論文（*Article*）

Orthogonal Disciplines

A New Science of Diversity that Generates: College 2, Decade Colleges, Auxiliary Universities, Organizations as College Students, and Universities of Creativity

リチャード・テイボァ・グリーン
Richard Tabor Greene

3 Research Questions--What Will Solve Some Lackings in Traditional Disciplines, Be a Scientific Basis for Cross-Discipline Work, and Explain Who Rises to the Top of All Traditional Fields?

Existing universities, with their disciplines and corresponding professions, are generating ever narrower people, given ever narrower educations, publishing theses on ever narrower topics, at the same time that more and more real problems of our societies are falling between the cracks between such narrow disciplines, professions, and people. Higher education is producing people of general incapability, well versed in sub-fields, so small, that virtually no one, outside the sub-field, can understand or use what they do. Combining different disciplines and professions, in particular projects or as cross-function teams, has proven difficult where not entirely ineffective. The basis of getting two or more different fields to interact well is missing or incomplete, due to tacit routines hard to make explicit and re-found in contexts of other disciplines, differing knowledge formats preferred in various disciplines and professions, and ignorance of social status markers and conditions in fields other than one's own, among others.

Result--A Categorical Model of 54 Orthogonal Disciplines that Purport to: Solve Lacks in Traditional Fields, Form a Scientific Basis of Cross-Discipline Work, and Explain Who Rises to the Top of All Traditional Disciplines

This paper presents 54 orthogonal disciplines, cutting across all traditional disciplines, and explaining who rises to their tops, that were suggested by 315 eminent people in 63 diverse strata of society, half American and half global. These 54 orthogonal fields solve failings in traditional ones, and constitute a research basis for getting different fields to deeply and precisely interact. These orthogonal fields are an alternative to other proposed bases of unifying the disciplines such as consilience (Harvard's Wilson), cognitive psych (Harvard's Bok), and the philosophy and epistemologies of knowledge (Clark, Kuhn and others).

Method--Recursive Nomination Process from 315 Eminent Nominators to 54 Sets of 150 People "Great" at Each Orthogonal Discipline

A model of 63 strata of society was made, 5 people for each of the 63 strata were nominated via a delphi process among University of Chicago MBA students, for a total of 315, half American half global, these 315 were asked to nominate two things: the capability basis of all those at the top levels of performance in their respective field (these answers producing a categorical model of 54 orthogonal disciplines), and, later in time, 150 people for each of the 54 orthogonal disciplines who exhibited top level mastery of that orthogonal discipline (in whatever traditional field). Over 8100 people (54x150), thusly nominated as great at some particular orthogonal discipline were then given interviews and questionnaires over a five year period. The results were analyzed

to produce categorical models of the 54 orthogonal disciplines and of the principal skill contents of each of those 54 orthogonal fields. This paper presents only the categorical model of the 54 orthogonal fields and other papers present the models of skills in each individual orthogonal field.

Results--54 Orthogonal Disciplines, That Cut Across All Traditional Ones, Determining Who Rises to Their Tops, Identified

Categorization of interview and questionnaire results resulted in a final model of 54 orthogonal fields, each of which cuts across all traditional fields and determines who rises to their tops.

Discussion and Implications--New Sciences of: Diversity, Excellence, Curriculum; New Colleges of 92 Courses for Each Orthogonal Field

Six applications of orthogonal disciplines are explored in some detail, with detailed examples furnished for some and suggestive, but informal, datasets presented for others. These include: a second college for people between 38 and 42 (college 2), other college experiences between other decades of life (decade colleges); an entire meta-university surrounding existing ones and researching/teaching orthogonal disciplines (the auxiliary university); universities that teach departments, processes, events, managers, employees, professional staffs as students (entire organizations as college students); and entire colleges made up of 90+ courses on one orthogonal discipline (a University of Creativity, for example). The paper closes with hypotheses and open questions that might be explored by further research, and implications for establishing a Science of Diversity, a Science of Excellence, and a Science of Curricula.

Key Words : Knowledge Organization, Meta-discipline, Curriculum Theory, Cross-discipline, Science of Excellence, High Performance, Knowledge Formats

Are Traditional Disciplines Lacking?

The gap between disciplines grows ever wider. More and more of society's problems cannot be seen, defined, or solved by any one discipline acting alone. The people within disciplines grow ever narrower. Experts in any discipline, more and more, show up as ignorant of virtually everything else, all the world around their discipline (Bieber, Lawrence, Blackburn, 1992; Atkinson and Tuzin, 1992). Experts within different disciplinary sub-areas cannot understand or communicate with each other. The gap between capabilities one has upon graduating and capabilities needed by first employ grows ever wider. New grads' lack of tacit knowledge, social savvy, political infighting skills, persuasion and negotiation skills, and the gap between abstractions they learned and needed grounding of them in real experiences of others, all make new grads a pain to have around, when and where real work is getting done (MIT, 2003). The gap between amount of knowledge produced\published and amount actually noticed, read, and applied anywhere by anyone grows ever larger (Simon, 1981). There are now entire university faculties and decades of journals published, that are never consulted by anyone, about anything, their "knowledge" undemanded entirely. The American paradigm of research that produced this now spreads to Australia, England, Spain, and dozens of other nations, driving out publishing of personal opinion pieces with publishing of topics tiny enough to make their maths work and to expand numbers of articles published till their authors get tenured employ. Given that the repute of US research was largely, though not entirely, established by 2 generations of fleeing Europeans, not thusly educated toward narrow research methodology, this paradigm amounts to a huge, rather risky, experiment of unproven basis and validity, on the parts of both the US and its copiers (Smith, 1990).

Herbert Simon (Simon, 1981) in *Sciences of the Artificial*, decades ago, referred to the natural expansion of knowledge and splintering off of more and more sub-disciplines, and sub-sub-disciplines. Narrow sub-sub-disciplines filled with narrow people

whose entire careers take place inside them become "the norm". Virtually ignorant of all else, such people and their sub-sub-discipline have trouble orienting themselves and their work so as to be of notice and worth to the world at large. Note, this can be viewed as a problem of "handling diversity".

What is the Cure?

If the problem is a profound splintering of knowledge and people into professions and disciplines that do not easily understand each other or combine well, to the extent that major problems and opportunities in society go unaddressed, what are the solutions? This is not a new problem, though recent forms of it are worse than earlier forms of it, so there has been time for people to notice it and suggest responses. Some commonly suggested solutions include: a general education core before specialization (but this allows specialization to undo the good done by the general education core), combining disciplines in cross-discipline teams and projects (but these perform poorly because the professionals in them do not model and handle the world similarly), institutionalize inclusion of regular waves of new methods and technologies (but each discipline does not see how all others handle each wave's contents), consilience (but this extrapolates from twenty or so genetically specified social behaviors of humans to an uncountable--non-prespecifiable according to Kaufmann--infinity of yet to evolve such human behaviors, a leap that only true-believers in the "consilience faith" are ever likely to make, see Wilson in Damasio et al, 2001), cognitive psychology (supposed to unite all fields via the mental processes they all used to handle concepts but too much was known about knowledge to make this approach coherent and focussed--except that part of artificial intelligence expert systems building that focussed on expertise as something across all disciplines), philosophy of knowledge (this works well as a discipline across all others but it inevitably suggests many other crossing-discipline bodies of knowledge it leaves out and yet needs results from--sociology of knowledge, politics of knowledge, and so on). This paper suggests a new alternative:

- set up orthogonal disciplines, of aspects shared by all traditional disciplines, as separate academic departments, intersecting all traditional departments, that is "orthogonal" to them.
- set up set of people trained in both a traditional field and an orthogonal field, who are capable of in depth work in one field and working across all fields in one scientifically defined way.

Common solutions to the splintering of knowledge problem try to get disciplines to interact without having a formal, detailed basis for such interactions. The orthogonal discipline solution builds a set of new "disciplines" and corresponding "professions", each focussed on some area of knowledge shared across all traditional disciplines. Each such orthogonal discipline enables all traditional disciplines to interact with respect to its specific knowledge contents. The orthogonal disciplines solution is a divide-and-conquer solution--it divides the problem into dozens of distinct "orthogonal" disciplines, each of which enables specific interactions among traditional fields. Cognitive science, decades ago, when it was being born, was seen as forming a possible basis of sharing across diverse fields. Harvard University's Education School studied it for that purpose in part (Bok, 1986). However, making one sub-discipline (cognitive science is a sub-field of psychology) as the entire basis of inter-discipline sharing, failed. Cognitive psychology was both too broad and too narrow to do the job, missing social, technical, and other forces at play across fields and offering all sorts of mental processes, too many to choose from, for useful results. Orthogonal disciplines do not depend on just one discipline as the basis of combining and interacting diverse fields. They are dozens of fields, each of which plays the "cognitive science type" role of supporting sharing across fields.

One Origin of Orthogonal Disciplines: Complaints with, Trends in, Substrates of Existing Disciplines

The idea of orthogonal disciplines as solution to the splintering of knowledge and people problem has emerged slowly out of myriad disparate other solution ideas. What is new, and being reported in this paper, is professional research approaches to defining the orthogonal disciplines solution approach. We take an emergent insight and apply disciplined research procedures to defining it more comprehensively and exactly. Below I briefly present separate limitations of and trends across traditional disciplines, each of which can be used to define a set of disciplines "orthogonal" to traditional ones. The items below can form the basis of questionnaire items that get experts to suggest exactly what orthogonal disciplines are needed.

