to deliberation – and this is an impossibility with general interdisciplinary theory. Particulars of an interdisciplinary project in one field are not generalizable to interdisciplinary projects in other fields. Interdisciplinary research is in a sense speciated – each complex problem typically is unique and the solution can only be determined in its given context; thus interdisciplinary research should focus on how to make disciplinary skills and expertise more interlocking across presupposed barriers (Politi, 2017).

Frankly, the conclusion reached is that interdisciplinary research manifests, and always has always manifested, through knowledge production in general; the appropriate label simply did not exist yet, but labels do not preclude existence. All the ideas and notions that arise in interdisciplinary theory are present within the philosophical academy, in particular epistemology and philosophy of science, either explicitly or otherwise. The same ideas housed within disciplines must also be thematically analyzable, and I endeavour here to identify some commonalities to all disciplines and associated *prefix*-disciplines.

The key component of what ties a discipline to other human activities is that human endeavours can be collected and categorized under disciplines, academic or otherwise, and all reflect the inherent human desire to understand the Universe and our place within it. Furthermore, they speak to another facet of the human species that distinguishes us from other intelligent creatures on our shared planet – there is purpose to some of our actions beyond that of simple reward or survival paradigms. Essentially, all such actions taken by humans beyond basic survival and procreation are truly in some way an effort to understand the Universe. These endeavours can all be categorized and analysed in the terms of a discipline or some combination thereof, identified based on logic and reason. As mentioned, even abstract disciplines such as music or dance are analysable as disciplines. There must



exist some objective value for musical notes otherwise transposition would be impossible – acknowledging the objective value for notes has shifted over time. In a similar vein, performances of dance can be objectively good or bad.

If human endeavours are analysable into disciplines, then so too are disciplines into their fundamental components. Observing the parallels between disciplines, they are: 1) the *subject*, 2) the *measure*, 3) the *method*, and 4) the *cause*. *Subject* is the what, the thing, the actual object of study to be analysed – in biology, it is “things that are living *et al.*,” for artistic disciplines it is perhaps the human experience, or something an artist wishes to capture – but there is always a subject of art. Such a basic determinant was made by Plato in the *Gorgias*, who, through Socrates, argued there must be some object of study within an art – something oratory lacked (Plato, 2004). The *measure* refers to the variable or quality that is the source of analysis of the *subject*; it encompasses whatever undergoes *evaluation* within a given discipline, which carries forward into the third component – the *method*. The mode of action taken by the agent in order to study or express the *subject* using the specified *measure* encompasses this use of the term *method*. One does not prescribe *methods*, rather agents provide them in order that other agents may attempt inter-agent agreement, *i.e.* replication. Finally, the first three foundational components aggregate once more to generate the *cause*. With *causes*, full stories surrounding events, *subjects* of study, and complex interactions of agents are articulable, and questions of “why” answerable.

Interdisciplinarity, it seems, lacks one or more of these features. The first and most obvious omission is *measure*; as mentioned before, interdisciplinarity talks of the integration and synthesis of perspectives, and yet offers no way to measure this quality. In a similar vein, the field of interdisciplinarity also lacks real *subject* – the processes of integration and synthesis under supposed study is itself so abstract as to render reification impossible, as elaborated on previously. If anything, the discussions in the interdisciplinary field are heavy on *methods* – the how to do it – but as has been alluded to, proposed methods for knowledge production are of little use when the knowledge is itself ambiguous. Indeed, when the resultant product is more easily classifiable based on the problem it addresses it suggests those familiar with the product field lead the discussion of the methods used to achieve that product, *i.e.* by the so-called disciplinarians. Interdisciplinarity is necessary, but so are those who choose to specialize within a discipline.