- formalize attacks--add morality, say, because various disciplines end up being attacked for lacking it, add other topics for similar reasons (management and job/career skills added as grads of humanities and arts have to eat and the arts are an industry)

We regularly get attacks of physicians for being only money-motivated and therefore tending towards automatic ethics violation or business executives doing so. Morality tends to reappear as a practice crisis in part because all fields omit it from theory and practice treatment. Perhaps it needs to be an orthogonal discipline, studied in its own right yet applied in every distinct field.

- institutionalize regular inclusion of research method innovations--as computation changes what can be modeled and what data can be collected, update disciplinary capabilities

It could not be clearer that research methods, that get invented in one field, eventually spread to just about all other fields (recalcitrant ones capitulating a few generations later than most others). An example is brain glucose-use scanning which started in medicine but quickly was used in social psych, business marketing, and spy catching fields. Research methods, therefore, are a good candidate for being an orthogonal discipline that can be studied in its own right and applied to all other fields.

- add career success determinants--find out what best performers in the field have that average or low ones lack and research/teach it

Expert system research led to serious study of expert-novice differences. However, only in computer science, artificial intelligence sections, is such knowledge of expert-novice differences formally studied, taught, and presented, for the most part. Each of 30 other disciplines omits it, for some reason, though knowing how experts differ from novices in architecture, physics, law, and so on is powerful stuff worth serious research and teaching in any field, one would think. This leads to "expertise" as an orthogonal discipline, studied in its own right but applied in all other fields.

- assess costs of talents of the field--find what the discipline neurotically ignores or does as a cost of what it does well and fix it

Every talent of a person or group is a focus kept, hence, is obtained by not-focussing on other topics, which become eventually forgotten, or ignored--the "costs" of achieving that talent or focus. Individuals and groups tend to lose sight of what their talents cost them. As a result, at regular intervals, these costs, long ignored, grow large enough to overwhelm existing intents and plans, breaking into consciousness. Talent gets disrupted by such costs of talent--one of many sources of paradox that every field suffers from. Recognizing and handling such paradoxes is a major determinant of achievement and personal career success in every field. This suggests a paradox-handling orthogonal discipline, studied in its own right but applied to all other fields.

- "buddy" field research--select other disciplines to combine with and research links with them

Entire careers get made in academia and business by someone applying methods common to one field to an entirely different field. We can find Geertz applying literary criticism methods to the other field of anthropology, economists blindly taking the "next" type of mathematics and applying it to all ordinary economic cases, and myriad other examples. There is a physics of chemicals reacting, a physics of people reacting in crowds, a physics of products competing in markets, and so on. It is the concepts and operations on concepts of a field that other fields--physics, etc.--get applied to. This suggests an orthogonal discipline of the social sciences applied to each field's concepts, the physical sciences thusly applied, the arts and humanities thusly applied. These can be studied on their own and applied to all existing disciplines.

- fix human neuroses acting in the discipline--assess neurotic aspects of people in general and how they work in your discipline then fix their effects

Social psych, media and communication, anthropology, and other fields have researched and found how individual humans omit parts of themselves, their psyches, and their environments, distort other parts, and notice accurately still other parts. The talents that individual people have represent focus achieved which implies lots of parts of life not focussed on, which omitted parts gather and eventually overwhelm plans and projects talents propose. Economics has been hit hard by this gathering research on limitations of each human's thought capability. For economics, to make its maths work, assumed rational human thinking and acting, proven now, a mirage. However, all other fields have been hit somewhat less hard but still significantly by these results. People are constrained by aspects of themselves and their environments that they see and admit as well as by aspects that they fail to see and admit. This suggests a coping orthogonal discipline that works out in each other discipline how people cope with admitted and unadmitted constraints.

- categorize courses--for every discipline, categorize its courses and compare across disciplines, then standardize

Though every discipline has its own history, tradition, forces, pride, and future vision, over time highly similar patterns of courses appear across different disciplines. We find dozens of disciplines sharing the same research methods and statistics courses. We find dozens sharing the same "new technology courses" and "how to handle new

technology courses". Each such coherent sets of related courses found across different fields, suggests a distinct orthogonal discipline, to study in its own right and apply to all other disciplines.

- explicitize "community of practice" dynamics in the discipline--observe and research how people in the field work, alone and together, and make explicit continually tacit and latent forms of knowing, learning, interacting, and the like.

Every discipline handles knowledge. Indeed, that is just about all that any academic discipline does. Not surprisingly, knowledge itself, its forms and dynamics, does not differ all that much between disciplines--there are stories in literature and stories in physics, there are equations in physics and equations in literature plots, for example. Various important aspects of knowledge and handling knowledge, therefore, each constitute the basis of a distinct orthogonal discipline, studied on its own right, yet applied in all other fields.

- define critical discipline combinations--find "management", for example, that your field needs and uses, and define what parts of the management discipline (as taught in schools of business and the like) to incorporate within your field, as well as, how to tailor it precisely for your field's uniquenesses

The overt obvious content of some fields is practically, and sometimes theoretically, important to other fields. For example, many fields involve managing and management. Business studies this and results of business study of managing can be applied powerfully in lots of other fields--medicine, law, social psych, history, and so on. This is a subset of the above item on applying all fields to all other fields. This suggests particular subdisciplines in one field may actually be subdisciplines in all fields but just not structured that way or recognized as that at present.

- explicitize tacit knowledge and practical intelligence--make explicit what causes "best" performers to differ from average ones.

Every field is split into overt knowledge acknowledged, researched, and published, and covert, tacit knowledge (practical intelligence it has been called as well) that is powerful but not generally acknowledged and studied. One field or another from time to time comes up with a way to make tacit knowledge explicit. Psychology did this 50 or more years ago for many fields, then computer science "expert systems" work in artificial intelligence did this at the end of the last century. This suggests a particular aspect of knowledge that all fields share and that can be the basis of forming an orthogonal discipline. This is a subset of the item above on aspects of knowledge that all fields share.

The above ten constitute separate ways to suggest, find, or determine orthogonal disciplines. We can use each of them as the basis of questions in a survey to give to people to get them to define, for us, what orthogonal disciplines are needed and what each such orthogonal discipline should handle. If we survey a large appropriate sample of people, from many existing disciplines, and ask each of them, what repeated attacks have been made on their discipline, what were the sources of the last three changes in their discipline's methods of research, what do the most successful people in their field do that average and less successful people do not do, and like questions from above, we can group their answers, and organize them into a model of orthogonal disciplines, some of which may already be recognized, exist, and be used, and others of which will be utterly new territory.

Another Origin: Alternative Formats of Higher Education, as Specifiers of Orthogonal Disciplines Needed

Quite a diverse set of changes in and improvements of higher education itself have been suggested from time to time. Not surprisingly, given the severity of splintering of knowledge into disciplines and professions and the emergence of problems "between the splits" that no field handles or can handle, some people have suggested various new forms of higher education as a response. Each of these suggested new forms of higher education tries to handle the splintering of knowledge problem and some of its consequences. Thus, we can find in most (not all) such suggested new forms of higher education, specific needed orthogonal disciplines. The new forms of higher education suggested split into new things to be taught--which tend to suggest orthogonal disciplines--and new ways to deliver content to new types of student.

Some observers, noticing how similar configurations of courses appear in lots of fields, suggest defining a standard substructure of sub-disciplines for a lot of fields to share, with each field adding sub-disciplines beyond the shared standard part. While we like the diversity of courses in college catalogs, we also like standards in curricula that assure grads of all colleges, and disciplines, of a certain basic relevance and performance capability upon graduating. In particular, when people hire a lawyer, a chemist, and

a literature grad, it is irritating when none of them is even minimally competent at management, self change, teamwork, statistics, or making coherent presentations. We hear continual laments from society and social institutions about grads knowing some narrow disciplinary knowledge but absolutely nothing else, hence, being unable to function when hired. Hence, ways to practically define standard types of courses in each and all disciplines are welcome. Similarly, artificial intelligence, cognitive science, and brain scans laying bare various types and operations and bases of knowledge, have made clear many knowledge related phenomena shared by all academic fields and professions. We now understand, exactly, many types of knowledge and operations on knowledge, shared by all fields, as well as types and operations specific to some fields. This leads to a theoretically based standard set of subdisciplines shared across fields. Ways to theoretically define standard types of courses in each and all disciplines are welcome for this reason. All this calls for serious research to define orthogonal disciplines.

There is a general transition between life's third and fourth decades, called by some people the "mid-life crisis", it is real in most disciplines as a time when narrow specialization reaches its limits and people start to detach, get more general, move into management, and collaborate across disciplinary boundaries more. People experience this period as their last chance to get serious about life and who they ultimately will become. Some sort of college experience at this point has appeal, as a way to update minds to fit technical, social, knowledge changes around them. What should be taught in this new college? For one set of people, keys to success within their already chosen field is needed, hence, orthogonal disciplines. For other people, a transition out of their present field and into an entirely different, perhaps even opposite or compensating-for-weaknesses one is needed. Orthogonal disciplines here are not directly asked for but useful as bridges between the person's old abandoned field and his or her newly chosen one. Hence, researching and teaching people, whether deepening commitment to their existing field or investing in a new one, the keys to success, quality, expertise, creativity, effectiveness, and so on in any field as applied to their specific field, at this specific point in their lives, has great appeal. This calls for orthogonal discipline definition and development.

A generalization of the above point looks at putting some sort of college experience between every boundary between decades of life. The question is, what sort of college experience to put between which two decades. A logical sequence from bachelor's to master's to ph.d. degree suggests itself, but that makes people narrower, especially through ph.d. work. Some sort of college experience that moves people toward success within their already chosen field has appeal. In particular, an experience that prepares people for working across fields and combining different fields appeals for later decades in life. What is it? This calls for orthogonal discipline definition work.

Many people admitted to colleges and universities do not do well in them. Though profound impacts on their thinking and lives may nevertheless take place, most potential improvement is lost in lack of focus, no access to tacit knowledge, lack of practical intelligence from family and friends, and the like. The nature of knowledge and how to handle it goes untaught in most fields, so the students who excel become those with family or other outside resources and experiences that make them aware of knowledge and how professionals handle it. A something around college, an auxiliary to it, might be possible that helps people use college experience optimally, in part by teaching what all fields share about handling well different types of knowledge. Parents, investing money, and kids, investing years, would both get more for their investment if such a surround of college could be devised. This calls for invention and development of orthogonal type disciplines.

The gap between theory and practice grows ever larger in universities, especially the most famous ones. Employers complain about two or more years of socialization being needed to furnish grads with the tacit knowledge, practical intelligence, policy savvy, and like capabilities needed for effective functioning in the world. Existing disciplines leave procedural, tacit, practice skills out for the most part in a determined focus on research eliteness and research publishing-based fame. This academy drive for elite repute separates college institutions from the drive of their students for successful lives of accomplishment. There is a more serious point to be made here--that academics deliberately mystify their own sources of talent and professional success in an attempt to lower competition from younger generations and colleagues. Undoing mystification of knowledge handling success (the basis of scientific discovery success for example) can greatly expand

success of grad students who fail in current regimes, as they are judged to "lack talent", by faculty who spent years not sharing particular methods of success they used personally. This point, that political forces in discipline leaders sometimes cause them to deliberately fail to train up-and-coming generations well, should not be exaggerated. It should not be ignored either. Expert system building in industry, over a 20 year period, in field after field, found experts there deliberately not transmitting their best personal methods and techniques to disciples, peers, and rising generations. Ivan Illyich, interestingly, described this decades ago in his books (Illyich, 1971). This calls for invention and development of orthogonal type disciplines too.

Corporations are finding that their traditions of training and recent in-house "corporate universities" cannot keep up with the fast pace of new technology development and new social dynamics spawned by it. Training may be simply non-competitive; only educating may work. Moreover, piecemeal updating of personal knowledge bases often does not add up to change of corporate routine, structure, process, and destiny. In a way, corporations are seeking a way for themselves in their entireties, to become college students every ten or so years. If particular departments, processes, events, managerial strata, employee strata, and professional staffs are the students, what do you teach them? Something that moves every field into better excellence, expertise, quality, creativity, educatedness, effectiveness, and the like highly appeals, since everyone changing fields would put corporations into sudden chaos. This calls for invention of orthogonal type disciplines.

Topics like creativity, effectiveness, handling complexity that are found in every discipline, are important in their own right and have received some research attention. We can apply psychology, sociology, political science, philosophy, linguistics, and a host of other disciplines to study them, and we can, in turn, apply them--creativity, effectiveness, and so on--to each of many other disciplines to see what is unique in the cases of each domain where application occurs. We can examine famous cases of creation, major models of it, and the like. Trying, however, in any existing university, to do this comprehensively for any one such topic--say, creativity--is highly frustrating. Most of what one wants to study is not embodied in courses or research centers. Such broad, multi-disciplinary topics, are largely unlearnable and unresearchable in present university structures. This raises the question of some new institution of higher education dedicated to full treatment of a host of such cross-cutting topics. This is a call for invention of orthogonal disciplines.

New electronic universities are growing, having locked onto such principles as the 17 minute long class for laptop users and the 7 minute courselet for cellphone users. At first they attacked the soft underbelly of traditional higher education institutions--namely, fast moving tools, technologies, and standards needed for career promotion qualifications. Chained to such concretions they have to update curricula quite often and rapidly, to follow their fast moving knowledge targets. In a way they teach the grounding, the "how to do" layer missing from more abstract courses and contents in traditional higher education institutions. That makes grounding and how to work possible good candidates for orthogonal disciplines.

The above new formats for higher education, each asking for something like a set of orthogonal disciplines, were used to make questions given to nominators and nominees in this paper's study. For example, questions like the following were included in the interviews of nominators and nominees:

- what courses are needed but missing in your profession's professional schools
- what would a college for 38 to 42 year olds in your discipline be wise to teach/research
- what would colleges for 28 to 32 and 68 to 72 year olds in your discipline be wise to teach/research
- what set of coherent, integrated courses if added to existing ones in your discipline's colleges/grad schools would most improve things
- what would be most important to teach to departments, processes, events, managers, employees, and professional staffs of entire organizations studying together once per ten years
- an entire college teaching only one "orthogonal discipline" as defined by groupings of your answers to the above questions, would include what courses (if 90 courses on this one orthogonal discipline are required).

If you surveyed eminent people in a widely distributed sample of US society and asked them what should each of the above items contain if done well for their particular discipline (example, what gaps are there in their existing law curriculum, what

would a college for law-involved people between age 38 and 42 teach and research, what would such colleges for 28 to 32, 48 to 52, 68 to 72 years age groups best contain, what keys to success within law should be taught before, during, or after existing degree work to make graduates more successful and better performing in their profession, and so on), then you would be defining orthogonal disciplines.

This Paper's Method, Recursively Applied to Define a Set of Orthogonal Disciplines, then, Particular Orthogonal Disciplines

The method below is applied here, in this paper, to define a set of orthogonal disciplines; in later papers, versions of it are applied to define the contents of individual orthogonal disciplines in that set.

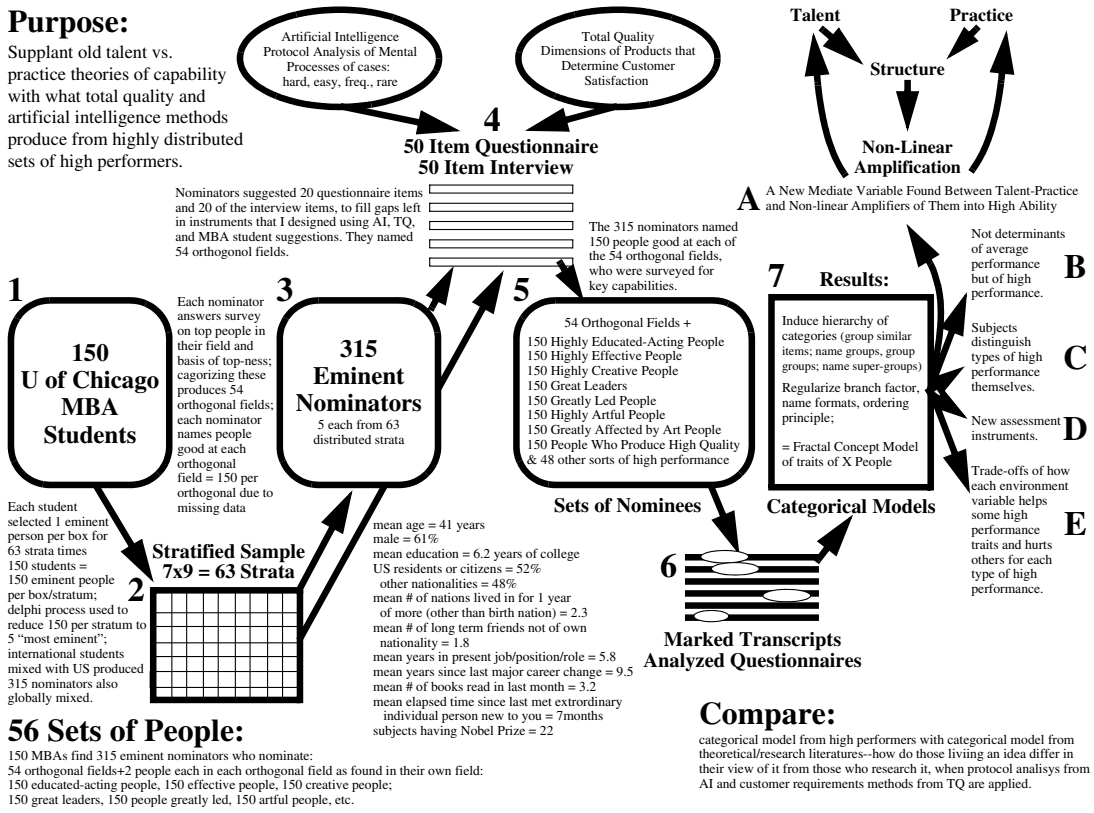
- interview eminent nominators in a stratified sample of society (a total of 5 people in each of 63 strata were interviewed for a total of 315)
- ask them questions about what forces, forms of excellence, trends, weaknesses, methods are shared by all traditional disciplines and questions about what courses new emerging formats of higher education should offer
- ask who the top people in their own field are and upon what basis they rose to the top
- categorize all answers to all the above into a model of X number of orthogonal disciplines, found as keys to success in every traditional field
- also ask them to nominate people good at each of the X number of orthogonal disciplines that were developed from the above categorization work (a total of 150 such nominees were obtained for each of, what turned out to be, 54 orthogonal fields)
- interview the 150 nominees, in each of the X number of orthogonal fields, using the same questions given the nominators
- turn interview results from both sets--nominators and nominees--into two models--one, of X number of orthogonal fields, and two, of the particular capabilities that constitute each such orthogonal field
- do the categorizing work above using the following steps: group similar answers, name groups, group similar groups, name such super-groups, continue till a hierarchy of categories results
- regularize that model by branch factor and principle of ordering to the extent possible (to make a partial fractal concept model)
- the result (illustrated below): a model of a set of possible orthogonal disciplines from things shared by existing disciplines and what emerging new forms of higher education need.