As a result, the best categorization of the product – the *cause* – revealed by interdisciplinary approaches should also occur disciplinarily. One of the finest examples alluded to is the interdiscipline of quantum mechanics. Although considered a field unto its own, when considered in terms of the *subject*, *measure*, and *method*, it is clear quantum mechanics is primarily physics; biochemistry is primarily chemistry with a biological bend. A comparative history and analysis of the progression of the Latin language heralded as an interdisciplinary project addresses a question primarily of linguistics (Leonhardt & Kronenberg, 2016). Proposed integrative studies on human cultural evolution that are interdisciplinary in nature



demonstrably address anthropological questions (Kolodny et al., 2018). Moreover, what makes these works knowingly interdisciplinary is little more than the fact that the authors themselves make the same arguments as presented previously – 1) they say they are interdisciplinary, 2) they reference the disciplines they base their work on, and/or 3) they imply they have integrated and synthesized from these disciplines. Yet there remains no way to determine whether their claims of integration and synthesis are “true”, or to what degree, for the myriad reasons presented and discussed to this point. Moreover, there is no need to.

Conclusion

Despite the tone taken in this manuscript towards some within the interdisciplinary community, one must recognize that this has not been against interdisciplinarity as an important component of pedagogy or research. It has been against the field of interdisciplinarity, for the reasons as presented previously. There is nothing new or unique in the theories and perspectives offered by academicians whose sole focus is interdisciplinarity; the language used by some of the biggest proponents reflects this; Newell, Szostak and Repko’s infamous line of “trick[s] to be perceived of as basic and fundamental” (Newell et al., 2008). The notion of combing through different literatures that may be applicable to a problem at hand and synthesizing the pieces that fit best is an intuitive human process that has occurred throughout the course of the modern Scientific Era and before. As Lauterbur addressed:

Historically, the record is clear. Chemistry, for example, was cobbled together from mystical alchemy, metallurgy, physics, mineralogy, medicine, and cookery, eliminating incompatibilities as it evolved and consolidated into a more-or-less unified discipline. Physics has been formed, and enriched, by contributions from astronomy, mechanics, mathematics, chemistry, and other sciences. We have recently observed the rationalization of much of biology by chemistry, with the help of physics (Lauterbur, 2003).

It is true that the general motifs and categorical themes originally incepted by the first interdisciplinarians reflect the nature of interdisciplinary research, and the initial methods for considering perspectives may have opened the eyes of the Academy to what had been intuitively occurring, but not actively incorporated. Simultaneous this, it is unequivocally apparent that the job of the academic interdisciplinarian, however, is complete – the Academy remembers and is more than aware of the copious benefits of not considering their research in isolated silos, should they ever have thought to do so. The endless quibbling over just what is meant by particular terminology is the discipline of analytical philosophy; interdisciplinarians merely focus on a subset of those terms while ignoring much of the epistemological consequences therein, as addressed previously. To suggest that an individual not explicitly instructed to synthesize and integrate knowledge is incapable of doing so or otherwise deficient at the task is arrogant on the part of interdisciplinarians. It is also



disingenuous of purported interdisciplinarians who, resulting from the thick jungle of confusing terminology and by presenting their arguments with enough twists and turns to disorientate a trapeze artist, denigrate genuine interdisciplinary efforts simply because they lack some unconfirmable, unobservable – and thus epistemologically unjustifiable – level of synthesis and integration “between disciplines.” It is also outrightly hypocritical of interdisciplinarians to treat their subject matter in a way identical as disciplinarians would, essentially crating the “Discipline of Interdisciplinarity” and entailing some future fragmentation within the community into “sub-disciplines of interdisciplinarity”, as predicted (Albert & Laberge, 2017; Jacobs, 2014).

The optimum path forward for the interdisciplinary community is to accept that the Academy has heard their message at large and to come to true consensus regarding the details of their definitions. Dialogue should focus on examples of interdisciplinary works and furthering the connection of the concept of interdisciplinarity within the historical record of humanity and the philosophy of science, instead of seemingly trying to squeeze blood from a stone and make it appear as though interdisciplinarity is *novo informatio*. Moreover, the fundamental issues of claiming interdisciplinarity as a field remain – how does one study the ambiguous, nebulous “integration and synthesis of knowledge” without essentially being an epistemologist, in which case acknowledge “the study of interdisciplinarity” as a sub-discipline of epistemology, as paradoxical as it may seem. Finally, recognize that at no time should one “have to justify [themselves] every time [they] adopt an interdisciplinary approach to study a problem;” one should use whatever method, tool, or perspective that helps solve the problem.

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