This process has been applied to produce papers on the following orthogonal disciplines as of this writing: educatedness, effectiveness, creativity models, creativity steps, quality globalizations, purposes of all arts, purposes of all leadership, management domains/levels/functions.

The Stratified Sample Used

	Science	Art	Humanities	Social Science	
Economic	technology ventures, idea markets, invention markets	museums, exhibitions, concerts, tours, coffee houses, clubs	resource limitation management; mystifications, historic preservation	economics: markets, pricing, regulation, trade regimes & orgs	
Political	voting gaming representation campaigning	awards, cannons	agreement limitation management, power embeddings realization	political science: elections, campaigns, administrating, consensus	
Cultural	ethics and religion policy making social clubs charities	art venture districts	meaning limitation management. false consciousness identifying	anthropology: deliberate culture invention, community enhancement	
Social Change	democratization globalization	social cabarets	confidence and direction limitation management, frame-limited revolts	sociology: social process and structure-- decline, fixing, invention	
Traditional	astronomy geology meterology oceanography space sciences	painting, music (song writers, performers, conductors), sculpture, dance, comedy, drama (theatre stars, movie stars), poetry	history philosophy	tribal community: festivals, calendars, wealth inheritance, bias in laws	
Establishment	physics biology chemistry math	performance, design	literature, counseling regimes, critics, awards, theatre industries	rise and fall of civilizations, rutted cultures	
Emerging	information media silicon and non-silicon computing h/w	digital art, interactive art, socially composed art, cyberart, virtual worlds	applied humanities, group composing, composing contests	networks, social virtuality	

The Orthogonal Disciplines: Research Process Flowchart



	Engineering	Professions	Fad & Fashion	Lifestyle	Systems
	financial engineering, inventors agriculture	business and management advertising & marketing	fashion designers, branding, multi-industry marketing by events	housing, communities locale type	technical innovation, quality movements
	cyberdemocracy, internet funding of campaigns, net volunteer management	administration military	party politics, third party movements	involvement dimensions	policy deployment, dissatisfaction deployment
	community organizing, environmental	religion education	lifestyle inventions, green movement	performing-consuming balance; diet, videogaming, manga	diversity management & expansion
	innovation venture districts/clusters	movement builders	intellectual movements, liberation movements	social entrepreneurs, self funding "profitable" charities	coalition building, foundation grants
	exploration, civil, architecture	medicine, nursing welfare	crowd generation, trend riding marketing, trend seeding, social imbalance exacerbations	festival organizers, theme parks, global event organizers	value sharing, negotiation, non-medical healing, reputation networks
	mechanical, electrical, aeronautics & space	law & justice	epidemic generation, rights movements (human rights etc.)	consumer movement	value sustaining/imposition
	biological & genetic, computer, internet society, nano tech--their blends	info tech, quantum devices	internet options: 6 billion channel TV broadcasting, agile economy	lifestyle inventors, micro institution development via viral growth regimes	complex adaptive systems research

Results--What Exactly Are the Orthogonal Disciplines, as a Set?

This research used fractal concept modeling applied to results of two sets of questions--one set derived from the origins of orthogonal disciplines above, and the other set derived from the six application types of orthogonal disciplines above. The resulting model is given below.

Examining the model below a number of immediate observations can be made. In some ways, orthogonal disciplines are where disciplines reflect on themselves and evaluate/improve themselves. Orthogonal disciplines are meta-disciplines in this way, in analogy with "meta-"cognition (Flavell, 1977). Meta-ness involves fields seeing how they might apply to other fields, fields seeing how other fields might apply to themselves, fields seeing how they share knowledge types and operations with other fields, like knowledge compilation processes (Nonaka and Teece, 2001), compiling tacit knowledge into explicit knowledge, compiling explicit knowledge into behavior routines, compiling practices into theories, compiling theories into practice routines. It also involves seeing how social dynamics (part political, part psychological, part anthropological) influence and limit knowledge dynamics of a field. The latent, incipient or tacit routines of one era, in the next era are formalized and formally taught, for example. So orthogonal disciplines capture the anthropology, psychology, politics, sociality of knowledge communities and their practices so that people understand and intervene with such community dynamics not just in conceptual dynamics. The full humanity of bodies of knowledge, that is, of the human communities that sustain and elaborate them, is covered in orthogonal disciplines, though of minimal interest to traditional disciplines. At present, only the histories of physics, medicine, geology, literature, and so on tend to recognize the full community and human dynamics that undergird, hinder, or break through particular conceptual contents in them. Orthogonal disciplines do this much more thoroughly, with broader research questions generated and more diverse methods applied. Beyond this, orthogonal disciplines are many other disciplines applied to any one discipline. For example, geology applied to literature is a real stretch and not so fruitful except via huge leaping analogy, but philosophy applied to literature and vice versa, literature applied to philosophy, the history and sociology of physics, and the like are not stretches and offer immediate obvious benefits. The cost of doing them is compiling knowledge from one knowledge model type (favored by the discipline itself) to others (other disciplines it is applied to or that is applied to it). One conclusion is--orthogonal disciplines are also meta-disciplines. They are orthogonal, in that they research topics shared by all traditional disciplines. They are meta in that they research just those aspects of any discipline that, if you become aware of them, by reflection, reveal things all fields share, like knowledge, like the social influences within knowledge-battles of a field, and the like.

Discussion: Some Example Orthogonal Disciplines--Expertise, Quality, Complexity, Technologies

The archetype for orthogonal disciplines--the discipline of "expertise"--was created in the last two

54 Suggested Initial Orthogonal Disciplines: Found Inside Every Traditional Discipline,
Combining Tacit Knowing, Practical Intelligence, Knowledge Evolution Dynamics, Declarative & Procedural Knowledge, Theory and Practice Knowledge.

		Person	Performance	Adaptation	Diversity	Reflection	Compilation
BASICS	SELF	educatedness*	REALITY: diversity* (handling it)	MODEL: structure* (social & cognitive)	EXPERIENCE: cases	META-KNOWING: humanities & arts of knowing	KNOWLEDGE TRAITS: knowledge models
		effectiveness*	complexity (handling it)	system*	theories	natural & social sciences of knowing	knowledge aggregations
		creativity*	error (handling it)	quality	expertise	professions & engineering of knowing	knowledge explicitness & consciousness
PRODUCTIVITY	MANAGE	management functions*	PRODUCE: leading*	STYLE: artfulness (handling constraintlessness)	GLOBALITY: global effectiveness (Western, Eastern, both)	META-DISCIPLINES: humanities & arts of 1 discipline	COMPILATION EVENTS AND SPACES: intellectual spaces and interfaces
		management levels*	composing/design*	coping (handling constraints)	power types	natural & social sciences of 1 discipline	social spaces and interfaces
		management domains	performing*	paradox (handling incongruity)	morality (establish solace systems)	professions & engineering of 1 discipline	emotional artistic spaces and interfaces
TRANSFORM	INFLUENCE	influence	DISCOVER: data (collecting & analysis)	LEARNING: entrepreneurship sources*	CHANGE: fashion (idea/method)	SOCIAL ALGORITHMS: social and intellectual revolution: liberty, freedom, historic dreams, conserve novelty	SURPRISE TYPES: knowledge evolution dynamics and patterns (Abbott)
		careers* (+job finding)	research (processes)	event management	ecosystems (of ideas & practices)	natural selection in and out of biology	knowledge sequence, context, size gaps
		technology (social life etc.)	venture (founding)	organizational learning	innovation practices (movements of change)	changing be to have in psychology, religion,	knowledge patterns and recognition, signal to noise

decades of the last century by artificial intelligence software people who traipsed around the world, finding experts and turning some significant part of their knowledge into software applications. A side-effect of this was noticing how experts in diverse fields differed from novices in similar and identical ways (Chi, et al, 1988). A further step was replications of immensely difficult skills, in novices, by skilled practice in the mental and social protocols found in experts at those skills. This "skilled practice" model of expertise went against generations of psychology research attributing performance to differences in inherent abilities or "talents" (Sternberg and Grigorenko, 2003). Creativity researchers added to this the finding that levels of fame, for creative outputs, were a linear function of hours of practice in dozens of entirely different fields--more practice, more fame (Simonton, 1999). This provided powerful support for the skilled practice model and against the traditional psychology-of-abilities-and-talents model.

Another orthogonal discipline, quality, happened to have a world-wide 20 year long social movement promoting it, called the Total Quality Movement. In this movement, launched among businesses by Japanese firms, but spreading beyond business to government, non-profit, arts, and elsewhere, quality, as a function to attain, and set of skills was "totalized" that is, removed from one profession--quality assurance--and given to entire workforces as something they were responsible for (Cole and Scott, 2000; Greene, 1993). Totalization of quality goals and means in this social movement soundly defeated older professionalization of quality, raising the question of whether totalization of complexity handling, error handling, expertise development, creativity, and other orthogonal fields would similarly outperform older, more traditional professional handling of them. Whether you totalize quality or not, every field concerns itself with the quality of its results, methods, and processes.

Every eight years new intellectual movements, new technologies, new software capabilities pass over the world, affecting disciplines and practices (Hucszinski, 1993). You can find them spreading across all existing disciplines. Most of the journal articles in traditional fields are merely rote applications of new ideas, technologies, or software capabilities invented in other fields to one's own different field. Though academics are immensely competitive about and proud of this work, it is intellectually derivative when viewed in even a slightly historical perspective. The re-articulation of research questions, research methods, and research results of every field re-founded on each new intellectual movement, new technology, and new software capability, is a major orthogonal discipline in its own right. Proliferation of DeVry Institute style colleges that tailor course selections and contents quarterly to match closely industry-employer needs, serves a research function, because their current curricula show us what substrates and interests underneath traditional disciplines are evolving and toward what. Not surprisingly over a third of the curricula changes each year in their curricula are technology related.

An example of one of the less obvious boxes in the model of 54 orthogonal disciplines above has its place here. Under the Reflection column, the Meta-Knowing section, the natural and social sciences of knowing (one of the 54 orthogonal disciplines in the model) fall all the contents of Andrew Abbott's book *Chaos of Disciplines* (Abbott, 2001). This president of the American Sociology Association lays out social and psychological and cultural reasons that patterns among ideas repeat themselves on fractal size scales within and across disciplines throughout history. Similarly I could cite books for every other box of the 54 on the model.

Uses 1: Why Not Just Update Existing Course Lists as Our Response to Orthogonal Disciplines?

Many people, maybe not realizing their own conservatism, will want to merely use orthogonal disciplines to suggest gaps in existing course offerings. For each orthogonal discipline they will suggest a course or two to add to each existing discipline. This, however, is an extremely conservative and partial response. First, each orthogonal discipline can be developed on its own, with dozens of courses just to flesh out its own research questions, methods, and possible results, quite independently of applying it to other traditional disciplines. Second, each orthogonal discipline, on its own, can sustain 90 or more courses, without even pushing any of its defining dimensions to their thinkable limits. Third, a great many orthogonal disciplines are simply missing entirely from existing course offerings and hiring, in each department, staff specially for it, is less efficient than hiring staff for a separate department of the orthogonal discipline and getting them to master applications to each of several other departments. Updating existing course

offerings truncates severely the intellectual depth and practical impact possible with orthogonal disciplines.

Uses 2: Do Orthogonal Disciplines Support Combining Fields and Cross-functional Teaming?

Anthropologists (Brown and Duguid, 2000; Lave and Wegner, 1999) studying document systems within sets of related companies and venture businesses in Silicon-Valley-like clusters found that knowledge traveled easily and well within professions ("communities of practice" that shared tacit knowledge, practical intelligence, and the like), but with difficulty across professions (practices). The knowledge had to be reformatted and re-articulated and re-imagined and re-framed in order to cross from one discipline to another. Cross-functional teams, by this view, dysfunction because all the translating across format, articulation means, imagination, and framework takes time, effort, and induces error and misunderstanding, absent from within-discipline team work. If, as the present paper suggests, the way to handle this is to constitute 54 orthogonal disciplines that cross all traditional ones, so we have people who specialize in expertise as it appears in all fields, or quality, handling of error, educatedness of performance, effectiveness, creativity and so on, will that form a basis of combining fields and cross-functional teamwork better by far than we now have?

Answering this question would require a separate research paper in itself. Here I can outline the argument that such future research will probably follow. When we try to get knowledge to flow across boundaries between different fields, practices, professions, we have re-formatting, re-articulation, re-imagination, and re-framing work to do. If, however, such work has already been studied, done, and published by people in each of 54 orthogonal disciplines, so that expertise, as it appears and is defined and done differently in all traditional fields and professions, is known, as is quality, educatedness, effectiveness, creativity, handling of error, handling of complexity, and so on, then the work of translating is instant, a matter of reading, and unambiguous, without outstanding errors or distortions--it has, in other words, been professionally researched. Of course, the thing to do is put this to a test--train people in various orthogonal disciplines and put them into situations of combining fields or working on cross-function teams and compare their performance, satisfaction, and results with people prepared for such work with present means. That, as I said, is a future research project not yet done. Readers should note that orthogonal disciplines, tested thusly, constitute a research basis for handling diversity in general in knowledge and practices of our world. They constitute the components of a new *Science of* handling diverse types of *Diversity*.

Uses 3: Possible Uses of Orthogonal Disciplines, Once They Are Invented

Drives towards new formats of higher education were used above in this paper to furnish questionnaire items used to get people to define particular orthogonal disciplines needed by such new formats. Here the same new formats are seen not as sources of defining orthogonal disciplines, but as places to apply them, once they are developed. The Check Up Option involves orthogonal disciplines used to spot gaps in existing curricula in existing disciplines. The New University Option involves establishing an orthogonal college between the third and fourth decades of life, a time of major career transition in nearly all fields, where people master what distinguishes high performers in their field from average ones, that is, the orthogonal disciplines. This is "College 2" a second college in everyone's life, later in life. Similarly, Decade Colleges between other later decades in life can be set up. We might, for example, establish a new "college" experience between everyone's second and third decades, 28 to 32 years old, for example, and make the content of that college orthogonal disciplines, because as people age, they more and more need to work across disciplinary boundaries. The Addition to Universities Option involves every university world-wide transformed by addition of a whole series of 20 or more new disciplines, each intersecting all traditional disciplines. This might take place initially as foundation of Auxiliary Universities, alongside existing ones, that prepared people for success in traditional disciplines and universities by using research on orthogonal disciplines to teach students how to succeed in traditional disciplines. Later such Auxiliary Universities would be folded into current established university frameworks and institutional processes. If college students become entire organizations then departments, processes, and events as well as roles--managers, employees, professional staffs--become students. Orthogonal disciplines allow complicated matching of traditional professions in such units to be bypassed as all such professions need Educatedness, Effectiveness, Creativity, and the rest of the orthogonal disciplines. Finally, even one orthogonal discipline expanded modestly and applied to, say, merely ten other disciplines most impacted by it, would comprise 90 or more individual courses.

This would allow creation of entire colleges dedicated to one orthogonal discipline, for example a University of Creativity, or a University of Quality.

Six uses, then, are conceivable, each is discussed below:

- curriculum gaps spotted and filled
- founding a second college, College 2, between life's 3rd and 4th decades
- founding Decade Colleges between other later decades of life (formalizing life long learning contents)
- founding Auxiliary Universities around existing Universities and growing them up till they become central as are existing traditional disciplines
- making entire organizations into college students, given orthogonal discipline study every ten years
- expanding each orthogonal discipline into becoming an entire college by itself, a University of Creativity, or University of Quality, for example.

Orthogonal Disciplines, Application 1: Course Offerings Checklist

I took course catalogs for all departments of Harvard, MIT, and Kyoto University, Tokyo Institute of Technology (approximately 6000 courses) and just using titles and very brief course descriptions there, categorized them under the model above of orthogonal disciplines. This was too imprecisely done to produce publishable results but it did hint at what more careful work in the future might produce.

If each department (of the 30 or so in each university) had 1 course per each orthogonal discipline, that would be 54 courses times 30 disciplines = 1620 courses per university or 6480 courses for the four universities. Since only slightly less than 6000 courses were listed for all four universities combined, that leaves at least 480 orthogonal courses missing. The hundreds of technology courses found in these four universities were, however, nearly all in engineering departments, not found in many other disciplines. So their immense number does not indicate coverage of the orthogonal discipline of technical bases of each separate field being represented in specific courses in that field. Similarly, the humanities and arts of any 1 discipline were present but all lumped in history or history of science courses, usually in history or philosophy departments. Hence their number does not indicate coverage of the orthogonal discipline involved. On the contrary, research and statistics (data collecting and analysis) courses were the most evenly spread, found in nearly all departments of all four universities. Courses covering theories, cases, and practices were similarly well distributed across most fields. A total of five orthogonal disciplines were covered in most departments, of these universities, and two more--technology and humanities and arts of 1 discipline--were lumped in one or two departments but not distributed across many, hence, not evidence for coverage of their respective orthogonal discipline. That leaves 54 minus 5 = 49 orthogonal disciplines largely missing in these universities.

It would be interesting to calculate the proportion of courses, in each department of each university, that are on orthogonal topics and see what performance outcomes of interest this correlates with, for faculty, for research, for teaching, for performance of graduates years after graduation. *However, here it is enough to point out that only approximately one eleventh (5 of 54) of the orthogonal courses possible are present in leading universities at present.*

Coverage of 54 Orthogonal Disciplines by 6000 Courses of Four Top Ranked Global Universities' Course Catalogs

Person			Performance			Adaptation			Diversity			Reflection			Compilation		
self	manage	influenc	reality	produce	discovery	model	style	learning	experience	globality	change	meta-knowing	meta-disciplines	meta-practice	knowledge traits	compilation cycle steps	surprise types
educatedness						structure (social & cognitive)			cases			humanities and arts of knowing			knowledge models		
effectiveness						system			theories			natural and social sciences of knowing			knowledge aggregates		
creativity						quality			expertise			professions and engineering of knowing			knowledge consciousness and explicitness		
	manage functions		diversity (handling)			artfulness			global effectiveness (Western, Eastern, both)			humanities and arts of 1 discipline			knowledge trait self mappings		
	manage levels		complexity (handling it)			coping			power (types)			natural and social sciences of 1 discipline			knowledge between trait mappings		
	manage domains		error (handling it)			paradox			morality			professions and engineering of 1 discipline			knowledge between trait reverse mappings		
	influence		leading			entrepreneurship (sources)			fashion			practice as liberation			knowledge context and size gaps		
		careers + job finding		composing/design		event management			ecosystems (of idea, methods)			practice as freedom and historic dream			knowledge sequence gaps		
		technology		performing		organizational learning			practices			practice as conserving novelty			knowledge surprise types		
				data (collecting & analysis)													
				research (processes)													
				venture (founding)													

Note: each * designates 1 course. Approximately 550 Orthogonal Courses out of 6000 Courses in the Course Catalogs of 4 World Famous Universities

Note: Nearly all departments have one or two history-of-the-field courses, Nearly all colleges have philosophy of knowledge courses handling the Reflection category above, Nearly all design/composition courses are in engineering departments; Nearly all grad school departments cover research processes and data collecting; IN SUM: the vast majority of courses (5300 out of 6000) are sequential hierarchical compositions from basic concepts to advanced ones; only 9% of all courses are "orthogonal" and most of these are inside one department not applied to all departments.

Orthogonal Disciplines, Application 2: College 2

There is a transition, called the mid-life crisis, that may or may not exist, in spite of popular publishings about it. There is a transition at the same time in life, in nearly all professions and disciplines, from utter narrowness of contribution, to more generality, more detachment, more managerial endeavors, more collaborations with those outside one's own institution. If we have to put a time period on it, the ages 38 to 42 are not a bad fit. In not a few organizations there are formal management choices made at this time in careers--some chosen for further promotion and some put out to pasture at early middle age. Most of us have tried phoning people who just received one or the other of these messages and found them unable for a few days or weeks to "come to the phone".

At the moment college is found only between the second and third decades of life. There is a general clamor for another "round" of college later in life and perhaps the ages 38 to 42 fit well for the reason given above. What should be different about a second college, "College 2", between the fourth and fifth decades of life? People might want to change careers,

that is, change from one discipline or profession to another. In that case, merely going back to college, as it was delivered between 18 and 22 years of age, would do. People might want to switch from ho-hum destiny within their existing field to excellence and leadership. In that case, merely doing what was done between 18 and 22 would not do. Perhaps graduate courses in the same discipline would do? But graduate coursework inevitably draws one towards research not practice. Orthogonal disciplines might then be what is needed--for they define various "excellence" boundaries within any field (in both its theory and practice).

Orthogonal Disciplines, Application 3: Decade Colleges

As soon as one thinks seriously about a further college experience beyond the one nearly everyone has between 18 and 22 years of age, say, between 38 and 42 years, the idea of others appears. Do people need a third college experience between say 68 and 72? Do they need one between 48 and 52? For many people, lacking resources, college stretches across decades like this--college between 18 to 22, masters degree between 28 and 32, Ph.D. between 38 and 42. Competition for jobs is causing graduate work to play the role that having an undergraduate degree played decades ago. That means basic college for everyone becomes 18 to 24, including a masters degree. Then, 28 to 32 becomes starting a Ph.D. and 38 to 42 becomes orthogonal disciplines, perhaps. The truth is, we do not know what weave of higher education with career progress people want now. Some students and I, again informally, too informally for research publication, tested these waters. We interviewed, by phone, 315 nominators from my previous research, asking each of them, in various ways, to lay out "ideal" and "realistic" weaves of higher education experience types with their wanted or actual career paths.

Favored Higher Education Paths from 315 Eminent Respondents in 63 Widely Scattered Fields Who Were Exposed to the Orthogonal Discipline Idea

Higher Education Paths Asked About (emphasis added for display here: * marks orthogonal discipline containing items)	is ideal for me	is practical for me
college at 18 to 22	0	26
college at 18 to 22; masters at 28 to 32	3	4
college at 18 to 22; masters at 28 to 32, masters at 38 to 42	4	12
college at 18 to 22; masters at 28 to 32, masters at 38 to 42, masters at 48 to 52	19	12
college at 18 to 22; masters at 28 to 32; Ph.D. at 38 to 42	***67***	***56***
college at 18 to 22 plus masters at 23 to 24 plus Ph.D. at 28 to 32	25	11
college at 18 to 22 plus college again at 38 to 42	15	23
college at 18 to 22 plus orthogonal discipline college at 38 to 42	27	***44****
college at 18 to 22 including orthogonal disciplines	0	***36****
college at 18 to 22 including orthogonal disciplines plus masters at 28 to 32	5	33*
college at each decade boundary, with 2nd, 4th, 6th being orthogonal disciplines	***27****	22
college at each decade boundary, with 2nd, 4th, 6th, being different masters degrees	***31***	22
college at each decade boundary: bachelors, masters, Ph.D., then new field: bachelors, masters, Ph.D..	11	8
college at each decade boundary: bachelors, masters, Ph.D., in one traditional field then bachelors, masters, Ph.D. in another field--with each degree, of all six, combining traditional disciplines with orthogonals 50/50	***81****	5

Orthogonal Disciplines, Application 4: Auxiliary Universities

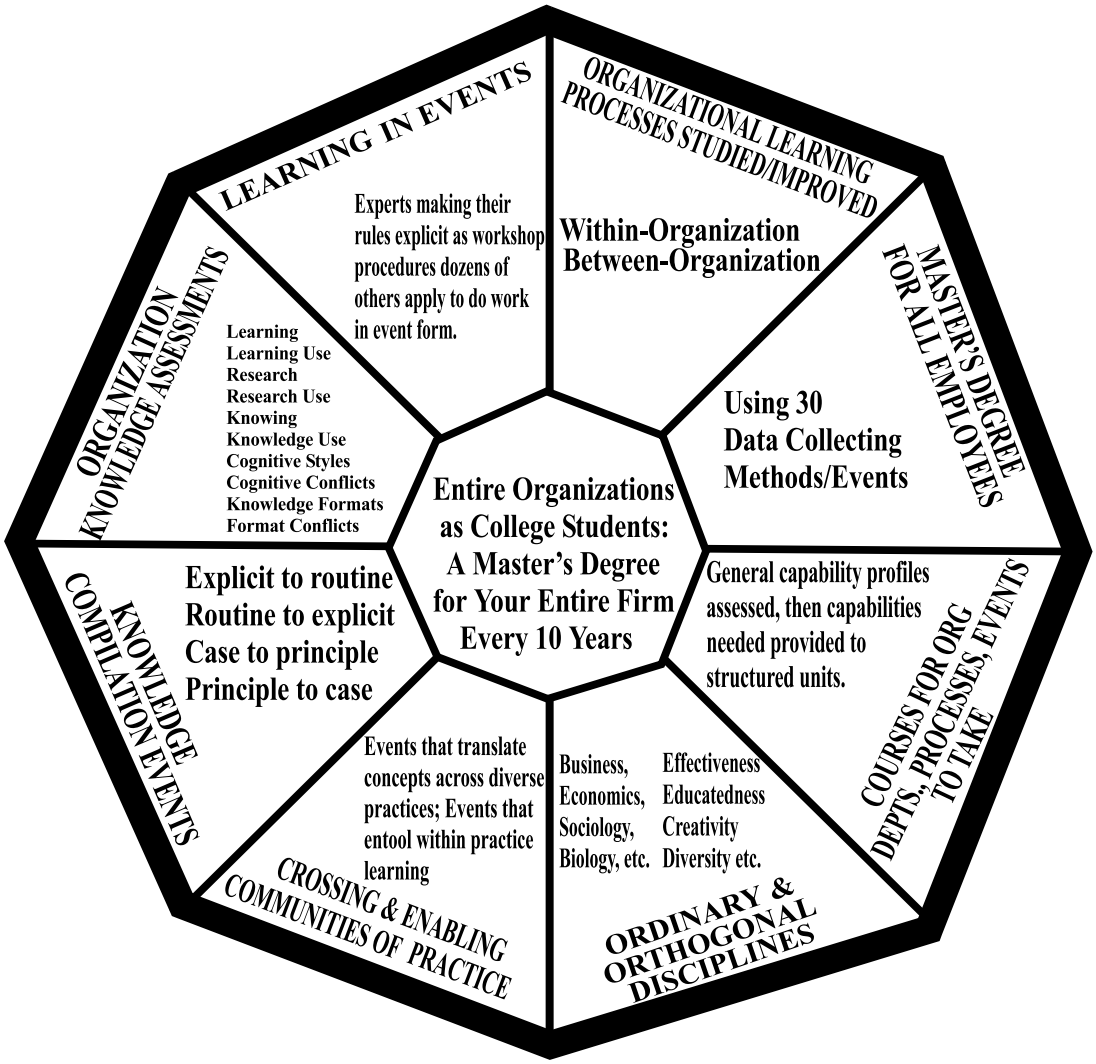
If existing universities do not teach or under-teach (and under-research) effectiveness, educatedness, creativity, handling diversity, handing complexity, handling error, structures, system effects, and quality and all the other orthogonal disciplines as they apply to each traditional discipline and on their own, what should we do? We can press for change but universities change by imperceptible degrees, the way water leaks, some say (Clark, 1987). We can instead surround universities with add-on institutions that prepare students to excel in college and career by adding orthogonal career coverage that colleges omit. Such Auxiliary Universities can be sold as ways to preserve the investment value parents and kids make in college from wayward kids and wayward faculties.

Orthogonal Disciplines, Application 5: Entire Organizations as Students

As soon as you seriously contemplate department, process, and event participants, along with managers, employees, and professional staffs as students of "college", the need for formal orthogonal disciplines raises its head. For entire organizations need to more or less keep people in their existing areas of expertise yet greatly improve their levels of aspiration and performance there. Orthogonal disciplines nicely do exactly this--they teach what distinguishes the top of any field from the average or below average members of it.

Assembling a consortium of universities to teach entire organizations, is usually needed, in part, because no one university has enough orthogonal discipline

coverage to do what companies and NGOs/agencies want done. To get critical mass in orthogonals, consortia uniting several universities, liberal arts and technical, engineering and professional schools, are assembled. If any one institution were already fully covering orthogonal disciplines, such consortia would not have to be assembled, perhaps, for this purpose.



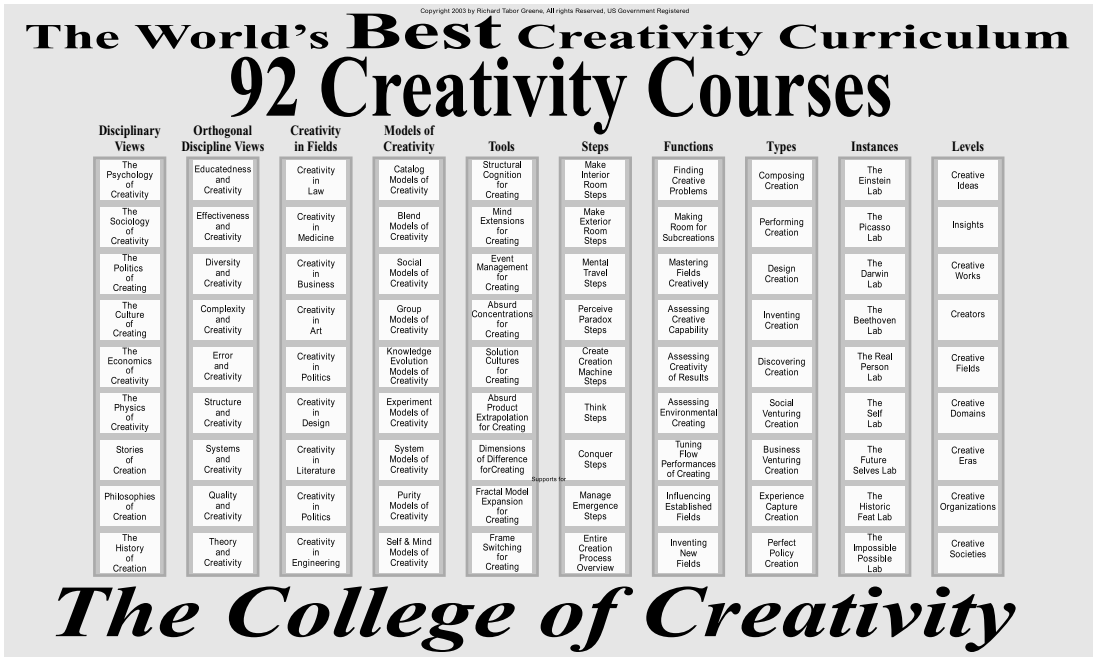
Orthogonal Disciplines, Application 6: University of Creativity, and others

Any one of the 54 orthogonal disciplines presented in this paper can itself become a college of its own. In part, you can do this by applying other disciplines to understand the orthogonal discipline and in part by, conversely, applying the orthogonal discipline to others. Other parts of doing this involve laying bare the mental tools, frameworks, models and theories that comprise the orthogonal discipline. Add analysis of key cases, types of the orthogonal discipline, and levels in society or psyche it gets applied to, and you have most of the rest. Finally, you can distinguish this one orthogonal discipline from closely related other orthogonals. The diagram below presents 90 courses on creativity in ten groups of nine each.

We can similarly compose a University of Quality, a University of Effectiveness, A University of Management Functions, and so on. This interplay of traditional disciplines with each other and with

orthogonal disciplines, and, interplay of orthogonal disciplines with each other, give us a systematic way to generate course coverage of any topic. In a way, they automate the elaboration, in curriculum terms, of any core concept. Lest some think a University of Creativity shallow or trendy, careful consideration of the economics of creating, the psychology of creating, or of the creativity in medical research, the creativity in Broadway show composing, and so on, for other courses listed below, belies that. Four years taking the 90 courses below would be a great education if each course fully deploys its own particular blends of disciplinary contents.

Similar course elaborations for a University of Quality, or University of Effectiveness, and so on, are possible and would differ in no important details from what is given below for the University of Creativity. The way orthogonal disciplines bring into research and teaching tacit knowledge, practical intelligence, procedural knowledge, global practices, practice improvement theory, and the like makes them precisely the bridge between theory and practice, the absence of which is so often lamented by people receiving university research or teaching. There is reason to suppose the productivity of whole society learning processes, in which research universities play such an important role, can be improved by inclusion of orthogonal disciplines, around existing universities, or within them, or, that failing, as competitor institutions to them.



Conclusion: Orthogonal Disciplines as a New "Science of Diversity"

The idea of disciplines orthogonal to traditional ones was defined and related to gaps and dysfunctions of existing disciplines and their associated professions. Things commonly happening to various different disciplines and new emerging forms of higher education were turned into questionnaire items given to nominators and nominees to get them to define a set of orthogonal disciplines. A reflective "meta-"ness to such orthogonal disciplines was found. A recursive process of research has been applied to define 54 orthogonal disciplines and can be later applied to each such orthogonal discipline to flesh out its specific contents. That recursive process has been defined herein and applied once. It produced a model of 54 orthogonal disciplines in six sets of nine disciplines each. Uses of orthogonal disciplines have been suggested, in a sequence from checking completeness of course catalogs to creating entire colleges dedicated to single orthogonal disciplines. Suggestive informal datasets on course coverage of orthogonals in major university curricula and career path weaves of higher education, including or not including orthogonals, wanted by eminent people in 63 fields have also

been presented to suggest that less than 9% of the orthogonal disciplines from this paper's model are now covered in any way in existing curricula and that a majority of eminent people in 63 fields felt a sequence of university experiences, half including orthogonals, was "ideal".

The following hypotheses are suggested, though not proved, by the analysis in this paper:

- the lackings of, trends across, excellences sought that are shared across existing professions and disciplines can be turned into a list of new disciplines, orthogonal to traditional ones
- orthogonal disciplines can be researched in their own right and can be applied to all traditional disciplines
- various emerging new forms of higher education, including later life forms of college and new colleges having entire organizations as students, require things supplied well by such orthogonal disciplines
- most of departmental curricula in existing universities build advanced concepts from basic ones; nearly all the rest of them consists of orthogonal disciplines applied to any one traditional one
- orthogonal disciplines are substantial and worthy of research and teaching on their own right, without dependence, socially, financially, or conceptually on traditional disciplines
- any one orthogonal discipline, by studying how it applies to ten or so other disciplines, and how ten or so other disciplines elaborate it (its psychology, its sociology, its politics, its economics, its history, and the like) can be elaborated into a college of its own, having 90 or more courses
- much that is not taught, because tacit, latent, practical, practice-related, involving other disciplines, and the like is captured by orthogonal disciplines and brought into full university research and teaching treatment
- there are diverse types of diversity in our world, each requiring specific attention, modeling, and response types such that a set of disciplines orthogonal to traditional ones becomes a Science of Handling Diversity, much needed now.

Orthogonal disciplines, latent in existing institutions, and as a concept, are worthy of research treatment and perhaps, design and implementation to meet needs manifestly ignored or incapable of being met by existing disciplines.

Some open questions that remain include the following. First, if orthogonal disciplines bind and combine traditional ones, what binds/combines the orthogonal ones? Is it traditional disciplines or some 3rd "orthogonal to the orthogonals"? If the latter, what are these 3rd level orthogonals to the orthogonals? Second, crossing and combining different national cultures closely reproduces the problems of crossing diverse disciplines of knowledge and professions. Are crossing and combining different national cultures alleviated or solved by use of orthogonals just as crossing and combining traditional disciplines and professions are? If not, what else is needed beyond orthogonal disciplines. If yes, why do orthogonal disciplines help diverse national cultures combine and do they also help any diverse cultures combine, such as the cultures of different genders, eras, families, organizations?

Hints of a New "Science of Diversity"

There are diverse types of diversity. There is diversity of gender, national culture, era, family style, profession, organization and many others. If we have a good way to handle the diversity of professions (and the disciplines that correspond with or generate them), will that same way work well in handling any or all the other types of diversity? A brief logical examination of orthogonal disciplines, as a possibly effective way to handle diverse disciplines and professions, and other forms of diversity, seems to be in order in closing this paper. It amounts to asking "what do we really have here". For example, we can define orthogonal cultures, orthogonal to national cultures, the culture of families, the culture of technologies, the culture of genders, the culture of eras, the culture of organizations, the culture of politics, the culture of commerce, and culture of symbol, ritual, and celebration, and so on. When we wish to use, modify, or characterize the culture of, say, Japan or Iceland, one approach, then, is to see how each "orthogonal culture" varies as we go from Japan to Iceland to South Africa and others. For another example, we can define orthogonal disciplines as this paper does above, and examine in Japan, Iceland, South Africa, and other national cultures how all of them define and do educatedness, effectiveness, creativity, handling complexity, handling error, management functions, and so on. Which set of orthogonals would be more powerful and effective? In both cases we are considering a divide-and-conquer strategy, by articulating 30 to 50 specific "orthogonal" dimensions along which to specify changes, and along which to fund and train and research and teach such changes. The orthogonal approach to

establishing a Science of Diversity assumes any one basis of combining disciplines or national cultures is insufficient. Depending on one field--cognitive science--as we did 30 years ago, to bind and combine disciplines or cultures does not work. So with the orthogonal field approach we instead depend on 30 to 50 new fields/cultures and actively research for each one, how standard traditional fields or cultures vary and why. There may simply be too much diversity, too many types of diversity, for any simple one "Field of Diversity Handling" to suffice.

A Test of this Idea of Orthogonal Disciplines

Thomas Tritton, President of Haverford College, helped close a conference on unifying all knowledge, kicked off by a keynote address by Wilson, author of a "consilience" idea that biologic knowledge of the evolutionary and neural sorts would unite social with hard sciences. He distinguished interdisciplinarity (one person working across boundaries) from multidisciplinarity (several people from different disciplines elucidating one issue together) from pandisciplinarity (nearly all disciplines applied to one issue, whether by individuals or groups). He also presented blocks to unifying work across disciplines. We can examine each of his blocks to see if orthogonal disciplines, as an approach, has power to handle them well, better than other proposals (including Wilson's consilience proposal). Much power comes from science breaking things into finer and finer categories, of which the disciplines are one important manifestation. Working across disciplines may weaken the power of focus that disciplinary specialization enables. This is block one. Dilettantism is a second block--working across disciplines is likely to involve or create people shallowly involved in a great many areas, lacking depth and powerful research results. Illusory connections is a third block. Efforts to work across disciplines are likely to generate lots of supposed connections, analogies, and commonalities that are of little worth, based on little or nothing, and that keep appearing like mental weeds. More practically, the fourth block involves condemnation of anyone claiming to be qualified across many or even a substantial few disciplines. Claims of multi-disciplinary mastery are likely to be death sentences, as other professors attack such "arrogance". The fifth block is most complex. Boyer suggested scholars discover, apply, teach, and integrate knowledge, though they practically are divided into some who mostly discover, and the rest who mostly teach, with few doing application and fewer doing integration work. In other words, distinguished people have already called for more integration work with virtually no changes or serious responses to show for their calls. Can orthogonal disciplines handle these blocks better than other approaches to integration like Wilson's consilience approach?

The orthogonal disciplines approach is the perfect vehicle for achieving cross-discipline integration while preserving the value of focus from specialization--because the orthogonal disciplines themselves are further specializations, making knowledge more articulated and categorically focussed rather than less, while achieving integration across all disciplines. The first block is perfectly handled by orthogonal disciplines. Much the same is true of the second block--dilettantism. Each orthogonal discipline is a discipline in its own right, where depth of publication, research, funding, and career advancement is achieved. Masters of each orthogonal discipline are not dilettantes. So the second block is perfectly handled by them. The third block is not so nice a story. The orthogonal disciplines constitute a formal and practical constituency in whose interest it is to exaggerate commonalities across disciplines. The orthogonal disciplines approach is as likely as any other to generate lots of false commonalities across fields. However, examination of expertise, as developed by artificial intelligence application work at the end of the last century, may calm fears of this somewhat. It turns out that powerful generalities across fields--fame a straight line function of hours of professional practice, experts differing from novices in ability to spot novel or anomalous configurations in field problem situations quickly and accurately, and so on--were found and validated with research at good standards. Expertise thusly developed by the artificial intelligence community did not suggest a lot of false commonalities that later needed public debunking. The fourth block--condemnation as arrogant--is handled rather well by the orthogonal discipline approach, if not perfectly. If I am professor of expertise, in any other field, or of quality, or of creativity, then I am not claiming to be an expert in any other orthogonal discipline. I am as narrow as anyone else in research is, except my discipline's results and knowledge apply to all traditional disciplines. Finally, the fifth block--no or little response to past calls for integration work--is in no way handled better by orthogonal disciplines than by other integration of field approaches. Any superiority to the orthogonal disciplines approach for handling this block is yet to be determined as this paper is the first formal presentation of the orthogonal disciplines approach. We do not really know what response to it will ultimately be. Yet

other integration approaches by professors much more famous than I, have drawn little response and funding sources have changed little to accommodate them so there is reason to be skeptical that the quality of ideation in this paper suffices to overcome institutional inertia and current patterns of funding.

The final score, then, is 2 of 5 handled perfectly, 1 handled pretty well with actual case data from expertise to prove it, and 2 handled badly though case data in one of those cases indicates not much weakness and though we have no response data for the second of those. A score of 70 out of 100 would summarize this situation well. Consilience, by my analysis and certainly by the analysis of a great many reviewers of Wilson's book on it, scores badly in comparison (chapters in a recent book/conference on it averaging a score of 40% or lower in handling the five blocks articulated above). For the five blocks--losing specialization's focus value, dilettantism, exaggerating commonalities across fields, arrogant appearance of multi-field expertise, and failure of prior calls for integration across fields--consilience threatens to make specialties go entirely away, it unites fields based on biological bridges from genes to behaviors (which some see as deep and others see as fallacious in part because environment affects on gene expression are so strong as to reverse overall gene effects in many cases, much research shows), it reduces differences into commonalities much as physics equations do, it is bold if not arrogant in intent, method, and claim, and it offers nothing particular to immunize itself from failure of prior calls to integration of fields. This result is cause for hope that orthogonal disciplines may take root, first in some pioneer imaginations, then in some pioneer institutions, then in higher education worldwide and history long.

References

1. Abbott, Chaos of Disciplines, U of Chicago, 2001
2. Atkinson and Tuzin, "Equilibrium in the Research University" in Change, American Association for Higher Education, Vol. 24, No. 3, May/June 1992.
3. Bieber, Lawrence, Blackburn, "Through the Years--Faculty and Their Changing Institution" in Change. American Association for Higher Education, Vol 24, No. 4, July/August 1992.
4. Bok, Higher Learning, Harvard University Press, 1986
5. Brown and Duguid, The Social Life of Information, Harvard Business School Press, 2000
6. Chi et al, The Nature of Expertise, LEA, 1988
7. Clark, The Academic Profession, Univ. California Press, 1987
8. Cole and Scott, eds, The Quality Movement Organization Theory, SAGE, 2000
9. Damasio, Harrington, Kagan, Mcewen, Moss, Shaikh editors, Unity of Knowledge, the convergence of natural and human science, Annals of the New York Academy of Sciences, Vol. 935, 2001
10. Illyich, Medical Nemesis, Basic Books, 1971
11. Flavell, Cognitive Development, Prentice Hall, 1977
12. Greene, Global Quality, ASQC and Irwin (now McGraw Hill), 1993
13. Huczynski, Management Gurus, Routledge, 1993
14. Lave and Wegner, Situated Learning, Legitimate Peripheral Participation, Cambridge, 1999
15. MIT, "MIT Welcomes its First Interdisciplinary Major", MIT Soundings, Fall, 2003.
16. Nonaka and Teece, eds, Managing Industrial Knowledge, SAGE, 2001
17. Simon, Sciences of the Artificial, MIT, 1981
18. Simonton, Origins of Genius, Oxford, 1999
19. Smith, Killing the Spirit, Higher Education in America, Viking, 1990
20. Sternberg and Grigorenko, eds, The Psychology of Abilities, Competencies, and Expertise, Cambridge, 2003
21. Tritton, Integrated Learning, passing fad or foundation for the future in Damasio et al, 2001 above.